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Homa Therapy agriculture environment cattle and human health document of five fold path mission

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Abstract

Agnihotra is a gift to humanity from ancient- most Vedic Sciences of bio energy, medicine, agriculture and climate engineering. It is the basic fire in HOMA THRAPY. It is the process of purification of the atmosphere through the agency of fire, prepared in the copper pyramid tuned to the biorhythm of sunrise/sunset. By practice of Agnihotra, one start noticing that that tension of mind disappears and one begins to experience peace. The mind is reshaped so nicely, so delicately, so effortlessly by sitting in Agnihotra atmosphere.

Homa therapy is a simple technique which can be practiced by every citizen of the world was standardized by Shree Gajanan Mahraj, from Aakalkt, Solapur, Maharashtra after long experience. After getting convinced its impact for humanity, he entrusted its further dissemination to a select group of people. Some of important organizations which are associated with teaching, research and extension of Agnihotra in the world are:

1. International Homatherapic Resaerch Institute, Akkalkot, Sholapur, Maharashtra, India
2. Five Fold Path Mission, Homa Therapy Goshala, Ladvi, Mandleshwar-451221, Maheshwar, Dist. Khargaon, Madhya Pradesh
3. Homa Farm, Tapovan Ratanpimpri, Parola-425111, Jalgaon, Maharashtra
4. Shreeniwas, 40, Ashok Nagar, Dhule-Maharashtra
5. Mahanubhav Madhav Ji Sansthan, Madhavashram, Bopal
6. Five Fold Path Mission, USA
7. Panch Sadhan Pracghar Kendra, Shivaji Nagar, Pune, India
8. Psychotonic Society of Warsa, Poland
9. Agnihotra University and Agnihotra Press, Maryland.

Extension work on Agnihotra outside was initiated by Shree Vasant V. Paranjpe since 1970. As a result Shree Paranjpe now millions of people in different parts of the world are practicing Agnihotra daily and harvesting spiritual and material happiness.

Besides there are large number of agencies, institutions in Australia, Brazil, Chile, Germany, Africa, Indonesia, Malayasia etc are actively involved in extension of Agnihotra on their own way.

The Nature of Agnihotra

Following are some of the thing told about Agnihotra in ancient sciences tradition:

Tremendous amounts of energy are gathered around the Agnihotra copper pyramid just at Agnihotra time. A magnetic type field is created, one which neutralizes negative energies and reinforces positive energies. Therefore a positive pattern is created by one who does Agnihotra merely by his/her performance.

When Agnihotra is performed, the Agnihotra smoke gathers practices of harmful radiation from the atmosphere and on very subtle level neutralizes their radioactive effect. Nothing is destroyed, merely changed from one form to another form.

When Agnihotra fire is burnt there is not just energy from the fire, but subtle energies are generated or thrust into the atmosphere by fire, Also consider the quality of

materials burnt wherein lies the full effect of this healing HOMA. Much healing energy emanates from the Agnihotra pyramid.

Effect of Agnihotra

Agnihotra renews the brain cells. It revitalizes the skin and it purifiers the blood. It provides the holistic approach to life.

Agnihotra has the ability to neutralize pathogenic bacteria.

One sit a Agnihotra fire and breathe in the smoke, which goes quickly into bloodstream and lungs. This has excellent effect on circulatory system and even more so if Agnihotra ash is ingested. The smoke has a good effect on the brain and nervous system.

If plant are kept in Homa atmosphere where vibration of Agnihotra pyramid fire are maintained, one subtle enough can actually see growth, communication etc, Plants receive nutrition from Agnihotra atmosphere, become happy and grow well.

Just as Agnihotra pyramid fire gives nourishment to plants, it provides the same for human life and animals.

The sun brings and takes the energy, which makes all conditions conductive to an anti pollution change. It calms the world. The pyramid is generator, the fire is turbine. The cow dung, ghee (clarified pure cow's butter without any additives) and rice then interact to form a composition which is thrust, surrounds, neutralizers and nutritionalizes the material. Then, with organic substances, this provides the nutrients for survival, yield and propagation. This is how the Agnihotra fire physically heals the atmosphere.

Thousands of people on all continents belonging to different races, languages, religions and spiritual groups who practice Agnihotra have remarked that simply by performing daily HOMA, (i.e. Agnihotra sunrise/sunset) they feel like a protective film surrounds them.

Components of Agnihotra

Pyramid: For Agnihotra you require a copper pyramid of a specific size. Copper is a conductor. Just at morning Agnihotra, all the electricities, energies, ethers are attracted to the pyramid at i Agnihotra timing- The time component of Agnihotra is one of the most essential aspect. Light radiated by sun at sunrise and sunset is termed as diffused light in the sky which has great ecological significance. Since sun at the rise or set becomes near to horizon in transverse/ oblique position, solar rays have to cover a longer distance to reach to the earth and in this course solal rays (electromagnetic waves) of visible spectrum of lower wave lengths i.e. violet, indigo, and blue and probably ultraviolet, X-rays and Y-rays are scattered and lost in the atmosphere. The other visible rays of higher wavelengths i.e. yellow, orange, red and infra red of invisible spectrum reach to the earth and the sky looks yellowish red at the time of sunrise and sunset. One can say that solar ray reaching to the earth at both times contains greater proportion of infra red which lethal but more penetrating and greater energetic in nature.

Rice: Brown rice. Highly polished rice looses nutritional value and hence brown rice. Only unbroken pieces of rice should be used for Agnihotra. If rice is broken, the subtle energy structure is disturbed and hence is not fit for Agnihotra healing fire.

Ghee (Clarified butter): Homemade ghee prepared from cow milk is well accepted for Agnihotra..This can last without refrigeration for long time. Ghee is a very special medicinal substance. When used in Agnihotra fire in acts as a carrier agent for subtle energies. Ghee helps in quick combustion of dung patties Powerful energy is locked up in this material.

Dried Cow Dung patties: Take dung from male of female progeny of a cow. Make a pan cake like patties and dry them in sun. Agnihotra fire is to be prepared from this dried cow dung.

Cow dung is treated as medicine in all ancient culture whether they are Indians of North or South Americans, Scandinavians, East or West Europeans, Africans and Asians.

How to Prepare Agnihotra Fire

Place a flat piece of dried cow dung at the bottom of the copper pyramid. Arrange piece of dried cow dung, which have been coated with ghee in the pyramid in such a manner as that allow air to pass, Apply a little ghee on the small piece of cow dung and light it. Insert this lighted piece of cow dung in the pyramid. Soon all the dung in the pyramid will catch fire. You may use a hand fan to blow the air and help the flame. However, do not blow through the mouth to avoid bacteria from the mouth getting into the fire.

Do not use any mineral oil or similar material to start the fire. At sunrise and sunset a good flames should be ready in the pyramid.

Agnihotra Process

Take a few grains of rice in a dish or your left palm and apply a few drops of ghee.

Exactly at sunrise utter the first mantra and after the word SWAHA add a few grains of rice from your right hand (as little as you can hold in the pinch of your fingers will be sufficient) in the fire.

Utter the second Mantra and after the word SWAHA add a few grains of rice from the right hand in the fire.

At sunset to the same by using evening Mantras.

If you miss the timing it is not Agnihotra and you will not get the healing effect on the atmosphere or in the ash.

After each Agnihotra try to spare as many minutes as you can for meditation. You can sit at least till the fore extinguishes itself. Agnihotra creates a medicinal and healing atmosphere.

Just before the next Agnihotra collect the ash and keep it in a glass or earthen container. It can be used for plants or making folk medicines.

Mantras

There are vibrations that exist everywhere. It is only vibrations when you go into it. Where there is vibration there is also sound. When we do these Mantras, the sounds we utter activate these special vibrations that will create certain atmosphere or effects. Then the desired results are realized. These vibrations exist for everything, so anything can be activated, controlled or changed by Mantras.

When one utters the Mantra with a pure mind into the Agnihotra pyramid at Agnihotra time, the ash retains that energy and healing properties of the ash become more powerful.

Agnihotra Mantras

At Sunrise

Soory'aya Sw'ah'a

(Add the first portion of rice mixed with ghee into the fire)

Soory'aya Idam Na Mama

Praj'apataye Sw'ah'a

(Add the second portion of rice mixed with ghee into the fire)

Praj'apataye Idam Na Mama

This completes morning Agnihotra.

At Sunset

Agnaya Sw'ah'a

(Add the first portion of rice mixed with ghee into the fire)

Agnaye Idam Na Mama

Praja'pataye Idam Na Mama

This completes evening Agnihotra

(a' is pronounced like a in 'father')

For timings and other information following websites will be helpful

www.homatherapyindia.com; www.agnihotra.com.au;

For Agnihotra materials-Please contact on following mail

Shree Rishikesh Paranjape, Dhule, Maharashtra

E-homatherapy@gmail.com, 09225135175

Homa Therapy in Agriculture

Agnihotra and plants: The ghee which is used in performance of Agnihotra is thrust into the atmosphere and attaches itself to the molecular structure of the soil, allowing the soil to retain more moisture. Thus plants grown in Agnihotra atmosphere are better able to withstand droughts. Agnihotra causes a change in the cellular structure of plant, which sends more nutrients to the fruits and less to the leaves, stem and roots. Performance of Agnihotra in the garden yields fruits and vegetables are superior. It reduces pest problems and organic gardening are made easier by using Homa technique.

A special configuration of Homa Pyramids is installed to activate a Resonance point on a Homa Farm. It requires in all 10 Pyramids which are charged with special Mantras, one in its life. Volunteers of Five Fold Path Mission are authorized for this. They will provide all logistic support with little expenditure for their travel and stay at the site. With establishment of Resonance 60 hectares area can be managed with exciting results. With establishment of Resonance 60 hectares area can be managed with exciting results.

Agnihotra fires along with several hours of Om Tryambakam Homa are performed daily, with more hours of Om Tryambakam Homa on full moon and new moon days. Ash is used as fertilizer and also for preventing pests.

Benefits:

- Rejuvenation of all kind of soils;
- Prevention, control eradication of plagues and diseases in all crops with short and long vegetative cycles.
    - Cereals like rice, corn, wheat
    - Vegetables like tomato, onion, cabbage, cucumber, cauliflower, beans, potato
    - Fruits like banana, mango, orange, lemon, papaya, pineapple, apple, pomegranate, guava
    - Nuts like peanut, walnut, cashew nut, coconut
    - Coffee, cocoa, cotton, etc.
    - Forest trees
    - Pastures
- Crops become superior in quantity, taste, texture, colour and dieses resistance.
- Homa Therapy controls and eradicates weeds.
- Homa Technology is cheap and no agrochemicals are required.
- Homa improves the health of cattle and no vaccinations are required. Homa Therapy improves quality and quantity of milk.
- Earthworms and honeybees are beneficially affected by Homa and they produce more.
- It is necessary to establish Homa seed banks and Homa farms to survive.

Homa Therapy and Human Health

Thousands of people all over the planet have been helped through the performance of this ancient powerful fire and use of Agnihotra ash. It helps in resolving many physical, emotional and mental problems, such as :

Asthma, sinusitis, Allergies, Arthritis, Ulcers, Gastritis, Burns, Wounds, Dermatitis, Gallbladder and Kidney Stones, Fears, Anger, Addictions, Cancer, Aids. Etc.

Agnihotra ash medicines were revived in modern times in Germany with wonderful results. They have researched and developed may formulas based on Agnihotra ash to bring relief too many medical problems.

For more specific information check our web pages and click on human health.

Homa Therapy in cattle health

There is some information that regular performance of Agnihotra and its administration to cattle improves their health, production and even there is claim for large number of female in Homa atmosphere. We request for its verification.

"What technology has done and persists is doing nothing short of raping the land ,the air we breathe, of all nutrients, destroying plant life with pesticides, insecticides, polluting human beings with chemical fertilizers and food additives. All this is taking its toll now. Man cannot survive this era without mass attempt at counteracting the destruction. This mass attempt is practice of Homa Therapy is an answer to resolve current crises being faced by humanity. Methods of experimental science may soon prove to be useful to show that Homa Therapy may be the one single practice which can take care of the body and mind". Sincere involvement of every citizen of world for tree plantation and practice of Agnihotra is the need of hours and calls for your unconditional support.

Tree-Tree-Tree: Fire-Fire-Fire

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Flowering and fruiting characteristics of guava (*Psidium guajava* L.) cultivars under Himalayan terai region of West Bengal

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ABSTRACT

Guava (*Psidium guajava* L.) is an important sub-tropical fruit crop of India and successfully grown in Madhya Pradesh, Maharashtra Uttar Pradesh, Bihar, Andhra Pradesh, West Bengal, Punjab. To study the performance of guava cultivars in the Himalayan Terai region of West Bengal, the present experiment was carried out in the Instructional Farm of Dept. of Pomology & Post Harvest Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during 2013-2014 in randomized block design. Seven cultivars of guava plants having 3 year age were selected as individual treatments; i.e., L-49 (T_1), Baruipur (T_2), Khaja (T_3), Dudh Khaja (T_4), Pant Prabhat (T_5), Allahabad Safeda (T_6) and Bhagalpur (T_7). The maximum numbers of flowers (27.33) and fruit set percentage (80.15%) was observed in cv. Dudh Khaja (T_4) in summer season. The fruit drop percentage was lowest (29.72%) in cv. Khaja which was statiscially at par with all other cultivars except Allahabad Safeda during summer season. Fruit drop percentage was higher and statiscally at par in all the cultivars in winter season for all the cultivars compared as to summer season. Maximum number of fruits and yield per plant were recorded in Dudh Khaja for both summer season (17.50 numbers and 2.538 kg/plant) and winter season (8.5 numbers and 1.245 kg/plant). The maximum fruit weight (192.40g), fruit length (6.73cm), fruit diameter (6.73 cm) was observed in winter season in cvs. Khaja, Pant Probhat, and Dudh Khaja, respectively. Maximum TSS (12.37 ^{O} brix) was recorded in Dudh Khaja (T_4) and it was statistically at par with all other cultivars, whereas, ascorbic acid content was recorded highest in cv. Khaja (263.03mg/100g of pulp). Highest total sugar percentage (7.93%) and reducing sugar percentage (4.75%) was recorded in cv. Allahabad Safeda (T_6) during winter season.

KEY WORDS: Guava, Flowering, Fruiting, West Bengal

Guava (*Psidium guajava* L.), popularly known as *Apple of Tropics* under the family of Myrtaceae, is 5th important fruit of India in terms of production (2012-13). In India, guava is successfully grown in Uttar Pradesh, West Bengal, Bihar, Karnataka, Chhattisgarh, Madhya Pradesh, Maharashtra, and Odisha. In general, guava bear in three seasons namely rainy, winter and spring seasons in a year. Shikhamany *et al*. (1986) observed that guava bears thrice in a year viz. rainy, winter and summer which constitute 70, 27 and 3% of flowering. Mitra (1983) stated that there are two important cropping seasons in WB, i.e., rainy (flowering in April-May) and winter (flowering in September-October). The prevailing suitable agro-climatic condition may be the good scope for area expansion of guava in Himalayan terai region of West Bengal. However, little information is available in literature regarding the performance of different cultivars of guava in this particular locality. Keeping the view, it was considered necessary to study the performance of several guava cultivars in this region.

MATERIALS AND METHODS

The present experiment was carried out in the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during 2013-2014 in randomized block design. The soil of experimental site was sandy, well drained, with the following initial chemical characteristics: pH = 5.6; Nitrogen = 188.16 kg/ha; Phosphorous = 20.89 kg/ha; Potassium = 132 kg/ha. The guava palnts were planted in 2010 with a spacing of 4m × 4m. Seven cultivars were selected as individual treatments *viz*., L-49 (T_1), Baruipur (T_2), Khaja (T_3), Dudh

Table 1: Flowering & fruiting characteristics of different guava cultivars

Cvs.	No. of flower		Fruit set %		Fruit drop %		No. of fruits at harvest		Yield		
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Total
T_1	18.00ab	17.16ab	62.58 (52.30)a	67.11 (55.00)b	38.04 (38.06)ab	55.82 (48.33)a	12.00abc	6.33ab	1.964 ab	1.045ab	3.009ab
T_2	15.50b	10.66ab	71.67 (57.86)a	58.66 (49.95)bc	43.12 (41.03)ab	66.17 (54.45)a	6.83bc	2.66b	1.019bc	0.4bc	1.419bc
T_3	20.83ab	10.33ab	77.13 (61.41)a	61.03 (51.35)bc	29.72 (33.02)b	67.02 (54.94)a	12.33ab	2.16b	1.895ab	0.418bc	2.313abc
T_4	27.33a	16.66a	80.15 (63.58)a	77.42 (61.62)a	32.25 (34.63)b	50.35 (45.23)a	17.50a	8.50a	2.538a	1.245a	3.783a
T_5	19.33ab	13.16ab	73.92 (59.28)a	65.76 (54.21)b	38 (38.06)ab	66.92 (54.88)a	10.00abc	3.16ab	1.525abc	0.485abc	2.01abc
T_6	9.83b	5.66b	62.32 (52.12)a	53.47 (47.01)c	52.02 (47.87)a	55.56 (48.22)a	3.33c	1.33b	0.508c	0.207c	0.715c
T_7	15.83b	11.00ab	64.96 (53.67)a	50.12 (45.06)c	45.23 (42.25)ab	58.52 (49.89)a	7.33bc	4.33ab	1.068bc	0.641abc	1.709abc
LSD	11.02	9.00	NS	6.42	11.32	NS	9.00	5.39	1.308	0.814	2.089

Means in each column with the same letter are not significantly different at P d" 0.05 (values in parenthesis are the angular transformed value)

Khaja (T_4), Pant Probhat (T_5), Allahabad Safeda (T_6) and Bhagalpur (T_7). Seven treatments were replicated thrice with two plants per replication. Fertilizer application was given as nitrogen 260 g + phosphorous 350g + potash 100 g per plant, with half dose of fertilizers applied in the month of May and rest after rainfall in the month of September. Observations for several flowering and fruiting parameters like- number of flowers, fruit set percentage, number of fruit at harvest, fruit drop percentage, fruit yield (kg/plant), fruit weight (g), fruit length(cm), fruit diameter(cm), T.S.S. (^{O}Brix), total sugar, reducing sugar and non-reducing sugar percentage, ascorbic acid content (mg/100g of pulp) of different guava cultivars (treatments) were characterized and evaluated systematically and subjected to statistical analysis. The different chemical parameters like TSS (^{O}Brix), sugars, titratable acidity and ascorbic acid content were determined according to Rangana, (1977), A.O.A.C, (1984) and Mazumdar and Majumder, (2003). Analysis of variance for each parameter was performed using ProcGlm of Statistical Analysis System (SAS) Software (Version 9.3). Means separations for different accessions under different parameter were performed using Least Significant Difference (LSD) method (Pd"0.05). Data transformation was done following Gomez and Gomez (1983).

RESULTS AND DISCUSSION

Flowering and fruiting characters of guava cultivars

In summer season the highest average numbers of flower was observed (Table-1) in cv. Dudh Khaja (27.33) which was statistically at par with cvs. Khaja, Pant Prabhat, L-49 and lowest numbers of flowers were recorded with cv. Pant Prabhat (9.83). During winter season it was found maximum in cv. L-49 (17.16) which was statistically at par with all cultivars except minimum in cv. Allahabad Safeda (5.66). The fruit set percentage of summer season was found maximum in cv. Dudh Khaja (80.15%) and minimum in cv. Allahabad Safeda (62.32%) and fruit set percentage was statistically at par for all the cultivars. In winter season it was found maximum in cv. Dudh Khaja (77.42%) and minimum in cv. Bhagalpur (50.12%), respectively. The fruit drop percentage of summer season was lowest in cv. Khaja (29.72%) and highest in cv. Allahabad Safeda (52.02%), whereas, it was lowest in cv. Dudh Khaja (50.35%) during winter season and statistically at par for all the cultivars. The total number of fruits was harvested highest in cv. Dudh Khaja (T_4) during summer season (17.50) and winter season (8.50) and recorded lowest in cv. Allahabad Safeda (T_6) during summer season (3.33) and winter season (1.33), respectively. The yield per plant in summer season was recorded highest (1.964 kg) in cv. L-49(T_1) and lowest (507.9g) in cv. Allahabad Safeda (T_6), whereas, in winter season it was recorded highest (1.245 kg) in cv. Dudh Khaja (T_4) and lowest (207 gm) in cv. Allahabad Safeda (T_6). Table-3 indicates that highest total yield per plant (3.783 kg/plant) was recorded in cv. Dudh Khaja.

Table 2: Physical characteristics of guava fruits

Cultivars	Weight (g)		Length (cm)		Diameter (cm)	
	SS	WS	SS	WS	SS	WS
T_1	163.20a	164.50b	5.70c	6.47a	6.03bc	6.83a
T_2	148.93abc	154.63e	6.16b	6.56a	6.65a	6.67ab
T_3	161.80ab	192.40a	6.40ab	6.37a	6.25ab	6.28c
T_4	144.83c	146.13g	6.13b	6.48a	6.44ab	6.73a
T_5	151.90abc	153.80d	6.20b	6.73a	6.21b	6.32bc
T_6	152.56abc	155.20c	5.70c	6.38a	5.74c	6.23c
T_7	146.10bc	147.90f	6.66a	6.54a	5.65c	5.67d
LSD	16.60	2.0	0.34	NS	0.43	0.38

Means in each column with the same letter are not significantly different at P d" 0.05

Several workers from different places reported the performance of the different guava cultivars. Ghosh *et al.* (2013) reported from West Bengal that Banarasi cultivar produced higher average yield (73.7 kg plant^{-1} year^{-1}) followed by cv. Allahabad Safeda (71.6kg plant^{-1} year^{-1}). Fruit weight was found maximum in cv. Almond Iskbala followed by cv. Red Fleshed and cv. Apple Colour. Fruit quality in respect of TSS/acid ratio was the best in cv. Banarasi followed by cv. Khaja while maximum ascorbic acid content was in cv. Supreme followed by Seedless among 21 cultivars. Athani *et al*., (2007) evaluated different guava cultivars under Arabhavi conditions and revealed that cv. SR-2 recorded the highest number of fruits per plant (359.02 and 364.33 during 2001-02 and 2002-03, respectively). Babu *et al*.(2007) studied performance of eight year old guava selections under Meghalaya conditions and concluded that number of fruits per tree ranged between 184 (Selection-1) and 78.66 (Selection-13). Mitra *et al*., (1983) evaluated eleven guava cultivars of four years age and reported that total weight of fruits per plant varied from 21.1 kg in cv. Lucknow-49 to 3.2 kg in cv. Seedless under West Bengal conditions. According to Ahmed and Sisy (2013), flowering dates in genotypes No. 2 &12 were the earliest, whereas No. 15 was the latest in 2011 and 2012. Concerning flowering, genotype No. 9 gave the maximum number of flowers / tree (468.0-462.5) in 2011 and 2012, respectively. The best final fruit set (%) were in genotypes No 8 in 2011 and No. 6 in 2012. The maximum yield (kg/ tree) was in genotype No. 2 (88.85-89.99 kg) in both seasons, respectively.

Physical characteristics of fruits of guava cultivars

The present experiment (Table-2) reveals that the fruit weight of guava cultivars varied from 144.83 g (cv. Dudh Khaja) to 163.20g (cv. L-49) during summer season and in winter season 146.13g (cv. Dudh Khaja) to 192.40g (cv. Khaja). In winter season the fruit weight of cv. Khaja was statistically superior compared to all other cultivars. In summer season fruit length was recorded lowest (5.70 cm) in cvs. L-49 and Allahabad Safeda and maximum fruit length (6.66 cm) was recorded with cv. Bhagalpur which was statistically at par with cv. Khaja (6.40cm). In winter season it varied from 6.37 cm (cv. Khaja) to 6.73 cm (cv. Pant Probhat) and all the cultivars were statistically at par. The fruit diameter of summer season fruit was maximum (6.65 cm) in cv. Baruipur which was statistically at par with cvs. Khaja, Dudh Khaja and found minimum (5.65 cm) in cv. Bhagalpur which was statistically at par with cvs. Allahabad Safeda, L-49, whereas, in winter season, it was recorded maximum (6.83 cm) in cv. L-49 which was statistically at par with cvs. Dudh Khaja, Baruipur and observed minimum (5.67 cm) in cv. Bhagalpur, respectively. The physical properties of fruit were better for most of the cultivars during the winter season compared to summer season. The maximum fruit weight (192.40g), fruit length (6.73cm), fruit diameter (6.73 cm) was observed in winter season in cvs. Khaja, Pant Probhat, and Dudh Khaja, respectively.

Fruit weight ranged between 152.50 g (cv. L-49) and 97.7 g (Hybrid-2) under Meghalaya conditions (Patel *et al*., 2007). Athani *et al*. (2007) evaluated 19 guava selections/ cultivars under Arabhavi conditions and found that mean fruit weight ranged from 156.32 g in cv. Sardar to 46.84 g in GW-3 and GR-3. Biradar and Mukunda (2007) reported from Bangalore that, the maximum fruit length was observed in TG selection 5/12 (5.71 cm) followed by TG selection 6/8 (5.70 cm) and minimum (4.48 cm) in TG selection 5/11. Fruit weight was varied between 116 g (cv. Baraf Khana) and 49.50 g (cv. Lucknow-49) and weight of fruits per tree ranged from 75.34 kg in Cv. Lucknow-49 to

Table 3: Chemical characteristics of guava fruits

Cv.	TSS (°Brix)		Total sugar (%)		Reducing sugar (%)		Non reducing sugar (%)		Ascorbic acid (mg/100 g pulp)	
	Sumer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
T_1	9.26 bc	10.2 a	6.76 ab	6.86 ab	4.47 bc	4.47 a	2.96 ab	2.96 e	112.33 e	115.43 d
T_2	9.13 c	9.43 a	6.50 b	6.63 b	4.47c	4.48 a	3.05ab	3.06 d	211.56 b	218.06 b
T_3	10.26abc	10.53 a	7.36 ab	7.53 ab	4.67 ab	4.68 a	3.25a	3.29 b	258.16 a	263.03 a
T_4	10.76 a	12.37 a	7.50 ab	7.66 ab	4.56 bc	3.24 a	3.13ab	3.15 c	188.46 c	193.53 c
T_5	11.46 a	11.17 a	7.60 a	7.76 a	4.54 bc	4.56 a	2.06b	3.07 d	185.33 d	191.83 c
T_6	10.50 ab	10.80 a	7.73 a	7.93 a	4.73 a	4.75 a	2.94ab	2.95 e	187.83 cd	193.56 c
T_7	10.43 ab	10.93 a	7.46 ab	7.60 ab	4.25 d	4.29 a	3.34a	3.53 a	213.46 b	220.56b
LSD	1.24	NS	1.09	1.11	0.13	NS	0.04	0.04	3.00	4.28

Means in each column with the same letter are not significantly different at P d" 0.05

44.63 kg in cv. Seedless (Aulakh, 2005) under Punjab conditions. Athani *et al*. (2007) evaluated 19 guava selections/cultivars under Arabhavi conditions and found that mean fruit weight ranged from 156.32 g in cv. Sardar to 46.84 g in GW-3 and GR-3.

Chemical characteristics of fruits of guava cultivars

The present experiment reveals that the total soluble solids (TSS) of summer season fruits varied from 9.13^{O}Brix (cv. Baruipur) to 11.46 ^{0}Brix (cv. Pant Probhat) and in winter season 9.43^{O}Brix (cv. Baruipur) to 12.37^{O}Brix (cv. Dudh Khaja). Maximum TSS (12.37 ^{O}brix) was recorded in cv. Dudh Khaja (T_4) and it was statistically at par with all other cultivars in winter season. Total sugar was highest (7.73% & 7.93%) and lowest (6.50% & 6.86%) in cv. Allahabad Safeda and cv. Baruipur in summer season and winter season fruit, respectively. For both the season the total sugar content of cv. Allahabad Safeda (T_6) was statistically at par with all other cultivars except cv. Baruipur (T_2). Reducing sugar was found to be highest in cv. Allahabad Safeda for both summer (4.73%) and winter season (4.75%) and it was lowest in and cv. Bhagalpur (4.25%) in summer season and cv. Dudh Khaja (3.24%) in winter season fruit, respectively. Similarly non reducing sugar was found maximum in cv. Bhagalpur in both summer season (3.34%) and winter season (3.53%), whereas it was found minimum in cv. Pant Probhat (2.06%) in summer season and in cv. Allahabad Safeda (2.95%) during winter season, respectively. In both the summer and winter season, the ascorbic acid content showed statistical significance among the different cultivars and it was highest (258.16 mg in summer & 263.03 mg in winter /100g of pulp) in cv. Khaja (T_3) and it was lowest (112.33 mg in summer & 115.43 mg in winter /100 g of pulp) in cv. L-49 (T_1), respectively.

Singh (2011) reported that among different varieties, higher TSS, ascorbic acid and total sugar content was observed in cvs, Shweta, Sardar, Lalit and CISH G-5. According to Chowdhuri *et al*., (2008) among eighteen germplasm of guava, the fruit weight was larger in cvs. Kafri Khaja, Kazi, L-49, Bhagalpur and Mohammad Khaja, while, cvs. Dudh Khaja, Bhagalpur, Kabri, Allahabad Safeda and Kafri Khaja were superior in terms of T.S.S, total sugar, reducing sugar, and ascorbic acid. Ghosh *et al*., (2013) reported that fruit quality in respect of TSS/acid ratio was the best in cv. Banarasi followed by cv. Khaja while maximum ascorbic acid content was in cv. Supreme followed by cv. Seedless among 21 cultivars.

The maximum numbers of flowers (27.33) and fruit set percentage (80.15%) was observed in cv. Dudh Khaja (T_4) in summer season. The fruit drop percentage was lowest (29.72%) in cv. Khaja which was statiscially at par with all other cultivars except Allahabad Safeda during summer season. Maximum number of fruits and yield per plant were recorded in Dudh Khaja for both summer season (17.50 numbers and 2.538 kg/plant) and winter season (8.5 numbers and 1.245 kg/plant). The maximum fruit weight (192.40g), fruit length (6.73cm), fruit diameter (6.73 cm) was observed in winter season in cvs. Khaja, Pant Probhat, and Dudh Khaja, respectively. Maximum TSS (12.37 ^{O}brix) was recorded in Dudh Khaja (T_4) and it was statistically at par with all other cultivars, whereas, ascorbic acid content was recorded highest in cv. Khaja (263.03mg/100g of pulp). It may be concluded that cv. Dudh Khaja provided the highest yield, fruit set percentage, good chemical properties (TSS, total sugar percentage) whereas cv. Khaja recorded with highest ascorbic acid content and fruit weight in this particular locality.

REFERENCES

A.O.A.C. 1984. *Official methods of analysis*, 14th edition, association of official agriculture chemist, Washington, D.C., USA.

Ahmed, W.A. and Sisy, Z.E. 2013. Evaluation of some genotypes of guava trees grown under alexandria governorate condition. Vegetative growth, flowering and fruit quality. *World Applied Sciences Journal*. **28** (4): 583-595.

Athani, S.I.; Patil, P.B.; Swamy, G.S.K.; Sabarad, A.I. and Gorabal, K.R. 2007. Studies on growth parameters and fruit characters in guava cultivars. *Acta Hort.*, **735**: 271-275

Aulakh, P.S. 2005. Performance of different guava cultivars under the arid irrigated conditions of Punjab. *Progressive Horticulture*, **37**(2): 328-330.

Babu, K.D., Patel, R.K. and Yadav, D.S. 2007. Comparative evaluation of guava selection under North Eastern region of India. *Acta Hort.*, **735**: 99-103.

Biradar, S.L. and Mukunda, G.K. 2007. TG Seln. 5/12 – A promising genotype of Taiwan Guava from Bangalore. *Acta Hort.*, **735**: 85-89.

Chowdhury, R., Ray, K.S. and Ghosh, B. 2008. Studies on the fruit qualities of different guava germplasms. *The Horticultural Journal*, **21** (3): 105-108.

Ghosh, S.N., Roy, S. and Bera, B. 2013. Study on performance of twenty one guava cultivars in red and laterite soil of West Bengal under irrigated condition. *Journal of Crop and Weed*, **9**(2):81-83.

Gomez, K.A. and Gomez, A.A. 1983. Problem data in: Statistical Procedures for Agricultural Research (2nd Edition), Wiley-Inter Science Publication (John Wiley and Sons); New York, USA. Pp 275-315.

Mazumdar, B.C. and Majumder, K. 2003. Drtermination of chemical constuents. In: *Methods of physio-chemical Analysis of fruits*, Daya Publishing house, Delhi pp.93-139.

Mitra, S.K., Maiti, S.C., Sen, S.K. and Bose, T.K. 1983. Physico-chemical characters some guava varieties of West Bengal. *South Indian Hort.*, **31**: 62-69.

Mitra, S. 1983.Guava-The apple of tropics. *Farmer and Parliament*, **28**:19-20

Patel, R.K., Maiti, C.S., Deka, B.C., Deshmukh, N.A. and Roy, D. 2011. Variability studies in guava (*Psidium guajava* L.) genotypes for growth, yield and quality attributes at mid-hills of Meghalaya. *Indian Journal of Hill Farming*, **24** (1&2) 24-28.

Ranganna, S. 1977. Ascorbic acid In: *Manual of analysis of fruits and vegetable products*. Tata and Mc. Graw Hill Publishing Company Limited: New Delhi, India, pp. 94-101.

Sharma, A., Wali, V.K., Bakshi, P. and Jasrotia. 2013. An effect of organic and inorganic fertilizers on quality and shelf life of guava (*Psidium guajava* L.) cv. Sardar. *The Bio Scan*, **8** (4): 1247-1250.

Shikhamany, S.D., Iyer, C.P.A., Rao, M.H. and Subramanian, T.R. 1986. Variations in the seasonal nutrient status in relation to different yield patterns in guava cv. Allahabad Safeda. *Indian Journal of Horticulture*, **43**: 73-78

Singh, G. 2011. Varietal behaviour of guava under meadow orchard. *Progressive Horticulture*, **43**(2): 181-185

Swain, S.C. 2007. Effect of season on the vegetative and reproductive attributes of guava cv. Allahabad Safeda. *The Horticultural Journal*, **20**(1):8-10

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Effect of rooting media and IBA on the rooting behaviour and vegetative growth of Kiwi fruit (*Actinidia deliciosa* Chev.)

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ABSTRACT

A field experiment was conducted to evaluate the effect of different rooting media on the rooting behaviour and vegetative growth of kiwifruit cultivars namely; Hayward and Abbott located in the mid hill zone of Himachal Pradesh. It was observed that rooting characteristics and vegetative growth responded significantly to the interactive effect of different rooting media and cultivars. The study revealed that the rooting medium comprising forest soil + sand + soil (1:2:1) registered higher rooting (45.71 %) of cuttings in both the cultivars. This rooting medium resulted in highest number of main roots, secondary roots and total root length. The vegetative growth was also significantly influenced by various rooting media. Hayward had longest shoot length in all the media except forest soil + sand + soil (1:2:1) in which the cultivar Abbott resulted in higher shoot length. Leaf number was recorded to be highest in cuttings planted in medium containing sand + soil (2:1), however, largest leaf area was recorded in cuttings planted in medium forest soil + sand + soil (1:2:1) which was significantly higher than all other rooting media under study.

KEY WORDS: Rooting media, IBA, Kiwifruit

The Chinese gooseberry or kiwifruit (*Actinidia deliciosa* Chev.) is a deciduous and dioecious fruiting vine native to south and central part of China (Ferguson, 1984) where it is growing wild as well as in cultivated form (Lee, 1990). The fruit was introduced into New Zealand and Europe in the early 20th century. Its commercial cultivation has gained momentum after 1960 and is now being cultivated on large scale in New Zealand, Italy, Japan, China, USSR, USA, France, Germany, South Africa and Australia including India. To meet out the demand of kiwifruit plants for commercialization, the planting material is required on large scale which has necessitated the need for development of an easier, quicker and economic method of propagation. Although there are various methods of propagation for raising fruit plants such as grafting, layering, budding and tissue culture, but most of these methods are expensive, time consuming, laborious and require skills. On the other hand, raising of kiwifruit plants by cuttings is quick, less expensive and require less space and skill. A recommended dose of exogenous compounds have been applied to the cuttings to encourage rooting i.e. IBA (Indole 3-butyric acid) at 5000 ppm (Rana and Jindal, 2001; Srivastava *et al.*, 2006). Besides, application of growth regulators, rooting media also have profound influence on the ability of rooting of cutting in kiwifruit. Since the application of growth regulators and rooting media have a direct role in rooting and vegetative characters of kiwifruit cuttings, so the present study was carried out to find the combined effect of different rooting media and IBA at 5000 ppm on the rooting behaviour and vegetative growth of kiwifruit in the mid hill zone condition (1260 m) of Himachal Pradesh.

MATERIALS AND METHODS

The experiment was conducted during the month of January during 2012 in the Kiwi fruit Block of Department of Fruit Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.), located at $30^0 51'$N latitude. The experiment was laid out in a randomized block design with two factors viz., cultivars and rooting media having three replications. The experiment comprised seven treatments viz., T_1 (Sand), T_2 (Soil), T_3 (Sand + Soil, 2:1), T_4 (Sand + Soil + FYM, 2:1:1), T_5 (Banoak forest soil), T_6 (Banoak forest soil + Sand, 1:1) and T_7 (Banoak forest soil + Sand + Soil, 1:2:1). In this experiment, well matured dormant shoots i.e. hardwood cuttings of 25-30 cm length, 0.5-1.0 cm thickness and having atleast3 healthy buds were selected and cuttings were prepared under shade. These cuttings were planted in the polybags filled with different rooting media prepared

Table 1: Effect of rooting media on the rooting and callusing percentage in hardwood cuttings of Kiwifruit.

Treatments	Callusing (%)			Rooting (%)		
	Abbott	Hayward	Mean	Abbott	Hayward	Mean
T_1:Sand	25.00	22.00	23.50	32.00	37.00	34.50
T_2:Soil	18.00	15.00	16.50	24.00	28.00	26.00
T_3:Sand + Soil (2:1)	11.00	10.00	10.50	36.00	40.00	38.00
T_4:Sand + Soil + FYM (2:1:1)	13.00	11.00	12.00	42.00	44.00	43.00
T_5:Ban oak Forest soil	12.00	9.00	10.50	50.00	53.00	51.50
T_6:Ban oak Forest soil + Sand (1:1)	8.00	6.00	7.00	52.00	56.00	54.00
T_7:Ban oak Forest soil + Sand + Soil (1:2:1)	5.00	4.00	4.50	60.00	62.00	61.00
Mean	13.14	11.00		42.29	45.71	
$CD_{(0.05)}$						
Cultivars			NS			2.18
Rooting media			6.35			4.10
Rooting media x Cultivar			NS			NS

in different ratios according to the treatments mentioned above after treating them with recommended dose of IBA solution i.e. 5000 ppm and were kept under open condition. The observations on rooting and vegetative growth of hardwood cuttings planted in January were taken during October month on the various characters viz., rooting percentage, number of main roots, number of secondary roots, total root length, shoot length, number of leaves and total leaf area.

RESULTS AND DISCUSSION

Effect of rooting media and IBA on the rooting characteristics

The experimental results revealed that different rooting media and cultivars have shown significant effect on the rooting of the cutting of the cultivars. The highest rooting (62.0%) were recorded with cuttings planted in rooting medium containing forest soil + sand + soil (1:2:1) which was significantly superiorto all other treatments whereas rooting was minimum (26.0%)in cuttings planted in medium containing soil only. The results in respect to cultivars were also found to be significant and cv. Hayward recorded more rooting (45.71%) as compared to cv. Abbott which had 42.29 per cent rooting (Table 1).Similar results have been obtained in hardwood cuttings of kiwifruit cv. Allison (Anonymous, 1996). The data presented in Table 1 also revealed that highest callusing (23.50%) was recorded in sand medium, followed by the medium soil. Lowest callusing (4.50%) was observed in the cuttings planted in forest soil + sand + soil. The higher rooting percentage in forest soil has been attributed to the richness of forest soil in organic matter content and optimum moisture holding capacity which, in turn, promote root induction as well as increase the total length of roots (Loach, 1983). The results also showed that the cuttings planted in medium of forest soil + sand + soil resulted in highest number of main (15.64) and secondary

Table 2: Effect of rooting media on the number of main and secondary roots in hardwood cuttings of Kiwifruit.

Treatments	Main roots			Secondary roots		
	Abbott	Hayward	Mean	Abbott	Hayward	Mean
T_1:Sand	5.42	6.22	5.82	3.35	5.08	4.22
T_2:Soil	3.44	5.18	4.31	2.18	4.44	3.31
T_3:Sand + Soil(2:1)	5.92	7.12	6.52	2.50	6.25	4.38
T_4:Sand + Soil + FYM(2:1:1)	12.20	13.58	12.89	9.67	10.08	9.88
T_5:Ban oak Forest soil	7.42	9.52	8.47	7.44	8.77	8.11
T_6:Ban oak Forest soil + Sand(1:1)	13.50	14.22	13.86	9.78	11.19	10.49
T_7:Ban oak Forest soil + Sand + Soil(1:2:1)	15.20	16.08	15.64	10.74	12.19	11.47
Mean	9.01	10.27		6.52	8.29	
$CD_{(0.05)}$						
Cultivars			2.16			0.12
Rooting media			2.20			1.27
Rooting media x Cultivar			NS			1.34

Table 3: Effect of rooting media on the total root length and shoot length in hardwood cuttings of Kiwifruit.

Treatments	Root length (cm)			Shoot length(cm)		
	Abbott	Hayward	Mean	Abbott	Hayward	Mean
T_1:Sand	152.00	176.80	164.40	3.98	5.33	4.66
T_2:Soil	104.00	136.00	120.00	2.12	4.03	3.08
T_3:Sand + Soil (2:1)	137.00	157.00	147.00	4.73	6.94	5.84
T_4:Sand +Soil + FYM (2:1:1)	160.00	184.80	172.40	7.15	8.23	7.69
T_5:Ban oak Forest soil	162.00	170.00	166.00	5.64	6.62	6.13
T_6:Ban oak Forest soil + Sand(1:1)	148.00	173.50	160.75	6.24	7.01	6.63
T_7:Ban oak Forest soil + Sand + Soil(1:2:1)	168.00	199.50	183.75	8.58	7.12	7.85
Mean	147.29	171.09		5.49	6.47	

$CD_{(0.05)}$		
Cultivars	12.62	0.12
Rooting media	12.22	0.21
Rooting media x Cultivar	NS	0.26

roots (11.47) which was followed by forest soil + sand medium (Table 2). There was also significant variation between both the cultivars and highest numbers of main (10.27) and secondary roots (8.29) were recorded in Hayward cultivar. The interaction was found to be significant for secondary roots.

This finding can be attributed to the fact that forest soil is rich source of organic matter and nutrients which provided better conditions and nutrient supply to the cuttings. Also, as indicated earlier (Rana *et al.*, 1999) that sand has good drainage and aeration properties which might have promoted the root induction in these cuttings. It is also evident from the Table 3 that different rooting media and cultivars had significant effect on the total root length. Highest total root length (183.75cm) was recorded in the cuttings planted in the medium of forest soil + sand + soil. The poor performance of cuttings in the soil alone may be assigned to the fact that soil alone retain very high moisture content and has poor aeration than sand and forest soil, thus adversely affecting the rooting success and root growth of the cuttings. Erez and Yablowitz, (1981) were of similar opinion that high moisture in medium is also conducive for diseases and adversely affected the rooting of the cuttings.

Effect of rooting media and IBA on the vegetative characters

Experimental findings also showed that the vegetative growth was significantly influenced by various rooting media in both the cultivars under study. The present findings indicated that the largest shoot length (7.85 cm) was recorded in the cuttings planted in the medium of forest soil + sand + soil, however, the least shoot length (3.08 cm) was recorded with cuttings grown in soil medium (Table 3). There was also significant interaction between rooting media and cultivars. In general,

Table 4: Effect of rooting media on the number of leaves and total leaf area in hardwood cuttings of Kiwifruit.

Treatments	Number of leaves			Total leaf area (cm^2)		
	Abbott	Hayward	Mean	Abbott	Hayward	Mean
T_1:Sand	4.12	3.52	3.82	84.54	86.40	85.47
T_2:Soil	6.35	4.82	5.59	81.98	83.00	82.49
T_3:Sand + Soil (2:1)	7.82	5.10	6.48	84.50	86.20	85.35
T_4:Sand + Soil + FYM (2:1:1)	5.07	5.22	5.15	86.12	88.50	87.31
T_5:Banoak Forest soil	6.38	5.63	6.01	85.67	87.00	86.34
T_6:Banoak Forest soil + Sand(1:1)	5.66	3.26	4.46	87.00	88.98	87.99
T_7:Banoak Forest soil + Sand + Soil (1:2:1)	3.02	5.52	4.27	91.25	93.24	92.25
Mean	5.49	4.72		85.87	87.62	

$CD_{(0.05)}$		
Cultivars	0.12	0.22
Rooting media	0.22	0.40
Rooting media x Cultivar	0.30	0.39

Hayward had longest shoots in all the media except forest soil + sand + soil in which Abbott resulted in 8.58 cm shoot length. The data presented in Table 4 revealed that leaf number (6.48) was maximum in cuttings planted in sand + soil (2:1) while, largest leaf area (92.25 cm^2) was recorded in cuttings sown in forest soil + sand + soil (1:2:1) which was significantly higher than the remaining media. However, the minimum numbers of leaves (3.82) per cuttings and lowest leaf area (82.49 cm^2) were noted in the cuttings planted in sand and soil medium, respectively. The interaction with respect to these characteristics between cultivars and rooting media were also found to be significant.

The reason for more vegetative growth in forest soil + sand + soil may be ascribed to the fact that forest soils generally hold optimum level of moisture, have more organic matter and contain more number of beneficial soil micro-organisms than the common soil. The higher amount of nitrogen due to more organic matter tends to increase the vegetative and succulent growth of the plant (Nijjar, 1985).

REFERENCES

Anonymous. 1996. Annual Report, 1996-97. Department of Pomology, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, India

Erez, A. and Yablowitz, Z. 1981. Rooting of peach hard wood cuttings for the meadow orchard. *Scientia Horticulturae,* **15**: 137-144

Ferguson, A.R. 1984. KIWIFRUIT: a botanical review**. In:** J. Janick (ed.) *Horticulture Review*, *Westport: AVI Publishing*, pp 1-64.

Lee, S.H. 1990. Kiwifruit resources and production in China. *Acta Horticulturae*, **282**: 57-63

Loach, K. 1983. Rooting mixes for leafy cuttings. *New Zealand Gardner*, pp.3-4

Nijjar, G.S. 1985. Nutrition of fruit trees. 2nd ed. *Kalyani Publishers*. 21-22, pp 30-33.

Rana, H.S., Rana, V.S. and Bhardwaj, D.R. 1999. Vegetative multiplication of kiwifruit (*Actinidia deliciosa*) through dorment cuttings. *Annals of Forestry* **7(1)**: 56-59

Rana, H.S. and Jindal, K.K. 2001. Effect of types of cuttings and auxin treatment on the rooting of cuttings of some commercial kiwifruit cultivars. Haryana Journal of Horticultural Sciences **30** (1&2): 3-5

Srivastava, K.K., Hamid, S., Das, B. and Bhatt, K.M. 2006. Effect of Indole butyric acid and variety on the rooting of leafless cutting of kiwifruit under zero energy humidity chamber. *ENVIS Bulletin* **17**(1): 28-41

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Genetic variability in pummelo genotypes (*Citrus grandis* L.) under konkan conditions

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ABSTRACT

In Konkan region of (MS) India, preponderance of pummelo seedlings are found growing at scattered/isolated areas and chance for the selection of elite strains are high due to wide genetic diversity in the exiting germplasm. In order to reveal the genetic variability in pummelo (*Citrus grandis* L.) the fruit samples from diverse areas of province were collected and analysed for various physico-chemical attributes. In the present investigation wide range of variability with respect to fruit characters like spine length, fruit weight, rag weight, no. of fruits pre tree, yield per tree, seed number, rind thickness and oil gland density have been recorded. This variability can be exploited for the selection of elite genotypes for conservation, evaluation, utilization and a source for crop improvement in future breeding programme.

Key Words: Pummelo, genetic diversity, variability

Botanically pummelo is known as *Citrus maxima* Merr. (*C. grandis* Osbeck; *C. decumana* L.). In the western world, it is identified mainly as the principal ancestor of grapefruit. Taxonomically pummelo belongs to subgenus *Eucitrus* (commonly cultivated species of citrus) of the family Rutaceae, (2n=18). It has the biggest fruit among the citrus species (Ben, 2010). The areas in southern Thailand and northern Malaysia, which have the highest diversity of pummelos, are most likely the centre of origin of pummelos (Narong *et al*., 2005).

The top ten world producers of grapefruit (including pummelos) are USA, China, Mexico, South Africa, India, Argentina, Turkey, Cuba, Brazil and Tunisia (FAOSTAT, 2010). During 2010-11, the total area harvested, production and productivity of grapefruit including pummelo across the world was about 2,68,702 ha., 2,58,753 Hg i.e. 69,52,737 tones and 25.88 tones/ha., respectively. In India it is cultivated in U.P., Punjab, Maharashtra, Tamil Nadu and Karnataka for edible fruits. In India the area under grapefruit including pummelo is about 10,000 ha., with production and productivity about 2,60,300 tones and 26.03 tones/ha., respectively (Anonymous, 2012).

Food value per 100 g of edible portion*

Pummelo contains about 25-58 calories, 84.82-94.1 g moisture, 0.5-0.74 g protein, 0.2-0.56 g fat, 6.3-12.4 g carbohydrates, 0.3-0.82 g fiber, 0.5-0.86 g ash, 21-30 mg calcium, 20-27 mg phosphorus, 0.3-0.5 mg iron, 20 I.U. vitamin A, 0.04-0.07 mg thiamine, 0.02 mg riboflavin, 0.3 mg niacin, 30-43 mg ascorbic acid and 1.2 g dietary fiber.

It is heterozygous in nature and thus exhibits a great variability in seedling population. These elite chance seedlings possess desirable horticultural traits which can be selected as variety/strains after their evaluation under particular agro-ecological zone. With the advent of high yielding varieties of agronomical crops, the diversity found in minor fruit crops is vanishing or at the verge of extinction due to uprooting of indigenous isolated/ scattered growing citrus species in the natural habitat of the region. Importance of clonal selections in crop improvement is well recognized by several workers (Badge and Patil, 1989; Badiyala *et. al*., 1992). So, it is imperative to identify superior strains of pummelo for their collection, conservation, evaluation and utilization in the future breeding programmes. Hence, the present investigations were carried out to record the extent of genetic diversity and locate the elite genotypes possessing desirable fruit characteristics.

MATERIALS AND METHODS

The survey was conducted during the flowering and fruit maturity seasons. Sampling of fruits and leaves

*Analysis made in China and the United States (Morton, 1987).

started in October 2011 and finished in February 2012 while the study of floral characteristics was undertaken from February to April 2013. At each site, the latitude, longitude and elevation were recorded.

Survey of pummelo genotypes was conducted at different locations *viz*., Harihareshwar, Shriwardhan, Diveagar, Murud, Sarve and Revdanda of Raigad district of Maharashtra.

The material for present study consisted of 30 genotypes which were randomly selected. The genotypes were of different age and no special cultural practices have been followed. Among the population for the sake of convenience each entry was designated by CG-No. for pummelo trees. Sampling of 10 leaves, 5 flowers and 2 fruits was carried out randomly from each selected tree. The morphological characteristics used to characterize and discriminate the 30 pummelo genotypes were based on those prescribed for citrus by the International Plant Genetic Resource Institute (IPGRI, 1999), Rome and International Union for the Protection of New Varieties of Plants (Anonymous, 2003), Geneva taking into consideration all the precautions reported. Fruit samples were analyzed at Department of Horticulture of Dr. B.S.K.K.V. agriculture university (MS) India. The data was statistically analyzed according to method prescribed by Panse and Sukhatme (1995).

RESULTS AND DISCUSSION

The data pertaining to physico-chemical attributes of pummelo depicted a high degree of variability with respect to fruit morphology and quality characters (Table 1). The highest variability (178.08 %) was recorded for spine length on adult tree followed by number of seeds fruit^{-1} (48.57 %), number of fruits tree^{-1} (48.37 %), yield plant^{-1} (48.23 %) and rag weight (41.43 %).

In different selected strains, the height, canopy spread, stem girth and spine length on adult tree of pummelo ranged from 8.76 to 26.26 m, 4.47 to 21.06 m, 30.2 to 160 cm and 3-38.30 mm, respectively. These results are in line with the findings of Hassan *et al*., (2008) in mandarin, whereas Quang *et al*., (2011) and Tongleaw *et al*., (2012) in case of pummelo. The average leaf lamina length and width as well as ratio of leaf lamina length/ width fluctuated from 92 to 142.7 mm, 43 to 92 mm and 1.20 to 2.22, respectively. Petiole wing length ranged from 18 to 54 mm, width from 9.04 to 34.0 mm and leaf area from 36.52 to 85.47 cm^2. Average pedicel length, petal length, petal width, numbers of stamens, flower bud length and bud width ranged from 5.47 to 28.71 mm, 12.85 to 29.35 mm, 4.82 to 19.64 mm, 25 to 35, 13.58 to 28.56 mm and 6.21 to 15.35 mm, respectively. Similar results were put forth by Dorji and Yapwattanaphun (2011) in mandarin and other *Citrus* spp., Sanabam *et al*., (2012) in pummelo.

The fruit length, diameter and weight ranged from 96.5 to 192 mm, 114.65 to 205.41 mm and 543 to 2120 g fruit^{-1}, respectively. Whereas oil gland density ranged from 7-54 cm^{-2}. The numbers of segments, segment length, breadth and diameter of fruit axis ranged from 11 to 22 fruit^{-1}, 66.5 to 180.29 mm, 16.5 to 48.5 mm and 13.25 to 45.21 mm, respectively. The rind thickness of different pummelo genotypes ranged from 7.31 to 41.52 mm, pulp weight from 218 to 968 g fruit^{-1} and rag weight from 208.0 to 982.0 g fruit^{-1}. The number of fruits per plant varied from 35 to 170. Whereas, fruit yield ranged from 22.20 to 152.81 kg plant^{-1}. Number of seeds ranged from 19 to 118.5 fruit^{-1} and seed weight was 4.65 to 14.24 g per 20 seeds. Estellena and Odtojan (1992), Singh and Singh (2006), Patil and Reddy (2008), Srivastava *et al*., (2010) and Hazarika (2012) revealed alike results with current investigation in pummelo.

Variability in chemical attributes was found among different elite selected pummelo strains in which the moisture content, TSS, acidity, pH, ascorbic acid, reducing sugars, non-reducing sugars and total sugars in pummelo genotypes varied from 82.1 to 91.05 %, 6.5 to 10.8 ^{0}B, 1.08 to 3.7 %, 3.4 to 4.15, 23.75 to 40 mg/100 g, 1.47 to 2.9 %, 1.75 to 4.48 % and 3.22 to 6.85 % respectively. Samarasinghe (2005), Ara *et al*., (2008) and Haque *et al*., (2009) also reported wide variation amongst various chemical parameters studied in pummelo.

This indicates that elite strains may be selected directly from seedling population on the basis of number of fruits tree^{-1}, fruit weight, fruit length, diameter, size of oil gland, diameter of axis, rind thickness, weight of pulp, rag weight and ascorbic acid content for diverse purposes. Similar variations in fruit characters of Hill lemon was reported by Sandhu *et al*., (1999) and Singh *et al*., (2009). Likewise, fruits with large fruit size and weight, higher juice content per cent may be used for the preparation of value added products like juices and squashes (Badiyala and Sharma, 2004). Earlier, Punjab Agricultural University has released 'Punjab Galgal' a variety of hill lemon for general cultivation in the region. This variety was selected from farmers' field on the basis of various external and physico-chemical attributes and their further evaluated (Anonymous, 2008).

Further correlation studies revealed that the

Table 1: Physico-chemical characteristics of various pummelo genotypes (*Citrus grandis* L.)

Genotypes	Plant height (m)	Canopy spread (m)	Stem girth (cm)	Spine length on adult tree (mm)	Lamina length (mm)	Lamina width (mm)	Ratio of leaf lamina length/ width	Petiole wing length (mm)	Petiole wing breadth (mm)	Leaf area $(cm)^2$	Pedicel length (mm)	Petal length (mm)
CG-1	13.26	21.06	76.00	29.00	98.75	64.10	1.54	25.70	9.04	40.86	17.29	18.74
CG-2	17.26	10.95	79.00	Absent	108.27	66.14	1.64	41.45	22.09	73.79	14.60	15.21
CG-3	15.06	9.05	73.00	Absent	106.27	84.10	1.26	35.60	24.89	55.21	12.64	19.43
CG-4	11.26	4.47	30.20	20.50	142.70	64.31	2.22	37.10	25.88	85.47	18.94	22.48
CG-5	13.76	6.09	38.00	Absent	118.90	64.71	1.84	37.75	20.91	63.94	16.89	21.39
CG-6	13.76	8.00	54.00	38.30	109.40	60.12	1.82	28.87	21.81	43.35	20.28	19.94
CG-7	15.76	10.60	64.00	Absent	99.70	62.57	1.59	26.50	11.21	46.49	19.61	17.84
CG-8	14.26	10.25	100.00	Absent	117.00	65.23	1.79	31.64	18.50	58.68	15.19	15.35
CG-9	15.56	11.10	112.00	25.00	116.00	68.00	1.71	35.23	22.68	59.02	18.92	19.97
CG-10	11.46	10.26	60.60	Absent	120.00	78.00	1.54	25.00	14.00	67.18	22.47	20.25
CG-11	12.26	8.00	120.00	Absent	110.00	53.00	2.08	29.00	19.00	45.41	24.61	24.27
CG-12	11.26	8.35	160.00	22.50	111.00	52.00	2.13	31.00	21.00	50.89	20.75	23.51
CG-13	8.76	7.40	60.00	35.00	114.00	60.00	1.90	32.00	13.45	54.06	21.86	16.58
CG-14	10.96	7.00	80.70	Absent	94.00	43.00	2.19	24.00	21.00	65.78	19.84	25.52
CG-15	16.06	6.85	90.00	4.40	112.00	56.00	2.00	31.00	24.00	52.45	14.37	23.41
CG-16	26.26	6.79	62.00	3.00	98.00	60.00	1.63	29.00	27.00	42.48	18.87	20.78
CG-17	20.76	6.65	72.00	Absent	108.00	50.00	2.16	31.00	12.00	58.65	15.68	29.35
CG-18	14.26	9.23	97.40	Absent	100.00	83.00	1.20	35.00	34.00	60.90	28.71	22.38
CG-19	16.76	7.25	96.00	Absent	98.00	75.00	1.31	38.00	28.00	64.29	23.48	23.57
CG-20	13.96	6.65	94.00	3.80	126.00	68.00	1.85	33.00	19.00	59.25	24.89	18.71
CG-21	18.06	9.75	86.00	Absent	106.00	61.00	1.74	28.00	18.00	45.56	15.60	16.51
CG-22	18.56	7.54	78.20	35.00	110.00	74.00	1.49	40.00	15.00	69.24	19.57	14.77
CG-23	19.76	11.80	92.00	Absent	99.00	54.00	1.83	22.00	12.00	65.48	15.40	14.50
CG-24	14.26	10.37	110.00	Absent	96.50	48.00	2.01	34.50	21.00	36.52	18.48	21.51
CG-25	17.76	9.40	84.00	Absent	123.00	81.50	1.51	29.50	21.50	67.13	25.60	22.21
CG-26	17.56	7.65	97.00	Absent	138.00	92.00	1.50	54.00	18.00	65.35	15.81	26.57
CG-27	21.26	8.78	86.00	Absent	117.00	67.00	1.75	18.00	11.00	59.57	5.47	15.11
CG-28	14.06	8.45	96.50	Absent	92.00	71.00	1.30	36.00	25.80	61.25	19.54	20.24
CG-29	15.76	6.54	78.00	Absent	105.00	58.00	1.81	29.00	23.00	48.21	21.30	18.17
CG-30	14.56	7.80	57.10	Absent	112.00	67.00	1.67	30.00	12.00	67.60	10.80	12.85
Average	15.48	8.80	82.79	7.22	110.22	65.03	1.73	31.96	19.56	57.80	18.58	20.04
S.D.	3.60	2.89	25.38	12.85	12.01	11.39	0.28	6.78	5.95	11.01	4.74	3.94
C.V. (%)	23.24	32.81	30.65	178.08	10.89	17.52	16.20	21.21	30.44	19.05	25.48	19.66

Table 1: Continued…

Genotypes	Petal width (mm)	Number of stamens	Flower Bud length (mm)	Flower Bud width (mm)	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g fruit^{-1})	Oil gland density	Number of segments	Segment length (mm)	Segment breadth (mm)	Diameter of axis (mm)
CG-1	12.12	27.00	23.37	12.14	131.50	133.76	886.50	29.50	14.00	100.54	36.59	18.54
CG-2	11.54	29.00	15.40	6.21	111.00	146.50	1057.00	38.00	15.00	120.10	30.54	22.33
CG-3	13.00	28.00	17.64	12.53	118.50	136.94	761.50	28.00	13.00	180.29	28.10	14.21
CG-4	16.47	32.00	21.84	15.35	100.00	127.39	745.00	28.00	15.00	110.38	25.61	35.50
CG-5	15.62	30.00	15.67	7.77	115.00	124.20	840.00	38.50	11.00	100.51	41.44	22.14
CG-6	11.81	26.00	20.40	13.91	129.00	133.76	971.50	37.00	13.00	100.59	25.57	35.48
CG-7	12.14	25.00	16.53	7.82	133.00	124.20	1031.00	45.00	15.00	120.49	30.80	20.73
CG-8	11.97	29.00	17.41	12.57	192.00	165.61	1674.00	26.00	16.00	130.99	40.59	40.41
CG-9	15.33	25.00	19.58	10.53	110.00	117.83	679.00	49.50	12.00	120.50	25.59	40.89
CG-10	16.55	32.00	16.37	11.52	135.50	156.05	1222.50	17.00	13.00	110.32	30.54	45.21
CG-11	12.11	34.00	13.74	11.61	147.00	140.13	928.00	32.00	12.00	100.50	39.90	20.84
CG-12	19.64	34.00	16.24	10.63	106.00	114.65	555.00	52.00	14.00	78.25	34.32	20.29
CG-13	11.92	33.00	13.58	9.49	152.00	143.31	1153.00	30.00	14.00	110.58	45.50	30.34
CG-14	19.45	27.00	15.45	7.56	139.00	133.76	899.00	54.00	12.00	100.08	40.22	24.47
CG-15	7.49	29.00	15.15	8.40	158.00	205.41	2120.00	7.00	15.00	108.91	48.50	39.98
CG-16	18.55	33.00	19.92	12.44	112.50	132.64	705.50	46.50	17.00	78.59	16.50	18.50
CG-17	5.54	28.00	15.12	7.84	125.00	143.31	980.00	23.00	22.00	106.56	36.60	15.45
CG-18	14.10	31.00	22.74	14.79	130.00	150.32	1063.00	37.00	17.00	80.59	35.65	36.00
CG-19	12.27	35.00	20.60	11.31	129.00	146.50	1281.00	25.00	16.00	100.26	38.61	35.45
CG-20	14.91	30.00	18.65	14.37	149.00	140.13	1242.50	18.00	12.00	108.54	45.63	23.36
CG-21	13.52	29.00	14.31	8.55	109.50	165.61	943.00	30.50	20.00	79.24	40.50	37.63
CG-22	11.35	31.00	17.43	11.23	125.00	143.31	1364.00	23.00	11.00	135.11	45.00	24.50
CG-23	9.43	25.00	18.61	6.27	150.00	171.97	954.00	29.00	13.00	138.36	37.80	29.47
CG-24	17.66	28.00	13.78	10.84	98.00	127.39	796.50	48.00	15.00	110.50	30.50	30.31
CG-25	14.76	34.00	16.77	10.41	112.00	127.39	725.00	48.00	15.00	80.22	35.90	25.21
CG-26	15.67	30.00	28.56	10.56	152.00	159.24	1643.00	17.50	12.00	160.20	40.90	35.87
CG-27	10.58	34.00	23.36	12.50	96.50	143.31	569.50	37.00	12.00	75.54	28.10	31.69
CG-28	16.85	26.00	19.18	11.14	135.00	140.13	865.00	22.00	13.00	105.50	42.41	38.55
CG-29	13.47	28.00	15.51	8.37	125.00	132.17	543.00	17.00	13.00	66.50	29.12	13.25
CG-30	4.82	27.00	15.45	7.84	118.00	181.53	598.00	25.50	14.00	95.60	35.11	18.38
Average	13.35	29.63	17.95	10.55	128.13	143.61	993.2	31.95	14.2	107.14	35.40	28.17
S.D.	3.64	3.03	3.50	2.48	20.93	19.62	358.80	11.98	2.48	24.90	7.40	9.11
C.V. (%)	27.27	10.24	19.48	23.54	16.33	13.66	36.13	37.48	17.49	23.24	20.90	32.33

Table 1: Continued…

Genotypes	Rind thick-ness (mm)	Weight of pulp (g)	Rag weight (g)	Number of fruits tree^{-1}	Yield (kg plant^{-1})	Number of seeds fruit^{-1}	Weight of 20 seeds (g)	Moisture (%)	TSS (^{0}B)	Acidity (%)	pH	Ascorbic acid (mg/ 100g)	Total sugars (%)
CG-1	19.65	425.00	400.00	62.00	54.96	56.00	10.50	90.40	9.00	3.02	3.90	30.00	3.98
CG-2	10.29	590.00	260.00	48.00	50.74	23.50	12.14	86.40	7.40	2.15	3.75	27.50	6.85
CG-3	19.58	380.00	356.00	57.00	43.41	29.00	8.31	84.28	6.80	1.54	3.40	30.20	5.94
CG-4	15.92	300.00	349.00	70.00	52.15	40.00	6.12	87.54	6.50	1.35	3.80	23.75	5.05
CG-5	9.63	451.00	297.00	38.00	31.92	86.00	11.64	82.20	8.40	2.78	3.95	32.50	4.63
CG-6	17.54	449.00	392.00	60.00	58.29	50.00	14.24	84.00	7.90	2.50	3.80	28.75	4.41
CG-7	7.31	576.00	260.00	35.00	36.09	64.50	7.27	91.05	8.20	2.69	4.00	28.75	5.35
CG-8	30.58	587.00	982.00	55.00	92.07	110.00	11.91	83.51	8.00	3.02	3.50	29.00	3.55
CG-9	16.84	301.00	328.00	170.00	115.43	19.00	9.00	84.20	9.00	2.99	3.85	40.00	5.23
CG-10	20.98	569.00	512.00	125.00	152.81	37.50	9.74	84.56	8.10	2.60	4.00	37.50	3.72
CG-11	16.24	405.00	448.00	80.00	74.24	45.00	13.16	86.57	8.40	2.11	3.95	28.75	5.02
CG-12	14.87	255.00	271.00	40.00	22.20	40.00	8.80	89.24	8.90	2.45	4.00	33.75	5.57
CG-13	18.49	532.00	555.00	50.00	57.65	47.00	8.00	87.00	7.00	2.54	4.10	31.25	3.94
CG-14	18.64	404.00	439.00	75.00	67.43	60.00	8.14	86.30	8.40	2.01	4.15	32.50	5.29
CG-15	41.52	968.00	854.00	65.00	137.80	58.00	9.87	85.40	9.20	3.20	3.80	35.80	3.22
CG-16	14.19	388.00	336.00	37.00	26.10	20.50	11.61	89.10	7.00	2.47	3.90	30.90	4.00
CG-17	25.98	360.00	529.00	45.00	44.10	22.00	7.20	90.22	6.80	1.82	3.80	30.00	5.49
CG-18	19.65	372.00	471.00	59.00	62.72	77.00	5.34	82.10	8.00	2.11	3.80	36.25	4.93
CG-19	14.59	673.00	421.00	60.00	76.86	118.50	7.19	87.09	9.20	3.02	4.10	32.50	5.49
CG-20	14.28	579.00	375.00	55.00	68.34	84.00	11.12	89.94	9.00	2.57	3.70	31.25	4.72
CG-21	26.19	377.00	623.00	50.00	47.15	57.00	7.87	89.41	8.70	3.20	3.70	32.50	5.32
CG-22	12.97	673.00	506.00	63.00	85.93	106.00	9.50	86.00	8.90	1.71	3.80	31.25	5.24
CG-23	20.51	638.00	340.00	65.00	62.01	59.00	6.17	85.60	9.80	1.08	3.70	31.40	5.15
CG-24	9.84	439.00	309.00	90.00	71.69	38.50	8.48	87.95	7.80	2.30	3.90	31.25	4.85
CG-25	14.44	340.00	340.00	71.00	51.48	63.00	9.50	84.23	7.90	2.11	4.00	25.00	5.02
CG-26	15.67	654.00	659.00	64.00	105.15	64.00	8.86	82.70	7.20	2.86	3.50	28.00	4.31
CG-27	18.62	382.00	208.00	85.00	48.41	54.50	8.60	87.00	10.20	3.16	3.40	29.80	5.32
CG-28	20.56	505.00	332.00	42.00	36.33	38.00	5.20	90.00	8.20	2.54	3.50	30.00	5.59
CG-29	22.67	218.00	312.00	67.00	36.38	42.00	4.65	86.54	10.80	3.70	3.40	34.00	3.83
CG-30	21.61	484.00	235.00	170.00	101.66	22.00	4.78	85.50	10.10	3.57	3.80	29.40	5.85
Average	18.33	475.8	423.3	68.43	65.72	54.38	8.83	86.53	8.36	2.51	3.80	31.12	4.89
S.D.	6.74	156.15	175.38	33.10	31.69	26.41	2.48	2.56	1.07	0.63	0.21	3.40	0.81
C.V. (%)	36.77	32.82	41.43	48.37	48.23	48.57	28.13	2.96	12.80	25.16	5.62	10.94	16.50

Table 2: Correlation coefficients (r) of different characters in pummelo with fruit yield

Sr. No.	Parameters/characters	Correlation coefficient (r)
1	Altitude (m)	0.204
2	Stem girth (cm)	0.062
3	Plant height (m)	-0.179
4	Canopy spread (m)	0.052
5	Spine length on adult tree (mm)	-0.100
6	Lamina length (mm)	0.292*
7	Lamina width (mm)	0.237
8	Ratio of leaf lamina length/ width	-0.058
9	Petiole wing length (mm)	0.124
10	Petiole wing breadth (mm)	-0.110
11	Leaf area $(cm)^2$	0.221
12	Pedicel length (mm)	-0.019
13	Number of petals per flower	0.034
14	Petal length (mm)	0.009
15	Petal width (mm)	-0.213
16	Number of stamens	-0.048
17	Flower Bud length (mm)	0.046
18	Flower Bud width (mm)	0.024
19	Number of fruits/ tree	0.643**
20	Fruit weight (g)	0.594**
21	Fruit length (mm)	0.398**
22	Diameter (mm)	0.569**
23	Oil gland density (cm^{-2})	-0.429**
24	Size of oil gland (mm)	0.405**
25	Number of segments	-0.199
26	Segment length (mm)	0.302*
27	Segment breadth (mm)	0.248
28	Diameter of axis (mm)	0.579**
29	Rind thickness (mm)	0.407**
30	Number of seeds per fruit	0.106
31	Weight of 20 seeds (g)	0.097
32	Weight of pulp (g)	0.551**
33	Rag weight (g)	0.502**
34	Total soluble solids (TSS)	0.145
35	pH	0.077
36	Moisture	-0.430**
37	Acidity	0.216
38	Reducing sugars	-0.142
39	Total sugars	-0.360*
40	Non reducing sugars	-0.413**
41	Ascorbic acid	0.401**

*, ** = Significant at 5% and 1% levels respectively

correlation of fruit yield with number of fruits $tree^{-1}$ (0.643), fruit weight (0.594), fruit length (0.398), diameter (0.569), size of oil gland (0.405), diameter of axis (0.579), rind thickness (0.407), weight of pulp (0.551), rag weight (0.502) and ascorbic acid (0.401) content was highly significant and in positive direction. It was also positively and significantly correlated with lamina length (0.292) and segment length (0.302).

These findings are in agreement with the report of Long (1962) and Chakrawar and Jature (1980) who noticed the strong correlation between fruit size and weight in oranges and Kagazi lime, respectively. Singh *et al.*, (2009) stated in hill lemon strains that fruit rind thickness exhibited significant positive correlation with fruit yield

parameters like length, fruit diameter, fruit weight and fruit length/diameter ratio, which is matching with the foregoing findings. The results are also in consonance with the report of Bhowmick and Banik (2008) who noticed that there was a significant positive correlation of fruit weight with pulp content and breadth of mango. Moreover, Raghava and Tiwari (2008) also observed that fruit yield tree^{-1} was positively and significantly correlated with fruit weight and fruit length in guava that tallies with fore mentioned outcome.

However, negative and highly significant correlation was exhibited by oil gland density (-0.429), moisture (-0.430) and non reducing sugars (-0.413), while total sugar (-0.360) unveiled negative and significant correlation. (Table 2). In the present study, altitude, stem girth, canopy spread, lamina width, petiole wing length, leaf area, number of petals flower^{-1}, petal length, flower bud length, flower bud width, segment breadth, number of seeds fruit^{-1}, weight of 20 seeds, TSS, pH and acidity revealed positive but non-significant correlation with fruit yield.

There is a significant variability in the present pummelo population of the Kokan region. This variability can be exploited for the selection of elite genotypes for conservation, evaluation, utilization and a source for crop improvement in future breeding programme.

REFERENCES

Anonymous, 2003. Guidelines for the conduct of tests for distinctness, uniformity and stability. *International Union for the Protection of New Varieties of Plants Geneva. Citrus* L. – Group 4 Grapefruit and Pummelo

Anonymous 2008. Package and practices for fruits crops, Punjab Agricultural University, Ludhiana

Anonymous, 2012. FAOSTAT. FAO Statistics Division 2012, 22 January 2012. http://www.fao.org.

Ara, N., Bashar, M.K., Uddin, M.K. and Khalequzzaman, K.M. 2008. Evaluation of pummelo, *Citrus grandis* L cultivars in northern area of Bangladesh. *Journal of Agricultural Research (Lahore)*, **46**(1): 65-75.

Badiyala, S.D. and Sharma, S.K. 2004. Variability studies in galgal (*Citrus pseudolimon* Tanaka) in upper Shivaliks of Himachal Pradesh. *Indian Journal of Horticulture*. **61**(2):105-108.

Ben, G.B. 2010. Crop info and how-to guide in growing pummelo. Crops Review. com: towards an informed application of science and agriculture http://www.cropsreview.com/ pummelo.

Bhowmick, N. and Banik, B.C. 2008. Genetic variability and correlation studies for fruit physico-chemical properties of some mango cultivars grown under new alluvial zone of West Bengal. *Asian Journal of Horticulture*, **3**(2): 346-349.

Chakrawar, V.R. and Jature, S.D. 1980. Correlation studies on Kagzi lime strains. *Punjab Horticultural Journal*, **20**(1/2): 39-40.

Dorji, K. and Yapwattanaphun, C. 2011. Morphological Identification of Mandarin (*Citrus reticulata* Blanco) in Bhutan. *Kasetsart J. (Nat. Sci.)*, **45**: 793–802.

Estellena, N.T. and Odtojan, R.C. 1992. Pomological characterization of eight Pummelo cultivars, *Citrus maxima* (Burm.) Merr. *Philipp J. Crop Sci.*, **17**(3): 137-142.

FAOSTAT, 2010. http://www.cropsreview.com/pummelo.

Haque, M.N., Saha, K., Karim, M.R. and Bhuiyan, M.N.H. 2009. Evaluation of nutritional and physico-chemical properties of several selected fruits in Bangladesh. *Bangladesh J. Sci. Ind. Res.*, **44**(3): 353-358.

Hassan, N.A., El-Halwagi, A.A., Khalaf, R.M. Sayed, H.A. and El-Homosany, A.A. 2008. Morphological characterization, pollen grain fertility and some chemical characters of selected mandarin (*Citrus* Spp.) varieties. *Arab Univ. J. Agric. Sci., Ain. Shams Univ.*, **16**(1): 161-177.

Hazarika, T.K. 2012. Citrus genetic diversity of north-east India, their distribution, ecogeography and ecobiology. *Genet. Resour. Crop Evol.*, **59**: 1267–1280.

IPGRI, 1999. Descriptors for Citrus. *International Plant Genetic Resources Institute, Rome, Italy*. 75 p.

Long, W.G. 1962. The relationships among several physical and chemical measurements made on Oranges. *Florida state horticultural society*. 292-294 p.

Malik, S.K., Chaudhury, R. O., Dhariwal, P. and R.K. Kalia 2006. Collection and characterization of *Citrus indica* Tanaka and *C. macroptera* Montr. wild endangered species of northeastern India. *Genetic Resources and Crop Evolution*, **53**: 1485–1493.

Mitra, S.K., Maity, C.S., Ghosh, B. and Pathak, P.K. 2010. Genetic resources of pummelo (*Citrus grandis* Osbeck) in West Bengal, India. *Acta Horticulturae*, **918**: XXVIII International Horticultural Congress on Science and Horticulture for People: III *International Symposium on Plant Genetic Resources*.

Morton, J. 1987. In: *Fruits of warm climates*. Florida Flair Books, Miami, Pummelo. p. 147–151.

Narong, C., Chapman, K. and Griffee, P. 2005. Fruits of vietnam in food for all, FAO of United Nations at http://www.ecoport.org.

Olivera, R.P., Novelli, V.M. and Machado, M.A. 2000. Frequeneia de hibridos em eruzamenlo entre tangerine Crnvo e laranja Pera: analise de mareadores morfologico e RAPD. *Pesquisa Ag-ropccuaria Brasilcirn, Brasilia* **35**(9): 1895-1903, English Abstract.

Panse, V.G. and Sukhatme, P.V. 1995. Statistical methods for agricultural workers, ICAR Rev. Ed. By Sukhatme P. V. and Amble, V.N. pp. 145-146.

Patil, P. and Reddy, B.M.C. 2008. Ex situ characterisation and evaluation of pummelo germplasm. *National Symposium on Citriculture: emerging trends*. NRCC, Nagpur, 24-27.

Quang, H.T., Xuan, L. T., Mai, N.T., Trung, N. V., Lien, N. T. T., Phuong, T. T. B. and Loc, N.H. 2011. Genetic variability

of "Thanh tra" pummelo (*Citrus grandis* (L.) Osbeck) at Thua Thien Hue, Vietnam. *Annals of Biological Research*, **2**(4):306-314.

Raghava, M and Tiwari, J. P. 2008. Genetic variability and correlation analysis in Guava. *Indian J. Hort.*, **65**(3): 263-270.

Samarasinghe, P.W.S.M. 2005. Selection and conservation of good quality pummelo (*Citrus grandis* L.) mother trees. *IPGRI Newsletter for Asia, The Pacific and Oceania*, **47**: 21-22.

Sanabam, R., Somkuwar, G. Thingnam, G. Moirangthem,S. Handique, P. J. and S. Huidrom 2012. CIBMAN: Database exploring Citrus biodiversity of Manipur. *Bioinformation*, **8**(17): 838-840.

Sandhu, A. S., Kaur, H. and Chanana, Y. R 2000. Studies on variability in physico-chemical characteristics of lime and lemon selections. Proc. Nat. Symp. Citriculture, NRCC, Nagpur. 537-539.

Singh, I. P. and Singh, S. 2006. *Citrus Monograph*. NRCC, Nagpur, MS 96 p.

Singh, N. P., Gill, P. S. . Jawandha, S. K and K. Harminder 2009. Genetic variability in hill lemon strains (*Citrus pseudolimon* Tanaka) under Punjab conditions. *Not. Bot. Hort. Agrobot. Cluj.*, **37**(1): 238-243.

Srivastava, A. K., Singh, I. P. and Das, A. K. 2010. Citrus production constraints in Meghalaya: Issues and Strategies. *ENVIS Bulletin*, **18**: 18-28.

Tongleaw, S., Krisanapook, K. and Phavaphutanon, L. 2012. Analysis of 'Khao Yai' Pummelo fruit to estimate nutrient losses through crop removal. *Kasetsart J. (Nat. Sci.)*, **46**: 827–836.

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Variabilty and correlation analysis in grapefruit cultivars under subtropical conditions of Himachal Pradesh

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ABSTRACT

Grape fruit (*Citrus paradisi* Macf.) is an underutilized citrus species cultivated only in certain parts India. The present investigation was carried out at the Experimental Orchard, Regional Horticulture Research Station (RHRS), Dhaulakuan, District Sirmour (HP) and the Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry Nauni, Solan (HP) during year 2013. Variability and correlation studies of two cultivars (Ruby Red and Duncan) were carried out for plant growth characters, fruit and yield characters. Cultivar Ruby Red was superior in most of the characters compared to 'Duncan' while in correlation studies there was positive correlation observed for yield per plant with fruit weight (0.892), leaf area (0.852), acidity (0.841), size of vesicle (0.820) fruit length (0.777) and fruit breadth (0.769) whereas significant and negatively correlated with seed number per fruit (-0.771).

KEY WORDS: Correlation, Grapefruit, underutilized and Variability

Grape fruit (*Citrus paradisi* Macf.) is an important underutilized citrus species grown in tropical, semitropical and subtropical regions (Reuther, 1973) and is popular breakfast fruit in other countries. Due to high nutritive (vitamin-C and B) and medicinal value, the demand of grapefruit is increasing steadily in urban population (Singh and Saxena, 1970).For future improvement in grapefruit, there is a great need to develop high yielding cultivars. Success of any crop improvement programme mostly depends on the nature and magnitude of genetic variability present in the crop and extent to which the desirable characters are heritable. Hence, studies on genetic variability with the help of suitable genetic parameters became important for an effective breeding programme to improve the yield potential of the grapefruit cultivars. Yield is very complex entity, influenced by several yield components sensitive to the environmental fluctuations. Thus, the selection based on yield components will have better chance of success. It is therefore, necessary to know the types and nature of yield components and their inter relationship. The correlation coefficient analysis provides information on their relative importance of various contributing characters. Character association of plant characters with fruit yield is of great importance to breeder in selecting desirable genotypes to develop high yielding cultivars. Keeping in view the above facts the present investigation was carried out on variability, character association analysis to predict information of two grapefruit cultivars.

MATERIALS AND METHODS

The present investigations was carried out at the Experimental Orchard, Regional Horticulture Research Station (RHRS), Dhaulakuan, of district Sirmour (HP) and the Department of Fruit Science, in Dr YS Parmar University of Horticulture and Forestry Nauni, Solan (HP) during year 2012-2013.Morphological observations on different plant growth (height, spread, girth, leaf length, leaf breadth and leaf area) and fruit characters (fruit length, peel-thickness, number of segment, size of vesicle, seed number, TSS, total sugar, reducing sugar, non-reducing sugar, acidity, vitamin C, fruit weight and yield) were recorded.The biochemical parameters were recorded as per the Association of Official Analytical Chemist **(1970).**The statistical analysis was carried out for variability for each observed character under the study using MS-Excel and OPSTAT packages. The T-statistic is used to compare mean values of the two varieties (each with five replications) because the number of treatment was less i.e. two. From the T-statistic, T-value was calculated and compared with the table value 2.33. Simple correlation was calculated by using OPSTAT packages between different plant growth, fruit and yield characters.

Table 1: Plant growth, fruit and yield characteristics of grapefruit cultivars

S.N.	Characters	Plant traits	2012-13		
			Ruby Red	Duncan	t_{cal}
1.	Plant growth characters	Plant height (m)	2.45	3.11	3.19
		Plant spread (m)	3.27	2.54	2.48
		Plant girth (cm)	28.11	22.08	3.51
		Leaf length (cm)	8.15	7.60	2.36
		Leaf breadth (cm)	3.65	2.79	5.87
		Leaf area (cm^2)	35.58	20.18	19.52
		Wing length (mm)	24.88	0.53	19.33
		Wing breadth (mm)	14.66	0.26	18.51
2	Morphological characters of fruits	Fruit length (mm)	79.99	63.23	5.50
		Fruit breadth (mm)	84.25	65.37	4.97
		Stalk mark (mm)	4.19	5.61	5.78
		Style mark (mm)	3.10	2.19	2.8
		Peel thickness (mm)	8.69	6.33	4.44
		Number of segment	12.40	10.60	2.50
		Size of vesicle (mm)	53.57	47.64	3.29
		Seed number/fruit	3.80	10.40	5.39
		Seed length (mm)	12.42	9.81	5.84
		Seed breadth (mm)	7.06	4.42	10.92
3	Physico-chemical characters of fruits	TSS (°B)	8.84	7.12	6.70
		Acidity (%)	1.67	1.15	3.79
		Total sugar (%)	5.65	4.51	3.67
		Reducing sugar (%)	3.24	1.48	5.59
		Non reducing (%)	2.41	3.03	3.35
		Vitamin-C (mg/100g ml juice)	50.33	44.69	2.93
		Juice percent (%)	49.97	42.03	4.95
4	Yield characters fruits	Fruit weight (g)	234.39	197.80	4.36
		Fruit number/tree	234.60	190.80	3.95
		Fruit yield (Kg/tree)	55.02	37.71	5.48

RESULTS AND DISCUSSION

Variability studies

Plant growth characters

The present investigation on grapefruit cultivar Ruby Red and Duncan recorded significant variation (Table 1) in the plant growth characters. Plant height, spread and girth of 'Ruby Red' cultivar (2.45 m, 3.27 m and 28.11 cm) showed significant variation in comparison to 'Duncan' (3.11 m, 2.54 m, and 22.08 cm).According to Singh and Dhaliwal (1980), plant height and trunk girth of 'Ruby Red' are in accordance, whereas tree spread of 'Ruby Red' and plant height, spread and girth in 'Duncan' are contradictory to the data of present finding.

'Ruby Red' recorded maximum leaf length (8.15cm), leaf breadth (3.65 cm), leaf area (35.58 cm^2), wing length (24.42 mm) and wing width (14.53 mm) in comparison to cultivar Duncan. Similar results for leaf length and leaf breadth were obtained by Kumar (2013)in different citrus species i.e. *Citrus sinensis* cultivar Mosambi.

Fruit characters

Morphological characters

The data pertaining to fruit characters (Table 1) showed significant variation in the two cultivars studied. Fruit length (79.99 mm), fruit breadth (84.25 mm), peel thickness (8.69 mm) number of segments (12.40), size of vesicle (53.57 mm), seed length (12.42 mm) and seed breadth (7.06 mm) were maximum in 'Ruby Red' while Duncan (10.40) had higher seed number per fruit.The present investigation on fruit length is in contradiction with study of Dubey *et al.*, (2013) whereas, Arora and

Table 2: Simple correlation between different characters of grapefruit

Grapefruit	Plant height	Plant spread	Plant girth	Leaf area	Fruit length	Fruit breadth	Peel thick-ness	Number of segment	Size of vesicle	Seed number	TSS	Acidity	Total sugar	Vit. - C	Fruit weight	Yield
Plant height	1.000	-0.359	-0.761	-0.707	-0.629	-0.641	-0.815*	-0.746	-0.798*	0.630	-0.850*	-0.393	-0.797*	-0.586	-0.575	-0.615
Plant spread			0.475	0.725	0.463	0.274	0.655	0.581	0.214	-0.452	0.558	0.731	0.231	0.621	0.298	0.502
Plant girth				0.729	0.800*	0.710	0.649	0.461	0.852*	-0.827*	0.755	0.614	0.682	0.622	0.780*	0.739
Leaf area					0.847*	0.835*	0.863*	0.664	0.679	-0.860*	0.917*	0.836*	0.745	0.685	0.780*	0.852*
Fruit length						0.892*	0.665	0.509	0.720	-0.856*	0.783*	0.646	0.687	0.646	0.873*	0.777*
Fruit breadth							0.705	0.347	0.746	-0.909*	0.860*	0.626	0.824*	0.504	0.854*	0.769*
Peel thickness								0.685	0.536	-0.672	0.950*	0.665	0.751	0.639	0.467	0.629
No. of segments									0.444	-0.345	0.606	0.484	0.536	0.565	0.414	0.556
Size of vesicle										-0.766*	0.706	0.481	0.742	0.490	0.865*	0.820*
Seed number											-0.850*	-0.673	-0.808*	-0.666	-0.875*	-0.771*
TSS												0.660	0.861*	0.679	0.669	0.723
Acidity													0.521	0.436	0.654	0.841*
Total sugar														0.671	0.724	0.730
Vit. C															0.532	0.568
Fruit weight																0.892*
Yield																1.000

* = Significance at 5% level of significance

Daulta (1982) results are also not in line with present study. They found fruit length ranged from 9.72 to 10.32 cm, fruit breadth from 10.22 cm to 11.15 cm, whereas peel thickness ranged from 7.3 to 9.8 mm and are similar with the present findings. Findings of Singh and Lal (1982) for fruit breadth and seed number per fruit are also contradictory, whereas the numbers of segments are in line with the present study. The variation in above characters may be due to the difference in site of plantation, cultural practices or may due to nutritional deficiency at the planting site, and different cultivars taken by the authors for their studies.

Physico-chemical characteristics

The physico-chemical characteristics like TSS, acidity, total sugar, reducing sugar , vitamin-C and fruit juice were higher in 'Ruby Red' *i.e.* are 8.84°B, 1.67 %, 5.65 %, 3.24 %, 50.33 mg/100g, 49.97 % respectively while non reducing sugar (2.73 %) was higher in 'Duncan' (Table 1). Results quite similar with slight numerical variation for characters like juice per cent, acidity and TSS were obtained in their study by Singh and Dhaliwal (1980). The findings of Singh and Lal (1982), Mathur and Godara (1990) and Iahfaq *et al*., (2007) had similar results for physico-chemical characters as recorded under the present study.

Yield characters

Under present investigation the range of fruit weight 197.8-234.39 g, fruit number (190.80-234.39) and fruit yield (37.71-55.02 kg/ tree) were observed in cultivars Ruby Red and Duncan (Table 1). The fruit weight in the present study is not in agreement with the findings of Mathur and Godara (1990), Nabi *et al.*, (2004) and Iahfaq *et al.*, (2007). According to Rodriguez *et al.*, (2008) fruit yield is in line (34.96 kg/ tree) with the present study, whereas findings of Singh and Dhaliwal (1980), Arora and Daulta (1982) and Sidahmed and Khalil (1997) are in contradiction with values obtained in the present findings. The observed variation (s) could be due to difference in age of plant, nutritional deficiency, excessive flower and fruit drop, site of plantation, cultivars and cultural practices applied.

Correlation studies

The simple correlations among fruit yield per plant and other vegetative, fruit yield and quality characters for grapefruit cultivars were worked out and are presented in Table 2.

Significant and positive correlations were observed for yield per plant with fruit weight (0.892), leaf area (0.852), acidity (0.841), size of vesicle (0.820) fruit length (0.777) and fruit breadth (0.769) whereas significant and negatively correlated with seed number per fruit (-0.771). The association of fruit weight was found to be significantly positive with fruit length (0.873), fruit breadth (0.854) , leaf area (0.780) and plant girth (0.780) while it was associated significantly and negatively with seed number per fruit (-0.875). Highly significant and positive correlation was found in character TSS with peel thickness (0.950), leaf area (0.917), fruit breadth (0.860) and fruit length (0.783) and

negative with seed number per fruit (-.0.850). The relationship of fruit length with leaf area (0.847) and plant girth (0.800) was significantly positive. Vitamin – C and number of segment didn't show significantly positive correlation with any of the characters. Peel thickness had maximum positive correlation with leaf area (0.863) and negative with height (-0.815). Rodriguez *et al.,* (2008) had also observed significant and positive correlation for yield with fruit weight in different grapefruit cultivars. Whereas, Rabha *et al.,* (2013) had also found significant and positive correlation for fruit yield with fruit weight in citrus species.

REFERENCES

AOAC. 1970. Official method of analysis of the association of official analytical chemist (ed. William Horewitz) Benjamin franklin station Washington. D C. p. 978

Arora, R.K. and Daulta, B.S. 1982. Evaluation of different grapefruit cultivars (*C. Paradisi* Macf.) for their physico chemical composition and yield under Hissar conditions. Haryana *J. Hort. Sci.***11(3-4):**184-187

Dubey, A.K. and Yadav, D.S. 2004. Growth patterns in sweet orange (*Citrus sinensis*Osbeck) during spring flush under mid hill conditions of Arunachal Pradesh. *Haryana J. Hort. Sci.***33(3 & 4):** 163-164

Iahfaq, M., Ahmad, S., Awan, M.Z. and Nasir, M.A. 2007. Performance of grapefruit cultivars under agro-climatic conditions of Chakwal.*Pakistan Journal of Agricultural Sciences* **44(3):**472-474

Kumar, S. 2013. Genetic evaluation and pollination behavior of different citrus species M.Sc. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry: Solan (H.P.)

Mathur, M.M. and Godara, P.S.1990.Physico-chemical studies of some citrus species grown in arid irrigated regions of Rajasthan. *Haryana Journal Horticulture Science***19(3-4):** 251-255

Nabi, G., Jan, T., Gul, S., Kanwal, N. and Rahim, U. 2004.Performance of different grapefruit (*Citrus paradisi*Macf.) genotypes on sour orange (*Citrus aurantium* L.) rootstock under the climatic conditions of Peshwar.*Pakistan Journal of Biological Sciences* **7(10):**1762-1766

Rabha, A., Wangchu, L. and Singh, B. 2013. Studies on genetic diversity of citrus in east Siang district of Arunachal Pradesh.*Intl. J. Agric. Env. Biotech***6(1):** 131-137

Reuther, W. 1973. Climate and citrus behaviour. In: Reuther W, Webber HJ, BatchelorL(eds). The citrus industry, Vol 3, Div. Agric. Sci., University, Berkeley, pp 280-337

Rodriguez, S.B, Urrutia, V.M.M., Gonzalez, M.M.R. and Williams, T. 2008. Performance of various grapefruit (*Citrus paradisi*Macf.) and pummel (*C. maxima*Merr.) cultivars under the dry tropic conditions of Mexico. *Euphytica* **164**:27-36

Sidahmed, O.A. and Khalil, I.M. 1997. Performance of grapefruit under the ecological conditions of central Sudan I. growth, flowering and yield.*Annals of Arid Zone* **36(1):** 47-52

Singh, G. and Dhaliwal, G.S. 1980. Performance of grapefruit cultivars under Ludhiana conditions.*Punjab Horticulture Journal***20 (3/4):**140-142

Singh, A.R. and Lal, M. 1982. Performance of citrus fruits in the north Gangetic plains.*The Punjab Horticulture Journal* 22(1-2): 29-34

Singh, R. and Saxena, S.K. 1970.Grapefruit is steadily gaining popularity. *Indian Hort.*, **15(2):**11-12,29

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Evaluation of litchi cultivars in tarai region of Uttarakhand, India

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ABSTRACT

The litchi (*Litchi chinensis* Sonn.) is one of the commercially important fruit crops of Uttarakhand. In order to encourage its commercial development in Uttarakhand, many cultivars were introduced from various litchi growing regions of the country to evaluate their performance under local conditions. Regularity of fruiting, fruit cracking resistance, fruit weight along with higher pulp percentage and yield potential were considered priority for the commercial suitability of a cultivar. Cultivars evaluated included 'Rose Scented' and 'Calcuttia' from Uttarakhand, 'Late Bedana'and,' Early Bedana' from Punjab, 'Shahi', 'Purbi', and 'Mandaraji' from Bihar, 'Bombai', and 'Bombai Selection' from West Bengal. Among all the varieties evaluated, cultivar Rose Scented significantly registered maximum plant height (2.14 m), stem girth (82.93 cm) and canopy spread (1.80 m & 1.86 m). Significantly maximum panicle length (32 cm), number of mature fruit/panicle (15.3), fruit yield (57.82 kg tree^{-1}) and fruit cracking (20.12 %) were recorded in Rose Scented. However, maximum average fruit weight (23.60 g), pulp weight (18.56 g), TSS (22.29 ^{0}B) and minimum acidity (0.48 %) were recorded in Late Seedless. Based on these evaluations, the cultivars Rose Scented, Calcuttia, Late Bedana and China were deemed the most reliable in bearing and commercially viable.

KEY WORDS: cultivar, evaluation, Uttarakhand, *Litchi chinesis* Sonn.

Uttarakhand is one of the most popular states of the country known for its quality litchi production. The litchi industry in Uttarakhand is based on one major cultivar, the 'Rose Scented' (Mishra *et. al.*, 2014). Popularity of Litchi is due to excellent quality characteristics, pleasant flavour, attractive colours and great demand during the season (Yadav *et. al.*, 2010). Its cultivation is becoming popular due to its remunerative prices in the market therefore; area under its cultivation is increasing in Uttarakhand. However, very little information is available regarding the suitability of the cultivars other than Rose Scented, which can be grown, successfully under the prevailing agro-climatic conditions of the region. Therefore, the present investigation were undertaken to study the performance of different litchi cultivars under tarai region of Uttarakhand.

MATERIALS AND METHODS

The experiment was conducted at the Horticultural Research Station, Patharchatta, of GBPUAT, Pantnagar during the years from 2008 to 2013. Patharchatta represents a typical humid climate with cold winter and humid warm monsoon season. Ten commercial cultivars of different litchi growing regions of country namely Rose Scented and Calcuttia from Uttarakhand, Late Bedana and Early Bedana from Punjab, Shahi, Purbi, and 'Mandaraji' from Bihar, Bombai, and Bombai Selection from West Bengal planted during 1999 at 10 m X 10 m distance were selected for the studies. The experimental design used was randomized block design with 4 replications and 10 treatments (cultivars). Two trees were treated as one replication within each treatment for recording the observations. Recommended cultural operations were applied to all the plants since establishment of orchard.

Tree height was measured from soil surface to highest point of the crown with measuring tape. The data on tree height, spread (N-S and E-W both), stem girth, fruit yield, mean fruit weight, TSS, and titrable acidity were recorded as per standard methods. Spread was measured in both directions (N-S & E-W) and the stem girth was measured 10 cm above the ground level with the help of measuring tape. The fruits were picked at optimum level of maturity keeping in view their size, colour and taste and weighed on a balance separately from each tree for recording yield which was presented as kg tree^{-1}. The weight of the fruit was determined by weighing the fruits on the physical balance and mean of the fruit was presented. The weight of pulp, peel and seed was taken on electronic balance.

Table 1: Vegetative growth, yield, fruit weight and quality attributes of different litchi varieties (Pooled analysis 2008-2013)

#Treatments	Plant Height (m)	Stem girth (cm)	Plant spread (m)		Yield (kg/tree)	Av. fruit weight (g)	Fruit drop (%)	Pulp (%)	TSS (°B)	Acidity (%)
			(N-S)	(E-W)						
T_1	2.14	82.93	1.80	1.86	57.82	21.86	71.04	70.61	21.95	0.47
T_2	1.95	79.38	1.62	1.66	40.36	20.05	74.54	63.33	20.57	0.49
T_3	2.02	79.41	1.63	1.81	40.22	23.60	66.09	78.75	22.29	0.48
T_4	1.87	77.15	1.63	1.65	33.40	19.94	73.20	63.89	20.02	0.54
T_5	1.96	75.86	1.66	1.76	36.23	21.08	76.02	72.14	21.48	0.50
T_6	1.89	76.96	1.62	1.72	31.21	19.66	74.90	65.19	19.32	0.53
T_7	1.91	80.54	1.64	1.79	33.12	19.68	72.20	63.15	19.44	0.57
T_8	1.94	81.14	1.65	1.80	41.21	21.05	70.60	68.64	20.79	0.51
T_9	1.84	78.88	1.66	1.64	28.62	18.90	77.90	66.53	19.54	0.49
T_{10}	1.86	79.09	1.68	1.69	30.48	20.01	74.80	61.05	20.12	0.48
CD at 5%	0.047	1.60	0.027	0.033	3.82	1.16	NS	6.57	0.69	0.032

T_1-Rose Scented, T_2-China, T_3-Late Bedana, T_4-Mandaraji, T_5-Early Bedana, T_6-Purbi, T_7-Shahi, T_8-Calcuttia, T_9-Bombai, T_{10}- Bombai Selection

The TSS was determined with the help of hand refractometer. The titratable acidity was determined according to the methods of AOAC (1970). The pooled data was analyzed by using 'F' test as per randomized block design (Cochran and Cox, 1959).

RESULTS AND DISCUSSION

The data in Table 1 and Fig. 1&2 indicated that plant growth, fruit yield and quality characters significantly varied with cultivars during the experimentation. Tree height was recorded maximum (2.14 m) in Rose Scented followed by Late Bedana (2.02 m) and minimum (1.84 m) in Bombai. The highest stem girth (82.93cm) was recorded in Rose Scented followed by Calcuttia (81.14 cm) and Shahi (80.54 cm). The least stem girth (78.88 cm) and plant height (1.84 m) were observed in Bombai. Maximum value for plant spread in both the directions was recorded in Rose Scented (1.80 m and 1.86 m) and least plant spread in N-S direction was noted in Purbi (1.62 m) while minimum plant spread in E-W direction was observed in Bombai (1.64 m). Similar results were obtained by Yadav *et. al.* (2010) in litchi.

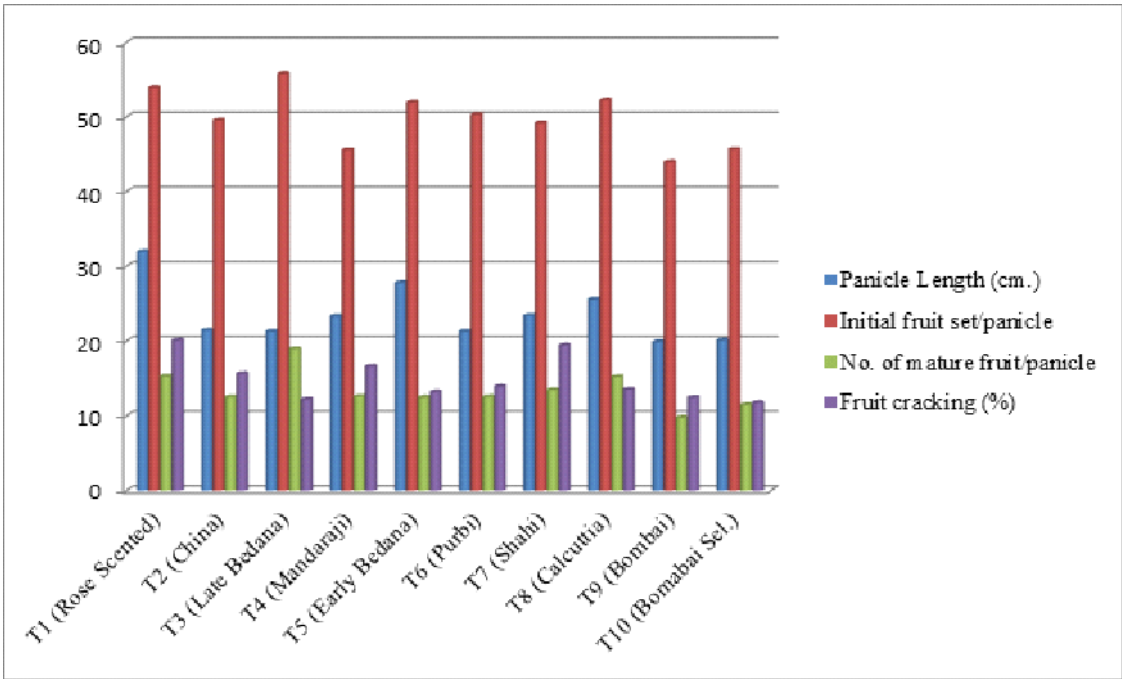

Fig. 01: Yield attributing characters of different litchi varieties

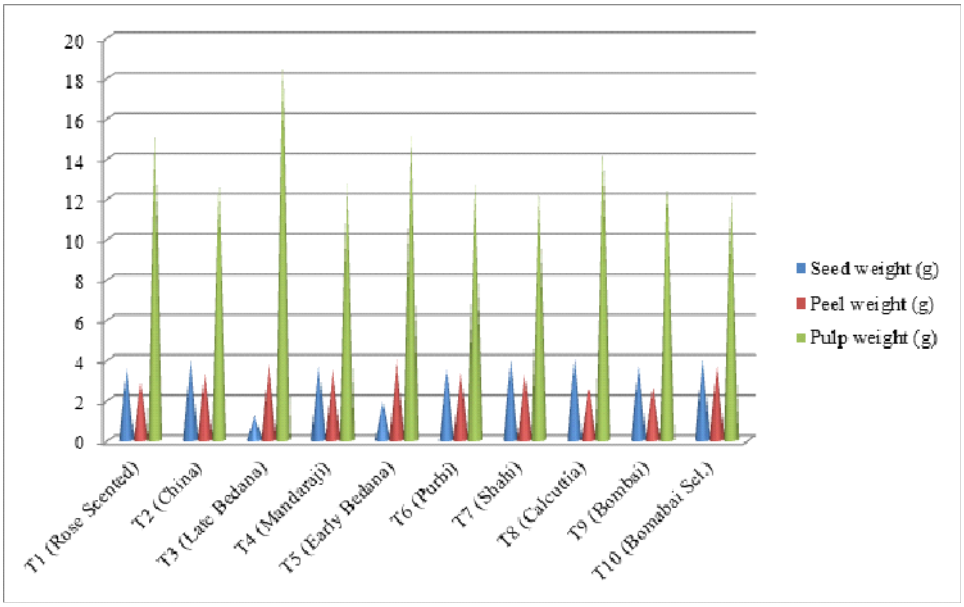

Fig. 02: Fruit characters of different litchi varieties

Higher yield attributing characters like maximum panicle length (32 cm), number of mature fruit panicle^{-1} (15.3) and fruit weight (above 21 g) were recorded in Rose Scented. However, fruit cracking was higher in Rose Scented (20.12 %) while fruit drop was non-significantly affected by various treatments. Significantly maximum average fruit weight (23.60 g) was recorded in Late Bedana followed by Rose scented (21.86 g) and Early Bedana (21.08 g). The highest yield was obtained in Rose Scented (57.82 kg tree^{-1}) followed by Culcuttia (41.21 kg tree^{-1}), China (40.36 kg tree^{-1}), Late Bedana (40.22 kg tree^{-1}) and Early Bedana (36.23 kg tree^{-1}). Minimum number of mature fruit panicle^{-1} (9.8), average fruit weight (19.40 g) and yield (38.80 kg tree^{-1}) were recorded in Bombai. Yadav *et. al.* (2010) also reported a maximum yield of 32.25 kg tree^{-1} in Rose Scented while higher fruit weight in Bedana and Rose Scented were obtained by Singh *et. al.* (2013) and Singh and Mishra (2013).

It is evident from Fig. 2 and Table 1 that different varieties significantly differed in various characters of the fruits. The fruit peel weight was recorded maximum in Early Bedana (3.99 g) followed by Late Bedana (3.81 g) and minimum in Calcuttia (2.57 g). The maximum fruit seed weight was observed in Bombai (4.05 g), Calcuttia (4.03 g), and China (4.0 g) and minimum in Late Bedana (1.23 g) followed by Early Bedana (1.89 g). Fruit pulp weight (18.56 g) and pulp percentage (78.75 %) were recorded maximum in Late Bedana followed by Rose Scented (15.44 g & 70.61%), Early Bedana (15.21 g & 72.14%) and minimum in Bombai Selection (12.22 g & 61.05%). This trend of result was in agreement with the findings of Yadav *et. al.* (2010) and Singh and Mishra (2013). The Shahi variety achieved the maximum level of acidity (0.57%) followed by Mandaraji (0.54%) and minimum in Late Bedana and Bombai Selection (0.48%). The maximum TSS was observed in Late Seed Bedana (22.29%) followed by Rose Scented (21.95%) and Early Bedana (21.48%). Similar Results were obtained by Yadav *et al*. (2010). Based on these evaluations, the cultivars Rose Scented, Calcuttia, Late Bedana and China were deemed the most reliable in bearing and commercially viable.

REFERENCES

AOAC. 1970. Official and Tentative Methods of Analysis, ed. 11. Association of Official agricultural Chemists, Washington, DC USA.

Mishra, D. S., Lal, R.L. and Chand, S. 2014. Delaying the harvesting period in litchi (*Litchi chinensis* Sonn.)cv. Rose Scented. *Prog. Hort.*, **46(2):** 273-275.

Singh, A. and Mishra, D.S. 2013. Studies on physical changes in litchi (*Litchi chinensis* Sonn.) fruits during fruit growth under tarai conditions of Uttarakhand. *Pantnagar. J. Res.*, **11(2):**239-242.

Singh, A., Mishra, D.S., Kumar, R. and Kumar, P. 2013. Physico-chemical changes in litchi cultivar rose Scented during fruit development and maturation. *Indian J. Hort.*, **70(3):** 328-332.

Yadav, S.K., Singh, S.S. and Singh, V.B. 2010. Evaluation of Litchi cultivars under foot hill region of Uttarakhand. *Prog. Hort.*, **42(2):** 232-234.

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Impact of Organic and Inorganic Fertilizers on Flowering, Fruiting and Yield of Cape gooseberry (*Physalis peruviana* L.)

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ABSTRACT

The use of integrated nutrient management techniques for maintenance of soil fertility and optimum nutrient supply without affecting soil health and environment is a sustainable approach. Cape gooseberry is a herbaceous crop grown for its edible fruit. It has great significance for diversification of the fruit market since it is a relatively new fruit which is as yet underutilized. It is usually cultivated as a short cycle (3-4 month) annual crop but in absence of frost it can be grown even as a perennial. Since Cape gooseberry is a potential crop for its medicinal value and as fresh fruit and there is an increasing demand for organic products the present study was carried out during 2013-14 at Horticulture Research Farm, Babasaheb Bhimrao Ambedkar University, Lucknow to study the effect of organic and inorganic fertilizers on the performance of Cape gooseberry. An experiment with twelve treatments replicated thrice was laid out in randomized block design. Biofertilizers used were Azotobacter and PSB (each @ 1.5 kg/ha) and Vermicompost (@ 1kg/plant) (alone and in combination) along with NPK doses. The vegetative performance with respect maximum plant height (78.44 cm), number of leaves (148.33), number of branches (11.33) and stem thickness (7.6 cm), number of buds (31.04), number of flowers (13.22), number of fruit (16.55), fruit weight (10.46 g) and fruit yield (224.07 g), was observed best in biofertilizer treatment T_1 (Azotobacter @ 1.5 kg/ha). Data with respect to average number of fruit size in polar diameter (26.97 mm), fruit size in equatorial diameter (33.73 mm) were recorded better under treatment T_9 (PSB + Vermicompost) over other nutrients i.e. 100% NPK and Vermicompost. The physico-chemical performance with respect to maximum fruit specific gravity (1.10) was recorded T_5 100% NPK and TSS (15.44 °Brix) in T_9 (PSB+ Vermicompost). However, the study has revealed that there was only a marginal difference between the performance of the crop under treatments T_1 and treatment T_9 although this difference was statistically insignificant. The performances of Azotobactor and PSB as biofertiliozers were found to have a very similar effect on the plant performance. Thus, on the basis of results presented it can be concluded that the application of biofertilizer was effective in enhancing the vegetative performance of the plant and the final fruit yield over other treatments.

KEY WORDS: Biofertilizers, Cape gooseberry, Inorganic Fertilizers, Organic Fertilizers.

The Cape gooseberry (*Physalis peruviana* L.) is native to Brazil but long ago became naturalized in the highlands of Peru and Chile and became identified with the region (Legge, 1974). It is a climacteric fruit grown in countries such as Colombia, Peru, Venezuela, Egypt, South Africa, and Australia, among others (Ramadan, 2011). Commonly known as *Rasbhari*, it is a quick- growing herbaceous crop belonging to the family Solanaceae (Sandhu and Gill, 2011). From the nutritional point of view, its importance is not less than any other major fruit crops, as the edible portion of berry contains 11.5% carbohydrates, 1.8% protein, 0.2% fat, 3.2% fibre, 0.6% mineral matter and 49mg ascorbic acid per 100g edible portion of fruit (Khan and Gower, 1955). Integrated nutrient management refers to the maintenance of the soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner (www.wikipidea.org). Water supply with high salinity has detrimental effects on soil fertility and reduces plant growth and productivity. Salinity reduces water availability and nutrient uptake by plants (Al-Karaki 2000).

Inorganic fertilizers are commonly used by most farmers because of relatively quick availability of nutrients to the plant, but their continuous use leads to damage of the ecosystem and soil health. Moreover, indiscriminate

use of high amounts of chemical fertilizers results in deficiency of nutrients other than those applied. Thus, there is a need to lay emphasis on management of natural resources like bio fertilizers, etc. Bio fertilizers are not a substitute, but a supplement, to chemical fertilizers for maximizing yield and also help to maintain a balance of the agro-ecosystem. There are reports of usefulness of these bio fertilizers in other crops of Solanaceae family, such as tomato, but none in Cape gooseberry. With this in view, the present experiment was undertaken to work out an optimum combination of biological and chemical sources of nutrients in Cape gooseberry.

MATERIALS AND METHODS

The present investigation entitled "Impact of Organic and Inorganic Fertilizers on Flowering, Fruiting and Yield of Cape gooseberry (*Physalis peruviana* L.)" was carried out during November 2013 at Horticultural Research Farm, Department of Applied Plant Science (Horticulture) at Babasaheb Bhimrao Ambedkar University Lucknow. The experiment was laid out in Randomized Block Design (RBD). All treatments were replicated four times and treatments were: T_0 – Control (rhizospheric soil), T_1 - *Azotobacter*, T_2 - PSB, T_3 - 100% NPK, T_4 - Vermicompost, T_5 - *Azotobacter* + PSB, T_6 - *Azotobacter* + 100% NPK, T_7 - *Azotobacter* + Vermicompost, T_8 - PSB + 100% NPK, T_9 - PSB + Vermicompost, T_{10} - 100% NPK+ Vermicompost and T_{11} - *Azotobacter* + PSB + 100% NPK +Vermicompost.

Biofertilizers (*Azotobacte*r and PSB), well known for their broad spectrum utility in various crops, were used in the experiment. These were applied as seedling treatment @ 1.5 kg/ha (Sandhu and Gill, 2011) and mixed proportionately in combined applications with standard dose of NPK (10, 10 and 5g/plant) and Vermicompost (1kg/plant). Source of fertilizer applied were urea (available N- 46%) for nitrogen, single super phosphate (P 16%) for phosphorus, and muriate of potash (K 60%) for potassium. All of the phosphorus and potassium was applied during final preparation of the soil before making the beds, while, half of the nitrogen was applied 30 days after transplanting and the rest was applied after 25 days. Data was recorded for vegetative parameters which included plant height (recorded with help of the meter scale), number of leaves, number of branches, stem diameter, number of buds, number of flowers, number of fruits(recorded manually), polar diameter of fruits, equatorial diameter of fruits (measured with help of Vernier calipers, Mitutoyo, Japan) and yield parameters of Cape gooseberry. Observations were recorded for bud initiation, flowering, fruiting and quality of fruits and the data were subjected to suitable statistical analysis.

Data was recorded for biochemical parameters which included specific gravity of fruit (Gauri Shankar, 1984) and total soluble solids recorded with the help of Hand Refractometer Erma, Japan) in ^{o}Brix.

RESULT AND DISCUSSION

During the experimental work the observation were recorded at monthly interval 45, 75, 105 days after transplant (DAT) and are presented in tabulated form in different tables. The maximum plant height (78.44 cm), number of leaves (148.33), number of branches (11.33) and

Table 1: Effect of different organic and inorganic fertilizers on vegetative growth of Cape gooseberry (*Physalis peruviana* L.)

Treatments	Plant height (cm)			Number of leaves			Number of branches			Stem diameter (cm)		
	45 DAT	75 DAT	105 DAT	45 DAT	75 DAT	105 DAT	45 DAT	75 DAT	105 DAT	45 DAT	75 DAT	105 DAT
T_0 Control (rhizospheric soil)	9.44	18.55	63.12	5.66	18.66	93.77	1.78	4.66	8.88	2.05	3.90	6.1
T_1 *Azotobacter*	21.55	35.55	78.44	12.66	46.33	148.33	3.78	8.89	11.33	3.09	5.8	7.6
T_2 PSB	17.33	34.55	72.44	10.77	40.22	145.22	2.66	8.00	11.00	2.06	4.6	6.8
T_3 100% NPK	17.88	33.55	72.78	10.22	44.11	142.78	3.33	9.00	10.88	3.00	4.7	6.9
T_4 Vermicompost	20.22	31.66	72.33	10.55	35.77	139.88	2.66	8.44	10.66	2.08	4.8	6.7
T_5 *Azotobacter* + PSB	20.22	34.68	73.00	10.69	45.11	143.98	3.50	10.78	11.92	3.03	5.30	7.0
T_6 *Azotobacter* + 100% NPK	15.15	29.33	71.89	8.78	41.33	142.22	2.66	9.11	11.12	3.02	5.10	7.1
T_7 *Azotobacter*+Vermicompost	18.90	30.33	72.90	8.90	42.22	142.89	2.77	9.44	11.77	2.99	5.20	6.90
T_8 PSB + 100% NPK	17.55	32.33	72.10	11.55	45.66	135.55	3.66	8.55	10.66	2.08	5.2	6.6
T_9 PSB+Vermicompost	20.55	35.12	73.99	12.44	46.11	147.22	4.22	9.22	11.22	3.04	5.6	7.4
T_{10}100% NPK+ Vermicompost	15.11	30.22	72.10	8.44	43.44	144.10	2.89	9.00	11.11	2.02	4.2	6.8
T_{11} *Azotobacter* + PSB + 100% NPK +Vermicompost	18.22	26.11	66.89	9.66	36.11	126.66	2.58	6.22	11.00	2.06	4.4	6.4
SE(d)	0.816	1.415	2.605	0.927	1.687	7.119	0.320	0.471	0.422	0.428	6.889	0.374
CD at 5%	1.692	2.936	5.405	1.922	3.500	14.767	0.665	0.976	0.877	0.888	N.S.	0.775

stem thickness (7.6 cm) was observed in treatment T_1 (*Azotobacter* 1.5 kg /ha) which was followed by with treatment T_9 (PSB+Vermicompost) although the difference between these treatment was statistically non significant (Table 1). This was followed by treatment T_5 (*Azotobacter* + PSB) plant height (73.00 cm), number of leaves (143.98), number of branches (11.92) and stem thickness (7.0 cm) was observed in treatment T_1 (*Azotobacter* 1.5 kg /ha) and plant height (72.90 cm), number of leaves (142.89), number of branches (11.77) and stem thickness (6.90 cm) was observed in T_7 (*Azotobacter* + Vermicompost) respectively although these two treatments were at par with each other.

It is obvious from the data in Table 1 that plant performance has shown a response to treatment with biofertilizers and vermicompost which is significantly improved over the control. This increase in plant height may be due to the build up of colonies of the biofertilizer innoculates and their growth promoting effects resulting from the enhanced availability of nutrients at vital periods of growth, and improved water status of plants, which results in increased cell metabolism resulting from enhanced enzyme activity, chlorophyll content and photosynthesis process (Kumar *et al.*, 2006). Azotobactor is primary source for increase the N uptake by the plants while PSBs improve uptake of phosphorous. A similar increase in the vegetative parameters viz. Diameter of stem (5.6cm), number of leaves (81.7), leaf length (13.2cm) leaf breadth (11.3 cm) and number of fruit (7.25) etc. have been reported in Cape gooseberry upon application of vermicompost (Dwivedi *et al.*, 2015) similar to the present study where application of vermicompost in combination with PSB has shown a significant performance. This has been also reported for tomato (Harikrishna *et al.*, 2002), marigold (Kumar *et al.*, 2006), *Tectona grandis* (Paroha *et al.*, 2009) etc. Biofertilizer and organic manures had a significant effect on maximum number of buds, number of flower, number of fruits fruit specific gravity, total soluble solids, fruit polar diameter and fruit equatorial diameter in comparison to control (Table 2 and 3). Average maximum number of buds (31.04), number of flower (13.22), fruits (16.55 fruit per plant), fruit weight (10.46g) and fruit yield (224.07) was obtained with treatment T_1 (Azotobacter) followed by (15.88 fruit per plant) T_9 (PSB+Vermicompost). This was followed by number of buds (29.10), number of flower (11.96), fruits (15.80 fruit / plant), fruit weight (10.12g) and fruit yield (208.57g) was obtained with treatment T_5 (*Azotobacter* + PSB) and number of buds (28.22), number of flower (11.29), fruits (115.70 fruit per plant), fruit weight (9.16g) and fruit yield (196.29) was obtained with T_7 (*Azotobacter* + Vermicompost) respectively although these two treatments were at par with each other. Data with respect to average number of fruit size in polar diameter (26.97 mm), fruit size in equatorial diameter (33.73 mm) were recorded better under treatment T_9 (PSB + Vermicompost) over other nutrients i.e. 100% NPK and Vermicompost. The physico-chemical performance with respect to maximum fruit specific gravity (1.10) was recorded T_5 100% NPK and TSS (15.44 °Brix) in T_9 (PSB+ Vermicompost).

The reason for increased number of buds and fruits per plant may be due to solubilisation effect of plant nutrients by the biofertilizers used which results in

Table 2: Effect of different organic and inorganic fertilizers on flowering and fruiting of Cape goose berry (*Physalis peruviana* L.)

Treatments	Number of buds			Number of flower			Number of fruit			Fruit weight (g)	Fruit yield (g)
	45 DAT	75 DAT	105 DAT	45 DAT	75 DAT	105 DAT	45 DAT	75 DAT	105 DAT	Average	Average
T_0 Control (rhizospheric soil)	0.99	2.33	16.10	1.11	3.32	7.33	2.44	5.99	8.99	7.43	105.55
T_1 *Azotobacter*	2.44	5.22	31.04	2.44	6.24	13.22	5.44	12.88	15.88	10.46	224.07
T_2 PSB	1.98	4.88	28.99	1.99	4.99	11.22	4.66	12.66	15.10	8.13	159.25
T_3 100% NPK	1.88	3.66	23.77	1.99	5.55	11.44	5.00	12.10	15.55	7.8	204.80
T_4 Vermicompost	1.55	4.55	22.77	2.10	5.22	10.11	4.88	11.77	15.55	9.1	198.89
T_5 *Azotobacter* + PSB	2.20	4.98	28.10	2.50	6.00	11.96	5.42	12.90	15.80	10.12	208.57
T_6 *Azotobacter* + 100% NPK	1.77	3.33	26.66	1.77	4.55	10.66	4.44	11.11	14.55	8.13	205.55
T_7 *Azotobacter* + Vermicompost	2.00	3.90	28.22	2.05	5.99	11.29	5.22	12.22	15.70	9.16	196.29
T_8 PSB + 100% NPK	1.66	4.00	27.44	2.33	5.55	11.13	5.22	12.10	15.44	9.06	157.40
T_9 PSB+Vermicompost	2.22	4.99	29.44	2.55	6.22	12.77	5.44	13.22	16.55	10.23	209.25
T_{10}100% NPK+ Vermicompost	1.44	3.88	27.33	2.44	5.77	11.66	4.77	11.55	14.99	8.26	195.92
T_{11} *Azotobacter* + PSB + 100% NPK +Vermicompost	1.44	4.10	20.55	1.88	4.66	9.99	3.77	10.88	11.55	7.96	138.88
SE(d)	0.13	0.25	0.97	0.11	0.23	0.44	0.15	0.47	0.50	0.35	22.51
CD at 5%	0.28	0.52	2.03	0.23	0.49	0.91	0.32	0.97	1.05	0.73	46.70

Table 3: Effect of different organic and inorganic fertilizers on fruit specific gravity, total soluble solids °Brix, fruit polar diameter (mm) and fruit equatorial diameter(mm)of Cape goose berry (*Physalis peruviana* L.)

Treatments	Fruit specific gravity	Total soluble solids °Brix	Fruit polar diameter (mm)	Fruit equatorial diameter (mm)
	Average	Average	Average	Average
T_0 Control (rhizospheric soil)	0.93	12.98	20.89	21.40
T_1 *Azotobacter*	1.02	14.55	26.61	29.26
T_2 PSB	1.05	15.00	23.76	23.90
T_3 100% NPK	1.09	14.14	23.52	23.8
T_4 Vermicompost	1.04	14.45	23.9	24.58
T_5 *Azotobacter* + PSB	1.10	15.02	26.98	25.70
T_6 *Azotobacter* + 100% NPK	1.07	14.15	22.84	23.04
T_7 *Azotobacter* +Vermicompost	1.08	14.77	24.67	24.15
T_8 PSB + 100% NPK	1.06	14.00	23.86	24.45
T_9 PSB+Vermicompost	1.04	15.44	26.97	33.73
T_{10}100% NPK+ Vermicompost	1.06	14.63	22.41	23.36
T_{11} *Azotobacter* + PSB + 100% NPK +Vermicompost	1.04	14.83	21.63	22.26
SE(d)	0.12	0.54	0.41	0.59
CD at 5%	N.S.	1.12	0.85	1.24

addition of N, P, K, Ca and Mg during the vegetative as well as reproductive phase of crop. These results are in accordance with findings in tomato (Patil *et al*., 2004; Harikrishna *et al;* 2002) and teak plants (Nicola *et al*; 2002).

The uptake of micronutrients in microbial inoculated plants was also noticed higher due to direct or indirect effects of inoculations which are also described earlier (Kothari *et al,* 1991). Inoculation of biofertilizers with chemical fertilizer increased growth and biomass as compared to individually applied biofertilizer and chemical fertilizer applied plants (Nagwani *et al*., 1998 and Paroha *et al*., 2009) also demonstrated in teak plants.

In the present study it has been observed that the application of biofertilizer was more effective than organic manure and nutrients, in enhancing number of fruit per plant (8.99) and fruit yield (105.55g). Among the organic manures and biofertilizers used the overall vegetative performance and early initiation of bud, flower and fruiting, was observed in T_9 (PSB+vermicompost) and treatment T_1 (Azotobacter) over control. However, since there was no significant difference between results recorded for both treatments hence they could be considered at par with one another.

REFERENCES

1. Al-Karaki, G.N. 2000. Growth and mineral acquisition by mycorrhizal tomato grown under salt stress. Mycorrhiza. 10, 51-54.
2. Dwivedi, Deepa H., Kumar, Pawan and Gautam, Shreesh Kumar 2014. Integrated nutrient management in Cape gooseberry (*Physalis peruviana L.*) for peri urban horticulture. *Indian Journal of applied research* **4(12)**: 26-27.
3. Gautam S. Kumar., Dwivedi Deepa H. and Kumar Pawan 2015. Preliminary studies on the bioactive phytochemicals in extract of Cape gooseberry (*Physalis peruviana* L.) fruits and their Products. *Journal of Pharmacognosy and Phytochemistry* **3(5)**: 93-95.
4. Gosling, P., Hodge, A., Goodlass, G., Bending, G.D. 2006. Arbuscular mycorrhizal fungi and organic farming. Agric. Ecosyst. Environ. **113(1-4)**, 17-35
5. Harikrishna B. L., Channal H. T., Hebsur N. S., Dharmatti P. R. and Sarangamath P. A., 2002. Integrated nutrient management (INM) on availability of nutrients, uptake and yield of tomato. *Karnataka J. Agric. Sci*., **15 (2)**: 275-278.
6. Khan K. F. and Gowder B. R. 1955. The Cape gooseberry a remunerative intercrop for orchards in Nilgiris. *South Indian Hort*., **3(4)**: 104-107
7. Kothari S. K. H. Marschner and Romheld, 1991. Direct and indirect effects of VAM and rhizosphere microorganisms on mineral nutrient acquisition by maize (*Zea mays L.*) in a calcareous soil. *New Phytologist*, 116:637-645.
8. Kumar T. S., Swaminathan V, Kumar S. 2009. Influence of nitrogen, phosphorus and biofertilizers on growth, yield and essential oil constituents in ratoon crop of davana (*Artemisia pallens* Wall.). *Electronic J. Environ. Agric. Food Chemistry*. **8(2)**: 86-95.
9. Nagwani H. C., Ananthapadmanabha H. S., Lakshmi G. V. and Samashekha P. V. 1998. Comparative effect of inorganic fertilizers and VAM fungi on growth of teak plants. My Forest, **34(1)**: 697-700.
10. Nicola A. P. Y. Alex and Igor A. T. 2002. Development genetics and evolution of symbiotic structure in nitrogen-fixing nodules and arbuscular mycorrhiza.. *Journal Teho Biol.* 214:215-232.
11. Paroha S., Chandra K. K. and Yadav R. 2009. Integrated effect of biofertilizers (AM, Azotobacter and PSB) fertilizers on growth and nutrient Acquisition by *Tectona grandis. Journal of Tropical forestry* **25(I &II)** 54-60.
12. Patil M. B., Mohammed R. G. and Ghadge P. M. 2004. Effect of organic and inorganic fertilizers on growth,

yield and quality of tomato. *J of Maharashtra Agril Univ.*, **29(2)**, 124-127.

13. Ramadan, M.F. 2011. *Physalis peruviana*: a rich source of bioactive phytochemicals for functional foods and pharmaceuticals. *Food Rev. Int.* 27, 259-273.

14. Sandhu S. and Gill B. S. 2011. Effect of integrated nutrient management strategies on growth and yield of Cape gooseberry (*Physalis peruviana* L.) *J.Hortl.Sci.Vol.***6(1)**: 29-32.

15. Shanker G. 1984. Determination of specific gravity of fruits and vegetables. Practical manual in horticulture. Balyog Prakashan, Allahabad. P 94

16. Smith, S.E., Read, D.J. 1997. Mycorrhizal symbiosis. 2nd edition. Academic Press, London, 605 p.

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Studies on the effect of integrated nutrient management on soil biological properties and yield in sapota cv. Kalipatti

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ABSTRACT

A field experiment was conducted during 2010-11 to optimize plant nutrients by integrated nutrient management and to find its effect on soil biological properties and fruit yield of sapota cv. Kalipatti. Maximum soil biological properties viz., soil microbial population, soil microbial biomass carbon, dehydrogenase activity, CO_2 evolution and fruit yield were recorded when part of plant nutrient requirement was met through conjoint application of 1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250 g PSB / plant.

KEY WORDS: Biofertilizers, soil biological properties, fruit yield, sapota

Sapota is important fruit crop of economic importance and offer sustainability in integrated farming options of marginal land agriculture systems. Despite this possibility, it failed to make major impact in the production scenario due to variety of factors important among them being the suboptimal nutrient management strategies in production systems. The soil- microbial – plant system, providing it is managed properly, holds great potential for meeting tree nutrient demands ecologically and efficiently. This is because more than 90 per cent of all nutrients pass through the microbial biomass to higher trophic levels (Kennedy, 1995). Through the integrated functions of the soil biological community, nutrients are converted from organic materials into plant available forms. The composition, activity and biomass of soil microbial communities have been shown to be influenced by various means of management practices. Intensive cropping with limited nutrient management options will have agriculture sustainability problems in future (Aseri *et al*., 2008). A better understanding of soil variables as influenced by long term nutrient management could lead to the identification of more precise indicators to monitor soil fertility that would promote sustainability. The principal component analysis of observed variables revealed that soil organic carbon, microbial biomass carbon, dehydrogenase activity and soil microbial population could be possible indicators for predicting soil fertility resulting from long term nutrient management experiments (Chinnadurai *et al*., 2014). Results of long term fertilizer experimentation in Indian conditions clearly indicated that use of inorganic fertilizers along with organic manures sustained physico-chemical properties of soil (Nambiar and Ghosh, 1984). Biofertilizers are gaining importance in sustainable agriculture. Various complementing combinations of microbial inoculants for management of major nutrients such as nitrogen and phosphorus are necessary for sustainability. Further, the use of biofertilizers along with organic sources of nutrients helps to conserve soil health by maintaining the equilibrium of organic matter and soil microflora ultimately helping to improve physical, chemical and biological properties of soil (Walia and Kler, 2009). Keeping in view the importance of judicious integration of mineral fertilizers, organic manures and biofertilizers to improve and maintain the most important natural resource base components of soil, the present study was initiated in 2010 -11 to optimize plant nutrient for sapota by integrated nutrient management and to find out its effect on soil biological properties and fruit yield of sapota cv. Kalipatti.

MATERIALS AND METHODS

The field experiment was conducted on sapota cv. Kalipatti during year 2010-11 at the Main Garden, Department of Horticulture, Dr.P.D.K.V. Akola (M.S.). The plantation was raised on medium black soil having pH 7.9, EC 0.39 mmhos/cm and available organic carbon 0.71%. The experiment was laid out consisting two levels of NPK fertilizers (75 and 100% of recommended dose), biofertilizers (*Azotobacter*, *Azospirillium* and PSB), vermicompost and FYM in different conjoint combinations. The treatments were replicated thrice, where

Table 1: Effect of integrated nutrient management on soil biological properties and fruit yield

Treatment	Soil Microbial Count			Dehydrogenase Activity (µgTPFg^{-1}24^{-1}hr	Soil Microbial Biomass Carbon (µg/g soil)	CO_2 Evolution (µg/100g soil)	Fruit Yield (kg/plant)
	Fungi (cfu g^{-1} soil)	Bacteria (cfu g^{-1} soil)	Actinomycetes (cfu g^{-1} soil)				
T_1	5.43	9.30	3.27	13.70	142.03	35.30	103.40
T_2	7.62	10.34	4.00	15.65	149.97	39.90	98.08
T_3	8.37	11.15	2.83	16.06	171.98	51.70	135.57
T_4	8.50	11.28	3.67	20.03	174.72	54.10	175.53
T_5	8.53	12.48	4.33	20.17	180.66	69.73	185.20
T_6	5.64	9.68	2.87	14.61	161.25	46.56	110.30
T_7	7.43	10.67	3.37	17.38	175.29	48.86	113.93
T_8	7.84	12.13	3.07	18.07	168.46	52.80	106.17
T_9	8.63	13.30	5.33	20.58	182.50	70.50	197.53
T_{10}	8.07	12.17	3.00	16.62	154.50	51.70	100.71
T_{11}	4.63	8.30	1.33	9.61	120.30	31.00	73.99
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m)±	0.11	0.29	0.47	1.41	1.08	0.39	4.43
CD at 5%	0.34	0.87	1.47	4.18	3.21	1.16	13.09

Treatment details: **T_1** (1500:1000:500 g NPK + 50 kg FYM / plant), **T_2** (1125:750:375 g NPK + 50 kg FYM + 250 g *Azotobacter*/ plant), **T_3** (1125:750:375 g NPK + 50 kg FYM + 250 g *Azospirillium*/ plant), **T_4** (1125:750:375 g NPK + 50 kg FYM + 250 g *Azotobacter* + 250g PSB / plant), **T_5** (1125:750:375 g NPK + 50 kg FYM + 250 g *Azospirillium* + 250g PSB / plant), **T_6** (1500:1000:500 g NPK + 15 kg vermicompost / plant), **T_7** (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter*/ plant), **T_8** (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azospirillium*/ plant), **T_9** (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250g PSB / plant), **T_{10}** (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azospirillium* + 250 g PSB / plant) and **T_{11}**(Control).

the significant differences were analyzed statistically in randomized block design as suggested by Panse and Sukhatme (1978). Different inputs of bio-organic and inorganic nutrient sources were applied in different conjoint combinations (T_1 to T_{10}) along with a control (T_{11}). The treatments comprised following combinations T_1 (1500:1000:500 g NPK + 50 kg FYM / plant), T_2 (1125:750:375 g NPK + 50 kg FYM + 250 *Azotobacter*/ plant), T_3 (1125:750:375 g NPK + 50 kg FYM + 250 g *Azospirillium*/ plant), T_4 (1125:750:375 g NPK + 50 kg FYM + 250 g *Azotobacter* + 250 g PSB/ plant), T_5 (1125:750:375 g NPK + 50 kg FYM + 250 g *Azospirillium* + 250 g PSB/ plant), T_6 (1500:1000:500 g NPK + 15 kg vermicompost/ plant), T_7 (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter*/ plant), T_8 (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azospirillium*/ plant) and T_9 (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/ plant) , T_{10} (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azospirillum* + 250g PSB/ plant) and T_{11} (Control).

NPK fertilizers sources were urea, single super phosphate and muriate of potash. Nitrogen was applied in two split doses. Biofertilizers consortia comprised of *Azotobacter*, *Azospirillium* and PSB were applied by mixing in FYM and vermicompost one week after application of inorganic fertilizers. The isolation of pure and viable count of soil microbial population was done by serial dilution technique on Nutrient Agar (bacteria), Martins Rose Bengal medium (fungi) and Kenknight and Munaires medium (actinomycetes). 10 g of soil from each sample was drawn and serially diluted aseptically to 10^{-4} for fungi, 10^{-8} for actinomycetes and 10^{-5} to 10^{-6} for bacteria. 1 ml of each sample dilution was spread on specified medium. After incubation period the plates were examined for the number of colonies developed. Number of colonies multiplied by the respective dilution factor gives the number of viable cells per gram of soil. Soil microbial biomass carbon (mg/ g soil) was estimated using chloroform fumigation method as described by Jenkinson and Powlson (1976). The dehydrogenase activity was examined by TTC method described by Klein *et al*. (1971) and CO_2 evolution of soil was determined by alkali trap method described by Anderson (1982).

RESULTS AND DISCUSSION

The results revealed that, conjoint application of mineral fertilizers, organic manures and biofertilizers influences soil microbial count greatly as compared to control (Table 1). Highest soil fungi count (8.63 cfu g^{-1} soil), soil bacteria count (13.30 cfu g^{-1} soil) and actinomycetes

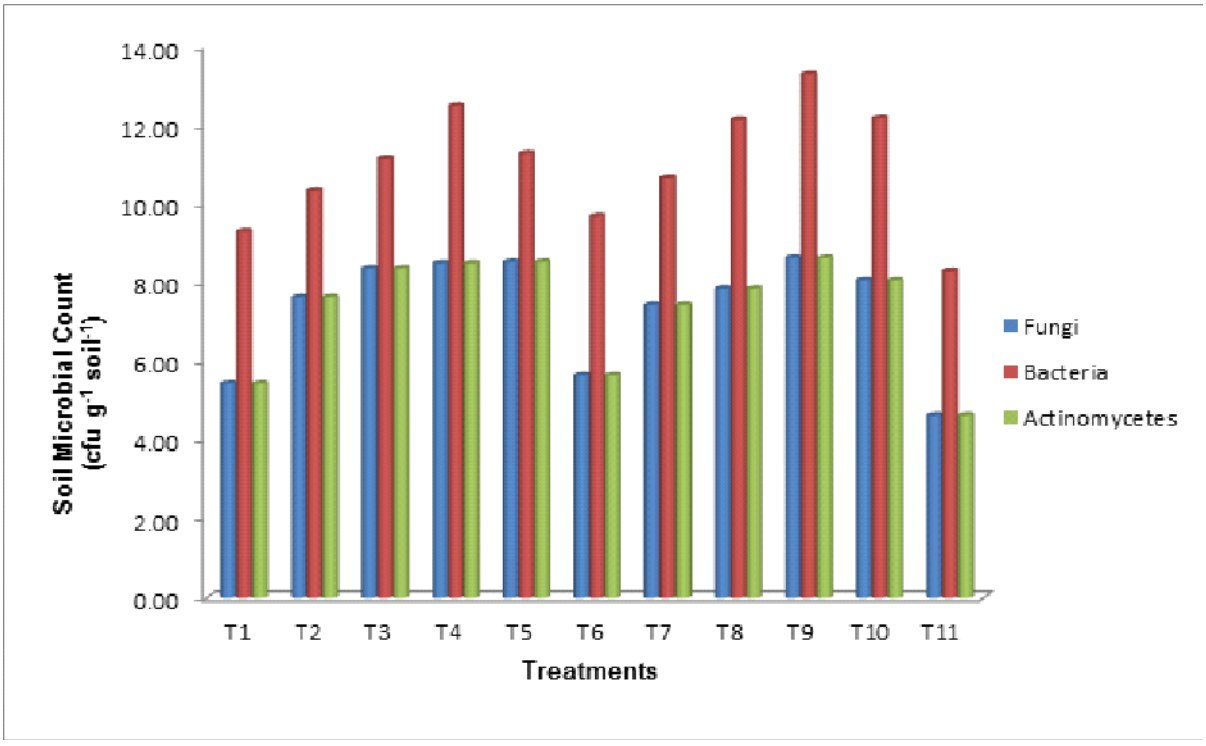
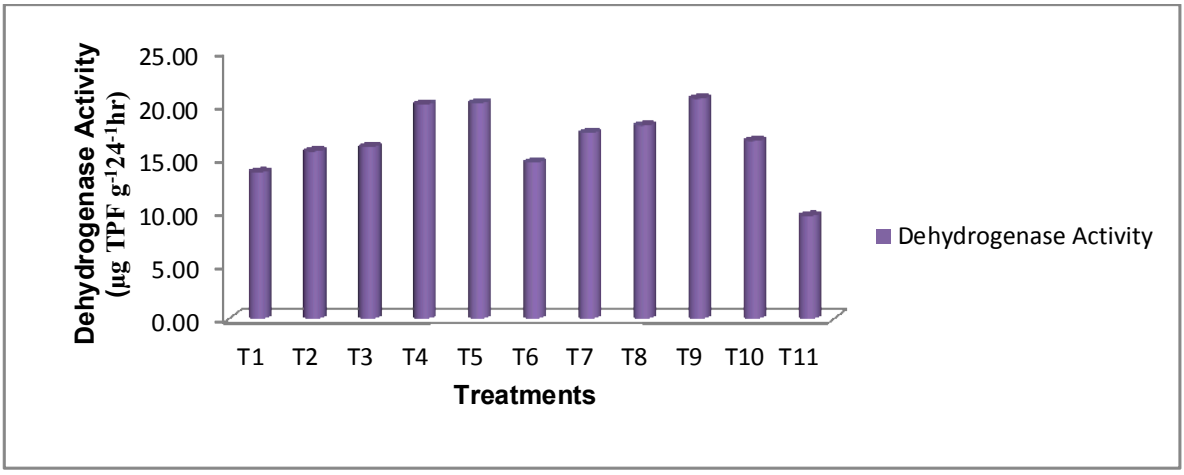


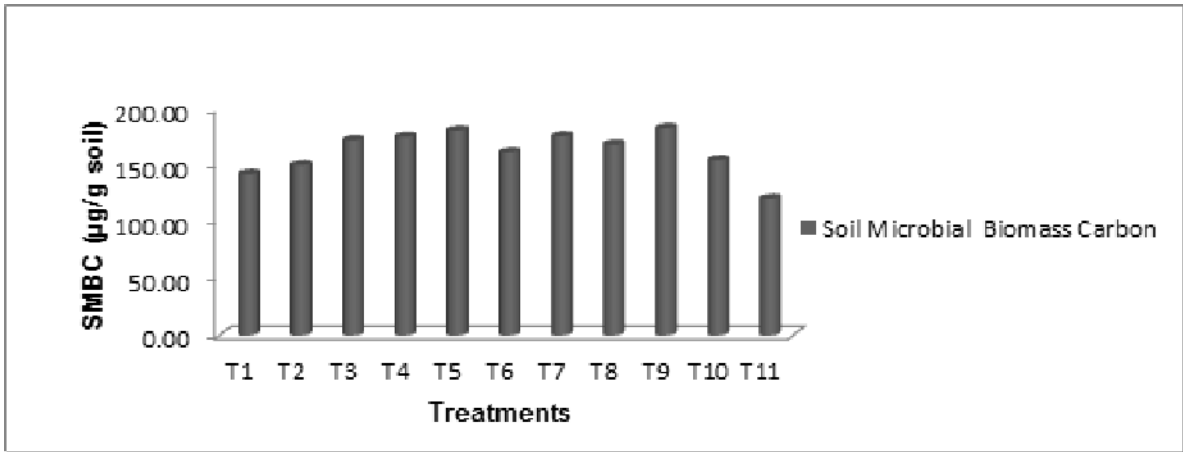
Fig. 1 Effect of Integrated Nutrient Management on Soil Microbial Count

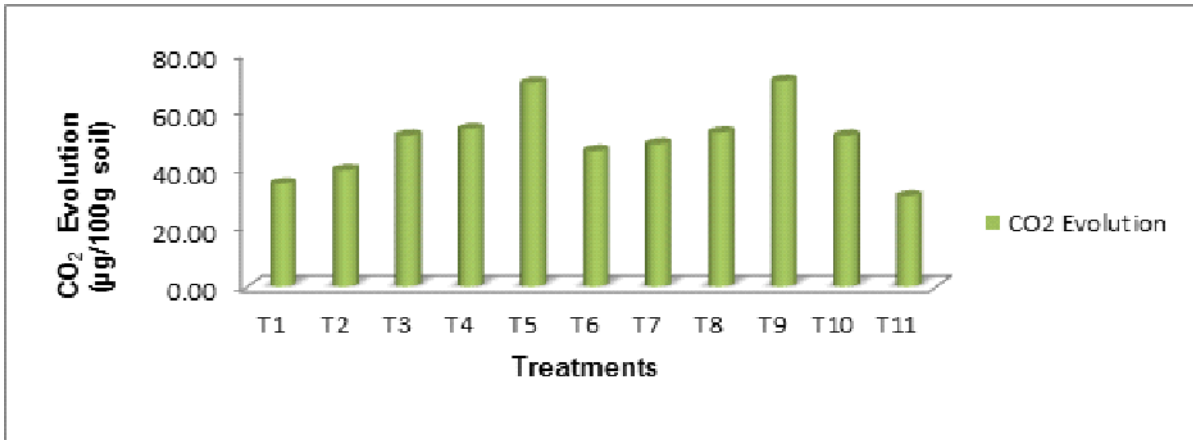
count (5.33 cfu g^{-1} soil) was recorded in treatment T_9 (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/plant) which was found at par with treatment T_5. The minimum soil microbial count was recorded in control (T_{11}). The increased microbial population might be due to application of different types of organic manures in turn provides adequate biomass as a feed for the microbes and helps in increasing microbial population in soil. Further the increased microflora in soil might be due to the addition of Azotobacter along with PSB mainly ascribed to the synergistic response of these microbes with host and the production of phytohormones or growth regulators by these microbes. These findings are in accordance with Srivastava *et al*. (2008) in citurs and Dutta *et al*. (2010) in litchi.

Soil biological properties *viz.*, dehydrogenase activity, soil microbial biomass carbon and CO_2 evolution were significantly influenced by the conjoint application of mineral fertilizers, organic manures and biofertilizers as compared to control (Table 1). Maximum dehydrogenase activity (20.58 g TPF g^{-1} $24hr^{-1}$), maximum soil microbial biomass carbon (182.50 mg/g soil) and maximum CO_2 evolution (70.50 mg/100g soil) was recorded in treatment T_9 (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/plant) which was found at par with T_5 while, minimum dehydrogenase activity (9.61 mg TPF g^{-1} $24hr^{-1}$), minimum soil microbial biomass carbon (120.30 g/g soil) and minimum CO_2 evolution (31.00 mg/100g soil) was recorded in treatment T_{11} (Control). The increases observed in dehydrogenase activity, soil microbial biomass carbon and CO_2 evolution may be related mainly due to increase in rhizosphere microbial population as a consequence of addition of organic manures and biofertilizers. The organic manures serve as an excellent food for microorganisms hence helps in augmentation of their activities such as organic matter decomposition, biological nitrogen fixation and phosphate solubilization. The measurement of these enzymatic activities can provide an early indication of changes in soil fertility since they are related to mineralization of such important nutrients as Nitrogen, Phosphorus and Carbon. The results of present findings are in conformity with findings of Aseri *et al*. (2008) in pomegranate and Patel *et al*. (2009) in sweet orange.

The overall multifaceted effects of conjoint application of mineral fertilizers, organic manures and biofertilizers that facilitated beneficial soil conditions in the present study also reflected the significant increase in the fruit yield of sapota (Table 1). Among different treatments maximum fruit yield (197.53 kg $plant^{-1}$) was recorded in







treatment T_9 (1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/plant) which was at par with T_5 whereas, minimum fruit yield (73.99 kg plant^{-1}) was harvested under treatment T_{11} (Control). The conjoint application of mineral fertilizers, organic manure and biofertilizers had a positive influence on the soil microbial plant system which holds a great potential for meeting tree nutrient demands. Through the integrated functions of the soil biological community, nutrients are converted from organic materials to plant available forms thus increasing levels of nutrients in assimilating area of crop due to which the rate of dry matter production was enhanced. Similarly due to rational partitioning of dry matter to economic sink, the yield attributes were

improved. The results are in accordance with the findings of Dalal *et al*. (2004) in sapota and Hebbara *et al*. (2006) in sapota.

REFERENCES

Anderson, J.P.E, 1982. Soil respiration. In A.L. Page, R.H. Miller and D.R. Keeny (ed.) Methods of soil analysis, Part 2. Chemical and microbiological properties, Agronomy monograph no. 9, ASA-SSSA Publisher, Madison, Wisconsin, USA, pp. 831-871.

Aseri, G.K., Jain, N., Pawar, J., Rao. A.V. and Meghwal, P.R. 2008. Biofertilizers improve plant growth, fruit yield, nutrition, metabolism and rhizosphere enzyme activities of pomegranate (*Punica granatum* L.) in Indian Thar Desert. Scientia Horticulturae, **117**: 130-135.

Chinnadurai, C., Gopalswamy, G. and Balachandar, D. 2014. Impact of long-term organic and inorganic nutrient managements on the biological properties and eubacterial community diversity of the Indian semi-arid Alfisol. Archives of Agronomy and Soil Science, **60(4):** 531-548.

Dalal, S.R., Gonge, V.S., Jogdande, N.D. and Moharia, A. 2004. Response of different levels of nutrients and PSB on fruit yield and economics of sapota. PKV Res.J. **28**: 126-128.

Dutta, P., Kundu, S. and Biswas, S. 2010. Integrated nutrient management in litchi cv Bombai in new alluvial zone of West Bengal. Indian J. Hort. **67(2):** 181-184.

Manjunatha, H., Ganiger, V.M., Reddy B.G.M. and Joshi, V.R. 2006. Integrated nutrient management in sapota using vermicompost to increase yield and quality. Indian J. of Agric.Sci. **76(10):** 587-590.

Jenkinson, D.S. and Powlson, D.S. 1976. The effect of biological treatments on metabolism in soil. V.A. method for measuring soil biomass. Soil Biol. Biochemistry. **8:** 209-213.

Kennedy, A.C. 1995. Soil microbial diversity in agricultural systems. pp. 249. In: Olson, R., Francis, F. and Kaffka, S. (eds) Exploring the role of diversity in sustainable agriculture. American Society of Agronomy, Madison, WI.

Klein, D.A., Loh, T.C. and Goulding, R.L. 1971. A rapid procedure to evaluate dehydrogenase activity of soils low in organic matter. Soil Biol. Biochemistry. **3:** 385-387.

Nambiar, K.K.M and Ghosh, A.B. 1984. Highlights of research of long term fertilizers experiments in India. LTFE, Research Bulletin No. 1, New Delhi, IARI, pp.97

Panse, V.G. and Sukhatme, P.V. 1978. Statistical Methods for Agricultural Workers, ICAR, New Delhi.

Patel, V.B., Singh, S.K., Asrey R., Lata N., Singh, A.K. and Singh, L. 2009. Microbial and inorganic fertilizers application influenced vegetative growth, yield, leaf nutrient status and soil microbial biomass in sweet orange cv. Mosambi. Indian J. Hort. **66(2):** 163-168.

Srivastava, A.K., Huchche, A.D., Das, A.K. and Kumar, D. 2008. INM method sustained productivity of citrus. NRCC Annual Report pp. 36-42.

Walia, S.S. and Kler, D.S. 2009. Organic versus chemical farming- A review. J. Res. Punjab Agric. Univ., **46(3&4):** 114-26.

Progressive Horticulture, Vol. 47, No. 3, Dec. 2015 : Proceedings of 1st Int. Symp. on Innovations in Horticulture for Nutritional Security, Conserving Biodiversity and Poverty Alleviation

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An expert system for mango (*Mangifera indica* L.) disease diagnosis and management

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ABSTRACT

This paper describes the development of a rule-based expert system for the diagnosis of diseases of Indian mango and to suggest the appropriate management. It follows an object oriented approach of presenting rules in the knowledgebase of expert system in the form of Object-Attribute-Value that allows developing knowledge base without using expert system shell software. Initially this system is developed for five major diseases (powdery mildew, anthracnose, bacterial canker, phoma blight and red rust), which may further be extended to different diseases of mango. This expert system is devised to show typical symptoms of the disease, weather parameters critical for rapid development of the diseases and suitable integrated disease management measures. After diagnosis, it also advises the management options of the different diseases. Expert system also include weather based forewarning of powdery mildew disease, which takes into account three weather parameters i.e., maximum and minimum temperatures, relative humidity and wind speed to find out whether weather is conducive for development of powdery mildew or not? If weather parameters are favourable, then the system advises its management options. It is good enough for providing appropriate advice for early diagnosis and integrated management of diseases for enhancing mango productivity. It would be helpful in early and accurate identification of diseases and their management by the application of biological, cultural, physical and chemical management methods. The system would serve as an effective knowledge dissemination tool and would empower orchardist for effective decision making for the timely management of the different mango diseases.

KEY WORDS: Expert system; Mango; knowledgebase; disease diagnosis; management of disease.

India ranks first among mango producing countries accounting for about 50 per cent of the world's mango production. The crop is affected by large number of diseases at all stages of its growth (Ploetz and Prakash, 1997). On an average, the crop suffers 10-15 per cent yield loss due to different diseases. One way to increase mango production and improve its quality is to reduce losses caused by these diseases. Identification of problems related to mango health and the implementation of control measures is therefore important. If diseases are not identified correctly or control measures are not adopted at right time, the loss may reach up to 90 per cent (Schoeman *et al.*, 1995). Keeping in view the limitations of mango growers in diagnosis of the different diseases and timely decision for the management of the different diseases, an expert system for diagnosis and integrated management of major diseases of mango has been developed at CISH, Lucknow.

The expert system is a computer program that uses artificial intelligence to solve problems within a specialized domain that ordinarily requires human expertise. It uses non-numerical domain-specific knowledge to solve problems with a competence comparable with that of human experts. The Expert System also called the Knowledge Based System is a tool for information generation from knowledge. Expert systems combine the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops.

There are many benefits of an expert system over human expertise. The knowledge contained in expert system is permanent, transferable, consistent and affordable while knowledge of human expert is perishable, difficult to transfer, unpredictable and expensive, respectively.

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In an organization the source of competitive advantage lies not in the knowledge but application of knowledge. The knowledge application system such as expert system, facilitates the transfer of knowledge between various communities of practice (Man Singh *et al.*, 2007)

This paper describes the development of a rule-based expert system for the diagnosis of diseases of mango and to suggest the appropriate treatments/management./ control guide-lines. The system can be used as a diagnostic tool by orchardists and for educational and extension purposes in mango pathology. It provides a diagnosis based on the description of the external appearance or behaviour of the affected tree. Corresponding pictures accompany the most important symptoms and certain measures to be taken are proposed (Mahaman, *et. al.*, 2002.). The system provides support to improve the decision-making ability of orchardists, extension workers, researchers, managers, trainers, etc.

MATERIALS AND METHODS

An object oriented approach was used for presenting rules in knowledgebase of expert system in form of Object-Attribute-Value (O-A-V) that allows developing knowledge base without the need of costly expert system shell software (Yialouris and Sideridis, 1996.). The following standard steps were followed for development of expert system software:

i) Knowledge acquisition*:* It involves acquiring heuristic and factual knowledge pertaining to particular domain from different sources.The reliability of diagnostic expert system depends on the quantity and quality of knowledge that it handles, i.e. the number of diseases it can diagnose and the appropriate representation of the domain expert knowledge. This can be achieved by the knowledge engineer with a knowledge acquisition procedure. Knowledge acquisition is the most critical and problematic phase in the expert system development (Yialouris and Sideridis, 1996). Knowledge acquisition though critical, has always been the bottle neck in developing expert system (Gaines, 1987).

Although an expert system aims to act as human reasoning process giving the same advice and making the same decisions as a human expert (Huirne and Dijkhuizen, 1992), there is a fear that the computer is going to replace the expert (Kahney, 1989; Nitsch, 1991). During the knowledge acquisition procedure, particular attention was paid to the accuracy of description of the symptoms and related problems associated with the main mango diseases.

ii) Knowledge representation (KR): A knowledge base (KB) contains the domain knowledge required for solving a specific problem. The knowledge base is represented in the form of rule base in our system (Harmon and King, 1985). The symptoms of different crop diseases are represented as object–attribute–value (O–A–V) as given in Tables. 1-2 (Yialouris and Sideridis, 1996). The KB is internally represented in tabular form as a relational database using MS® Access 2007 *. Each condition of a rule can be a simple sentence which is true or false, or an O-A-V triplet.

The knowledge base contains expert's knowledge in the given domain. The knowledge is represented in the linguistic form of IF-THEN rules (Table.3). Although different KR methodologies exist such as rules, frames, semantics nets, etc. but rule-based knowledge representation is the most commonly used methodology for developing agricultural expert systems.

However, for developing a robust expert system comprised with IF-THEN rule based logical models was used as the conventional expert system development technique was not sufficient.

One of the most important design considerations behind this expert system was to provide the best user-friendliness. So we tried to keep graphical user interface simplest. The startup screen of expert system is presented

Table 1: Approaches: Rule-based table of relations between symptoms and diseases

Mango diseases	Powdery mildew	
Spot	Appears on	Lower surface of leaf
	Has colour	White
	Has shape	irregular
	Symptom	White powdery growth

Table 2: Object-Attribute-Value form of knowledge representation

Disease Name	**CANKER**
The canker has colour	brown to black
The canker has shape	irregular
The canker is type of	Necrotic
Appearson	Leaves
Disease Name	Anthracnose
Appears on	Leaves (younger)
The Disease has colour	brown to black
The Disease has shape	regular (circular)
The Disease is type of	non-Necrotic

in Fig.1. The knowledge base consists of simple IF-THEN rules in form of forward chaining i.e. effect-to-cause (Table. 3).

The Mango Expert System was implemented from production rules (i.e., IF <effects >

THEN< causes >; LAI Jun-chen, *et. al.*, 2010; Fig. 3).e.g.

IF spot has 'colour white' THEN

Disease is 'Powdery Mildew'

Table 3: An example of knowledgebase rule to diagnose powdery mildew disease

Rule 1.
IF spot appears on 'lower surface of leaves'
AND spot has 'colour white'
AND spot has shape 'irregular'
AND spot has 'white powdery growth'
THEN disease is "Powdery mildew"

iii) User Interface: The interaction between the system and the user was kept as simple as possible. The Expert System provides the user, at the beginning of the consultation mode, the options to confirm or reject some of the very common symptoms. First of all, the user finds out the infected part.

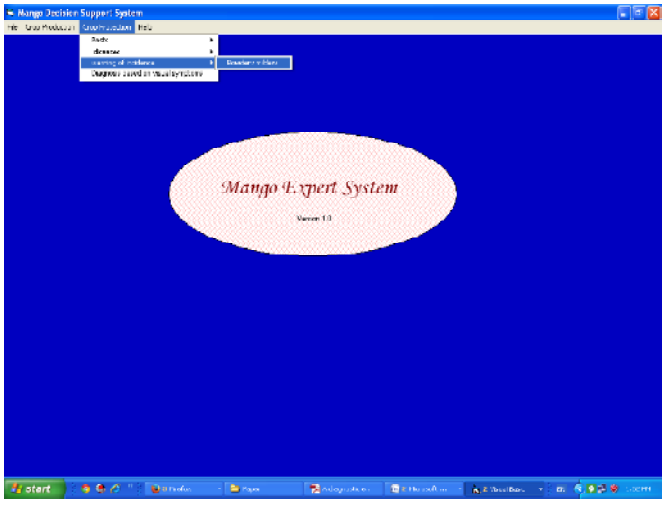

Fig 1. The startup page of expert system for mango

of the plant and the type of infection (**Fig.**2), If the type of infection has a very common symptom, such as a spot, the system prompts the user to determine the special characteristics of the spot (**Fig**.3) e.g. the colour and shape of spot. After supplying the system with this initial information, the system applies the data to the knowledge base and, asking for supplemental data from the user, tries to make a diagnosis. If the system diagnoses one or more diseases, it then provides option to display the management/control/treatment guide-lines (**Fig.**5).

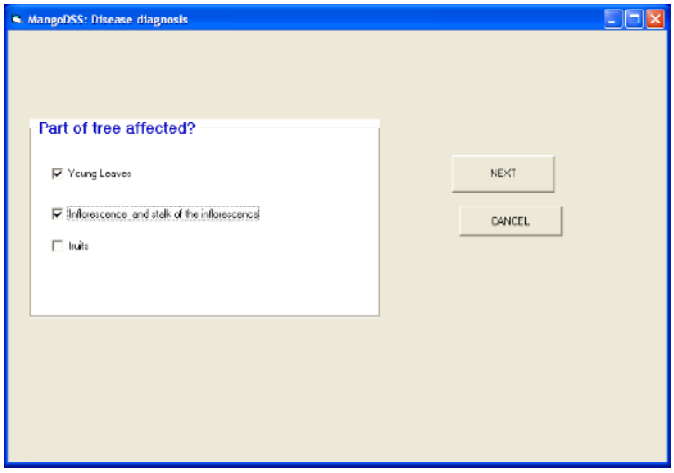

Fig 2. The screen depicting optionsforPowdery mildew diagnosis

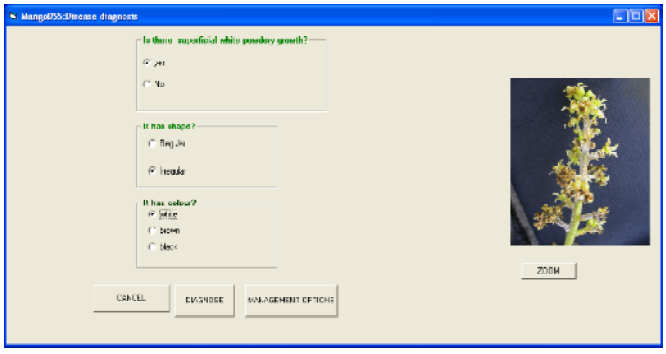

Fig 3. The screen for selecting options for diagnosis of Powdery mildew

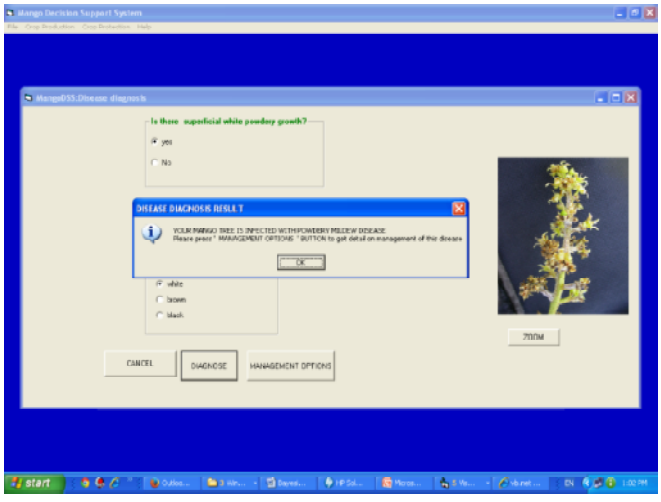

Fig 4. The screen showing diagnosed disease

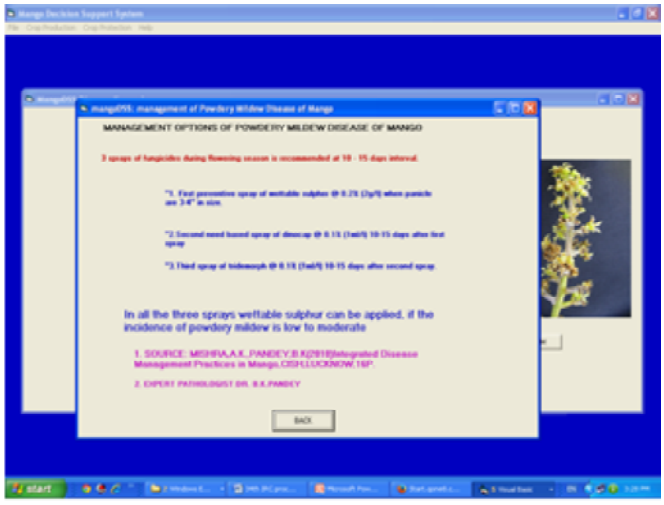

Fig 5. The screen showing management options for powdery mildew.

The expert system also has a module for diagnosis of Anthracnose disease of mango. A user can start diagnosis by initiating a question and answer session (**Fig**.6). First system asks about the part of the tree affected and provides multiple options to the user for selection of best suiting option. Once user selects the correct option, the system proceeds with more specific options/questions e.g. spots shape and colour. It also has multiple images of diseased part of tree to ensure more accuracy of diagnosis (**Fig**.7). It also makes diagnosis easier. Once diagnosis was completed, the system generates disease control/ management guide-lines (**Fig**.9).

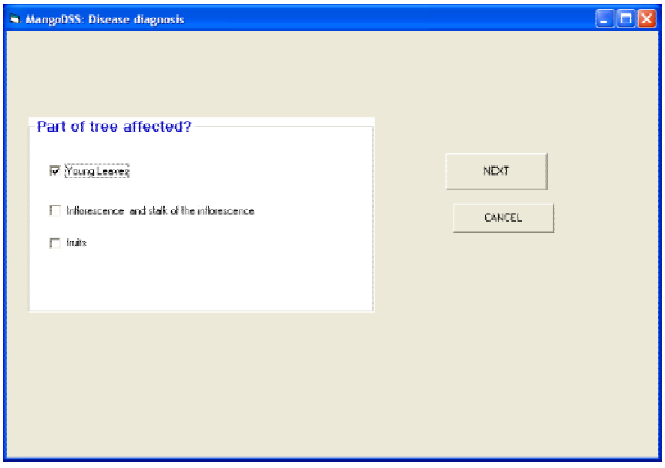

Fig 6. The startup screen for diagnosis of Anthracnose

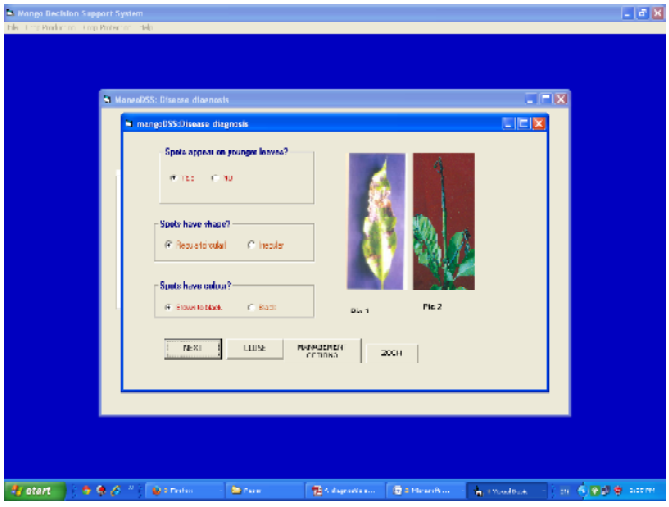

Fig 7. The screen showing the diagnosis options for Anthracnose

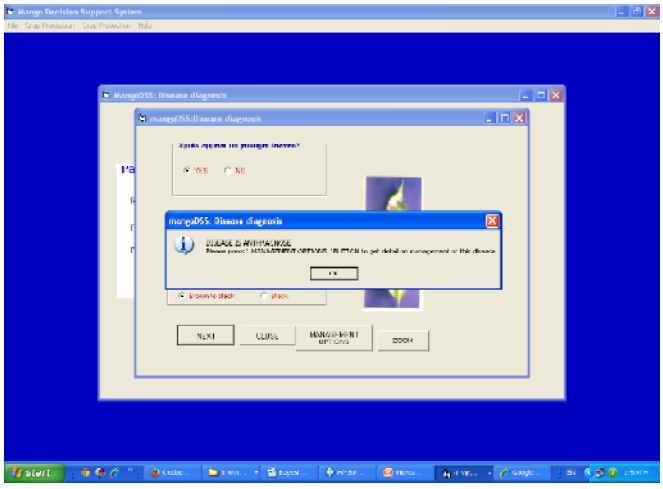

Fig 8. The screen with diagnosed disease i.e. anthracnose

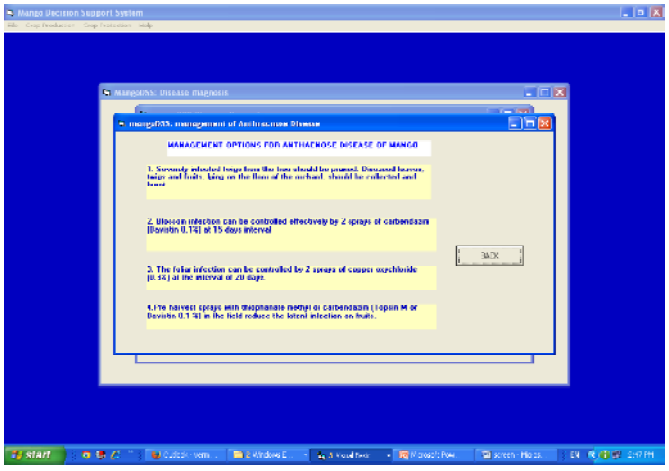

Fig 9. The screen showing guide-lines for treatment of diagnosed disease

Weather based forewarning expert system for mango diseases

Powdery mildew, caused by fungus *Oidium mangifeae,* is an important and serious disease of mango. In cases of severe infection of the disease more than 50 per cent crop loss may occur (Misra *et al*., 2010).The disease affects the inflorescence, stalk of the inflorescence resulting into heavy loss.

The disease spreads fast when the maximum temperature reaches around 35^{0}C, minimum temperature between 15 -17 °C, relative humidity between 50 – 60 per cent and wind speed is 2 -5 kmph. These conditions usually prevail in the northern parts of the country around middle of March.

Based on above findings, an expert system module was developed for weather based forewarning of powdery mildew disease, which takes into account three weather parameters *viz*., maximum and minimum temperatures, relative humidity and wind speed to find out whether weather is conducive for development of powdery mildew or not? If weather parameters are favorable for the development of powdery mildew disease, then the system generates the forewarning and advises its management options for the same (**Figs**. 10, 11 and 5).

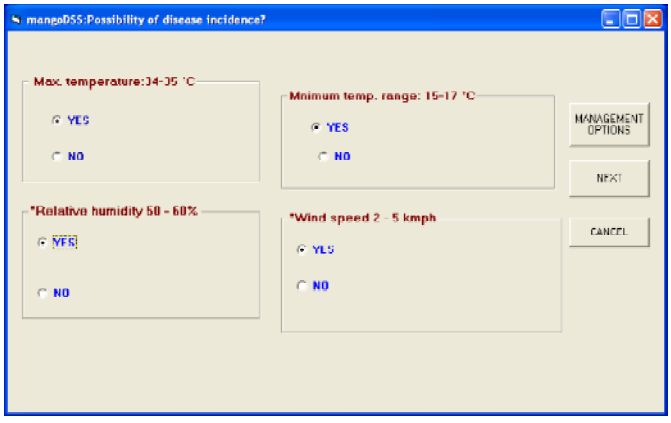

Fig.10 Expert system module for weather based forewarning of powdery mildew disease.

RESULTS AND DISCUSSION

In this paper, an object oriented approach of presenting rules in knowledgebase of expert system in form of Object- Attribute-Value have been utilized that allows developing knowledge base along with expert system directly without expert system shell software. The expert system for diagnosis of five major mango diseases *viz*., Powdery mildew, Anthracnose, Bacterial canker, Phoma blight and Red rust have been developed. After diagnosis, the expert system advises the management options for diagnosed diseases (**Figs**. 5&9).

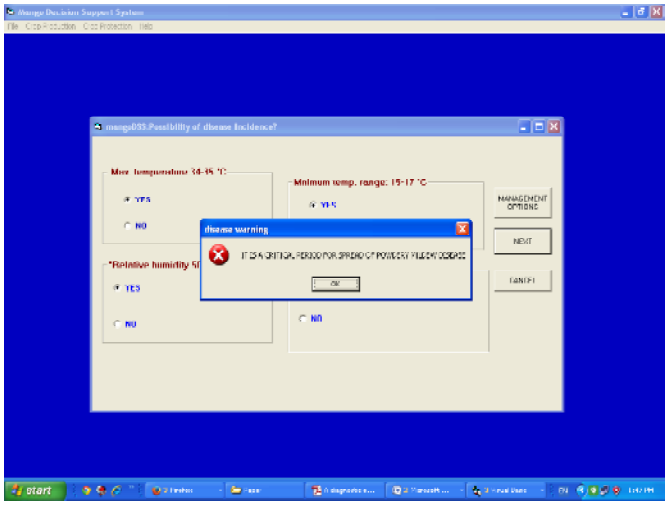

Fig. 11 A screen showing diagnosed powdery mildew disease.

A model based expert system for weather based forewarning of powdery mildew disease was developed that takes into account three weather parameters viz., maximum and minimum temperature, relative humidity and wind speed to find out whether weather is conducive for development of powdery mildew or not? If yes, then system advises its management/ control options (**Figs**.10, 11&5).

The method of expert system development using object oriented approach of presenting rules in knowledgebase in form of Object- Attribute-Value allows development of expert system directly using a programming language as front-end and a database management system as back-end, without the use of costly expert system shell software, is presented. The expert system was developed to diagnose the Powdery mildew, Anthracnose, Bacterial canker, Phoma blight and Red rust diseases of mango. After diagnosis, it advises suitable management options of these diseases. This software is being expanded to cover all pests' diseases and disorders of mango. The system will serve as effective knowledge dissemination tool and will empower orchardist for effective decision making in mango production. The expert system was evaluated following the conventional expert system evaluation methodologies.The overall system evaluation research study included verification and validation processes (Harrison, 1991).The verification process ensured that the knowledge in the system is consistent, complete and correct according to required specification(Kolhe *et al*., 2011). The knowledge base was

verified after compilation of all the rules and we made necessary alterations to ensure accuracy. Verification was done to ensure that there are no dead-end lines of reasoning that would result in unknown conclusions derived through the inference process. All the possible bugs in the system were located by the verification process. The functional performance was thoroughly checked. We ensured by running the software time and again by providing different combinations of all the possible inputs. The results given by the system have been validated with domain experts. It was found that the system performance was as expected.

REFERENCES

Gaines, B.R. 1987. An overview of knowledge acquisition and transfer. *International Journal of Man-Machine Studies* **26(4):** 453-472.

Harrison, S.R. 1991. Validation of agricultural expert system. *Agricultural System*. **35:** 265–285.

Harmon, P. and King, D. 1985. Expert Systems: Artificial Intelligence in Business. Wiley,

New York, NY, 283P.

Huirne, B.M.R. and Dijkhuizen, A.A. 1992. Application of decision support systems in farm management. *In: Preprints of European Workshop on Integrated System in Agricultural Informatics*, Bonn. pp. 61-71.

Kahney, H., 1989. Knowledge Engineering. The Open University, 238 P.

Kolhe, S.; Raj, K., Saini, S.; Harvinder and Gupta, G.K. 2011. A web-based intelligent disease-diagnosis system using a new fuzzy-logic based approach for drawing the inferences in crops. *Computers and Electronics in Agriculture*, **76:** 16-27.

Jun-chen, LAI; Bo, MING; Shao-kun, LI; Ke-ru, WANG; Rui-zhi, XIE and Shi-ju, GAO 2010. An Image-Based Diagnostic Expert System for Corn Diseases. *Agricultural Sciences in China*, **9(8):** 1221-1229

Mahaman, B.D.; Harizanis, P.; Filis, I.; Antonopoulou, E.; Yialouris, C.P. and Sideridis, A.B. 2002. A diagnostic expert system for honeybee pests, *Computers and Electronics in Agriculture*, **36:** pp. 17–31.

Man singh, G; Reichgelt, H. and Bryson, K.O. (2007). CPEST: An expert system for the management of pests and diseases in the Jamaican coffee industry, *Expert System with Applications*, **32:** 184-192.

Misra, A.K and Pandey, B.K. 2010. Integrated disease management practices in mango, CISH, Lucknow, 16P.

Nitsch, U. 1991. Computers and the nature of farm management. In: D. Kuiper and N.G. Rolling (Editors), The Edited Proceedings of the European Seminar on Knowledge Management and Information Technology, November 23-24, 1989, Wageningen The Netherlands. Agricultural University, Dept. of Extension Science, Wageningen, pp. 99-106.

Ploetz, R.C. and Prakash, O. 1997. Foliar, floral and soil borne diseases. *In: The Mango: Botany, Production and Uses.* Ed. Litz, R.E., CABI Publishing, U.K., pp. 281-326.

Schoeman, M.H.; Manicom, B.Q. and Wingfield, M.J., 1995. Epidemiology of powdery mildew on mango blossoms. *Plant Disease* 79 (5): 524-528.

Yialouris, C.P. and Sideridis, A.B. 1996. An expert system for tomato diseases. *Computers and Electronics in Agriculture*, 14: 61–76.

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Effect of different sources of organic manures and biofertilizers on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler

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ABSTRACT

The present experiment was carried out to evaluate the effect of different levels of organic manures (Farm Yard Manure, vermicompost and pressmud) and biofertilizers (*Azotobactor*, Phosphate Solubilizing Bacteria and *Azospirillum*) on growth, yield and quality of strawberry Cv. Chandler at Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, U.P., India, during the year 2007-08. Maximum plant height (17.59 cm), maximum plant spread (25.68 cm), maximum number of primary branches plant^{-1} (7.50), maximum number of secondary branches plant^{-1} (17.35), days taken first flowering (61.06), days taken from planting to first fruit setting (72.80), maximum fruit weight (11.75 g) and maximum fruit yield plant^{-1} (0.295 kg) were found with the combined application of vermicompost and phosphate solubilizing bacteria. Similarly, the treatments combination of vermicompost and phosphate solubilizing bacteria also significantly affected the total soluble solids (TSS) (10.75 ^{0}Brix), titratable acidity (0.82 %), vitamin C (57.24 mg/100gm fruit), reducing sugar (4.65 %), total sugars (5.95 %) and juice content (79.50 %). Conclusively, the application of vermicompost with Phosphate solubilizing bacteria was found most effective to improve the growth, yield and quality of strawberry Cv. Chandler.

KEY WORDS: Organic manures, biofertilizers, strawberry, growth, yield, quality

Strawberry (*Fragaria* x *ananassa* Duch.) is one of the most important minor temperate fruit of the India but it is also being grown in sub-tropical and tropical climates. It can be grown up to 12,000 feet from sea level in humid and dry regions. Its successful cultivation requires an optimum day temperature of 22-23^0 C and night temperature of 7-13^0 C (Shoemaker, 1954). Earlier, its cultivation was mainly confined to Nainital, Dehradun (Uttarakhand); Solan, Kullu (H.P.); Srinagar (J&K) but now it is successfully being grown in Gurgaon (Hariyana), Pune (Maharastra); Bengaluru (Karnataka) and some extent in U.P. (Singh, 1992).

Among various factors which contribute to growth, yield and quality of strawberry, nutrition is one of the most important aspects of crop production. Application of organic manures viz., FYM, vermicompost and pressmud not only improve the soil physical properties (water holding capacity, soil aeration, drainage and water retention capacity) but also prevent soil degradation and increase important micro organism population. Biofertilizer viz. *Azotobactor*, PSB and *Azospirillum* fix atmosoheric nitrogen and solubilize phosphorus to increase soil fertility and help plant growth and yield by increasing their number and biological activities. Keeping this fact in view the present investigation was carried out to find out the effect of different sources of organic manures and biofertilizers on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) Cv. Chandler.

MATERIALS AND METHODS

The present experiment had been executed at Horticulture Research Farm, Department of Horticulture, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad, UP during the year 2007-08. The experiment was tested in complete randomized design (CRD) with three replications and consisted of ten treatments namely T_1 (Control), T_2 (FYM + *Azotobactor*), T_3 (FYM + *PSB*), T_4 (FYM + *Azospirillum*), T_5 (Vermicompost + *Azotobactor*), T_6 (Vermicompost + *PSB*), T_7 (Vermicompost + *Azospirillum*), T_8 (Pressmud + *Azotobactor*), T_9 (Pressmud + *PSB*), T_{10} (Pressmud + *Azospirillum*). The organic manures viz. FYM, Vermicompost and presmud were applied at the rate of 314 gm plant^{-1}, 250gm plant^{-1} and 250gm plant^{-1}, respectively and bio fertilizers namely *Azotobactor*, PSB and *Azospirillum* each were applied at the rate of 2 gm plant^{-1}.

Table 1: Effect of different sources of organic manures and biofertilizers on growth and yield of strawberry (*Fragaria* x *ananassa* Duch.) Cv. Chandler

Treatment	Plant Growth					Yield	
	Plant Height (cm)	No. of primary branch per plant	No. of secondary branch per plant	Days taken first flowering	Days taken fruit setting	Fruit weight (g)	Yield per plant (kg)
T_1 (FYM + *Azotobactor*)	21.75	8.25	24.35	79.60	89.60	8.92	0.190
T_2 (FYM + *PSB*)	21.25	8.75	24.25	69.40	83.20	9.25	0.199
T_3 (FYM + *Azospirillum*)	21.50	9.25	25.50	74.20	78.40	8.75	0.194
T_4(Vermicompost + *Azotobactor*)	22.75	9.75	26.50	67.01	80.20	9.25	0.267
T_5 (Vermicompost + *PSB*)	23.95	10.50	27.35	61.06	72.80	11.75	0.295
T_6 (Vermicompost + *Azospirillum*)	23.50	10.25	26.95	63.06	73.50	10.75	0.285
T_7 (Pressmud + *Azotobactor*)	21.75	9.25	25.25	67.70	82.20	8.88	0.198
T_8 (Pressmud + *PSB*)	21.95	9.35	25.75	73.70	81.60	7.98	0.200
T_9 (Pressmud + *Azospirillum*)	22.95	10.35	24.95	68.40	84.20	8.92	0.250
T_{10} (Control)	19.75	6.50	17.92	84.40	91.70	6.92	0.150
SEM ±	0.680	0.412	0.828	2.902	3.462	0.375	0.056
CD at 5%	2.006	1.217	2.443	8.56	10.213	1.100	0.018

RESULTS AND DISCUSSION

The maximum plant height (23.95 cm), number of primary branches per plant (10.50), number of secondary branches per plant (27.35), days taken to first flowering (61.06) and days taken to first fruit setting (72.80) was observed in T_5 (vermicompost and PSB in combination) followed by T_6 (vermicompost and *Azospirillum* in combination) (Table-1). The maximum increase in vegetative growth characters of strawberry cv. Chandler under these treatments combination is supported by the fact that nitrogen through vermicompost. Similarly, maximum fruit weight (11.75 g) and maximum fruit yield per plant (0.295 kg) were found with the combined application of vermicompost and phosphate solubilizing bacteria (T_5) followed by combined application of Vermicompost + *Azospirillum* (T_6) and Vermicompost + *Azotobactor* (T_4).

Vericompost is the builder of protein and is the main constituent of protoplasm in plants thus, the increase in nitrogen supply accelerates synthesis of amino acids which might have indirectly exhibited increase in plant height of strawberry plant. Applications of vermicomposts to field soils have been reported to increase crop growth and yields (Buckerfield and Webster, 1998; Mba, 1983; Masciand-aro et al., 1997; Venkatesh et al., 1998; Vadiraj et al., 1998; Kale et al., 1992; Arancon et al., 2003b, 2004). Further, PSB was also helpful in cell elongation and cell division in meristmatic region of plant, this was due to the production of plant growth substances by PSB such as IAA and GA, similar findings have been reported by Arancon *et al.* (2003

Table 2: Effect of different sources of organic manures and biofertilizers on quality of strawberry (*Fragaria* x *ananassa* Duch.) Cv. Chandler

Treatments	TSS (%)	Titratable acidity (%)	Vit-C (mg/100 g fruit)	Reducing sugars (%)	Total sugars (%)	Juice content (%)
T_1 (FYM + *Azotobactor*)	9.25	0.97	53.54	4.32	5.50	77.25
T_2 (FYM + *PSB*)	9.50	0.92	53.50	4.40	5.75	73.25
T_3 (FYM + *Azospirillum*)	9.25	0.91	53.25	4.52	5.89	73.50
T_4(Vermicompost + *Azotobactor*)	9.85	0.95	53.75	4.60	5.91	75.75
T_5 (Vermicompost + *PSB*)	10.75	0.82	56.95	4.65	5.95	79.50
T_6 (Vermicompost + *Azospirillum*)	10.25	0.88	55.24	4.54	5.93	78.50
T_7 (Pressmud + *Azotobactor*)	10.15	0.88	54.74	4.42	5.65	75.50
T_8 (Pressmud + *PSB*)	10.10	0.93	53.95	4.28	5.25	77.25
T_9 (Pressmud + *Azospirillum*)	9.75	0.92	53.90	4.48	5.85	74.30
T_{10} (Control)	9.02	0.98	53.20	3.92	4.02	70.50
SEM ±	0.329	0.29	0.889	0.039	0.209	1.201
CD at 5%	0.971	0.085	2.621	0.117	0.615	3.543

and 2004) in strawberry and Ustad *et al.* (2005) in banana. Saraf and Tiwari (2004) found that phytohormones extracted from FYM help the plant growth and yield more luxuriously even with reduced doses of chemical fertilizers.

In present investigation the total soluble solids (TSS), total sugars and juice percentage were recorded highest in T_5 (vermicompost and PSB in combination) followed by T_6 (vermicompost and *Azospirillum* in combination) (Table-2). As reported by El-Hamid *et al.*, (2006) an increase in total sugars, TSS and juice percentage have arisen due to synergistic effect of nitrogen (due to vermicompost) and potassium (due to PSB). All the nutrients significantly reduce the acid content of strawberry fruits over control. The same results were also reported by Sahu *and Singh* (2005); Singh and Singh (1979) in strawberry and Kumari *et al.* (1997) in banana. However, the maximum Vitamin C content was observed in T_5 (vermicompost and PSB in combination) followed by T_6 (vermicompost and *Azospirillum* in combination) (Table-2). The similar finding was also suggested by Lucka *et al.* (1975) and Rana (2001) in strawberry.

REFERENCES

Arancon, N.Q., Edwards, C.A., Beriman, P. Metzger James, D., Lee, S. and Weich, C. 2003. Effect of vermicompost on growth and marketable fruit of field grown strawberry. *Pedbiologia*, **47 (5-6):** 731-735.

Arancon, N.Q., Edwards, C.A., Bierman, P., Welch, C., Metzger, J.D., 2003b. Effects of vermicomposts applied to tomatoes and peppers grown in the field, and strawberries grown under high plastic tunnels. Pedobiologia, **47:** 731–735.

Arancon, N.Q., Edwards, C.A., Bierman, P., Welch, C., Metzger, J.D., 2004. The influence of vermicompost applications to strawberries: Part 1. Effects on growth and yield. Bioresource Technology, **93:** 145–153.

Buckerfield, J.C., Webster, K.A., 1998. Worm-worked waste boosts grape yields: Prospects for vermicompost use in vineyards. The Australian and New Zealand Wine Industry Journal **13:** 73–76.

El-Hamid, A.S. Aza, Abbou, A.A., Mansour, S.A.A. and El-Sayed, A.A.A. 2006. Effect of some biofertilizers on yield and fruit quality of strawberry. *Annals of Agriculture Science*. Moshtohor, **44** (10): 251-264

Kale, R.D., Mallesh, B.C., Kubra, B., Bagyaraj, D.J., 1992. Influence of vermicompost application on the available macronutrients and selected microbial populations in a paddy field. Soil Biology and Biochemistry **24:** 1317–1320.

Kumari, U., Kumari K.P. and Padamaja, P. 1997. Efficiency of vermicompost on yield and quality of banana cv. Poovan. *South Indian Horticulture*. **45**: 3-4.

Lucka-M, Kalon, J. and Sady, W. 1975. The effect of organic fertilizers on the yield and chemical composition of the strawberry cv. Purpuratka. W. Krakowie ogrodnictwo. **104:** 129-145

Masciandaro, G., Ceccanti, B., Garcia, C., 1997. Soil agro-ecological management: Fertirrigation and vermicompost treatments. Bio-resource Technology **59:** 199–206.

Mba, C.C., 1983. Utilization of eudrilus eugeniae for disposal of cassava peel. In: Satchell, J.E. (Ed.), earthworm ecology: from darwin to vermiculture. Chapman and hall, London, pp. 315–321.

Rana, R.K. 2001. Studies on the influence of nitrogen fixtures and plant bioregulators on growth, yield and quality of strawberry cv. Chandler. Ph.D. Thesis submitted to Y.S. Parmar University of Horticulture and Forestry.

Sahu, S.K. and Singh, D.B. 2005. Effect of different levels of biofertilizers of growth yield and quality of Strawberry (*Fragaria x ananassa* Duch.) cv Sweet Charley. *Orissa Journal of Horticulture*. **33** (2): 82-85

Saraf, R.K. and Tiwari, J.P. 2004. Influence of integrated nutrient management on growth and yield of main and ratoon crop of muskdana (*Abelmoschus moschatus*). *Journal of Medicinal and Aromatic Plants Sciences*. **26** (1): 24-27.

Shoemaker, J. S. 1954. Small fruit culture. McGraw Hill Book Company INC, New York pp. 447.

Singh, R. 1992. Fruits. National Book Trust, India. pp.244

Singh, H. and Singh, R. 1979. Effect of organic manure and GA_3 on yield and quality of strawberry. *Punjab Hort. Journal*. **19**:71-73

Ustad, A.I., Patil, C.P., Swamy, G.S.K., Athani, S.I. and Patil, P.B. 2005. Effect of different combination of biofertilizers on growth and yield of banana cv. Rajapuri (Musa AAB). Journal of Maharastra Agriculture Universities. **30**(1): 44-46

Vadiraj, B.A., Siddagangaiah, Potty, S.N., 1998. Response of corian-der (Coriandrum sativum L.) cultivars to graded levels of vermicomposts. Journal of Spices and Aromatic Crops, **7**(2): 141–143.

Venkatesh, Patil, P.B., Patil, C.V., Giraddi, R.S., 1998. Effect of in situ vermiculture and vermicomposts on availability and plant concen-tration of major nutrients in grapes. Karnataka Journal of Agricultural Sciences 11(1): 117–121.

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Effect of post-shooting sprays of sulphate of potash and certain growth regulators on bunch characters and fruit yield of banana cv. nendran (AAB)

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ABSTRACT

An investigation was carried out at the Department of Fruit Crops, Tamil Nadu Agricultural University, Coimbatore with an objective to improve the bunch characters and fruit yield of banana cv. Nendran (AAB). The investigation consist of post-shoot application of SOP (2 %) and growth regulators (50 ppm GA_3, 25 ppm 2, 4-D, CPPU and Brassinosteroid @ 2 ppm) at the time of last hand opening and 15 days after first spray under split plot design with three replications. The combined foliar sprays of 2 per cent SOP and 2 ppm Brassinosteroid significantly increased the bunch characters *viz*., bunch weight (11.35 kg), finger weight (215.40 g),finger length (29.10 cm), pulp weight (180.22 g), pulp to peel ratio (5.13) and total bunch yield (29.38 tonnes/ ha) with relatively higher benefit: cost ratio (2.87). Thus, the overall study clearly indicates the benefit of giving post-shoot application of SOP in combination with growth regulators which improves bunch characters and fruit yield with economic vaibility.

KEY WORDS: Banana, Plant Growth Regulators, Sulphate of potash, Bunch characters

Banana (*Musa* spp) is one of the major commercial fruit crops grown in tropics, subtropics and plays a key role in the economy of developing countries. India leads the world in banana production and accounts for about 25.6 % among fruit crops and occupies about 0.796 million hectare with an annual production of 28.45 million tonnes (NHB, 2013). Among the banana varieties grown in India, the French Plantain cultivar 'Nendran' belonging to the 'Plantain' group (*Musa* AAB) is the most popular variety among growers and consumers, particularly in Tamil Nadu and Kerala for domestic and export markets. Since large quantity of photosynthates are move from the source to the sink *i.e.* leaves to developing bunches, any limitations in the supply of photosynthates at this crucial stage affect the bunch size and quality. Because of this problem, poor filling and development of fingers is often reported in almost all cultivars of commercial importance. Many reports have indicated the usefulness of post shooting spray of various SOP during fruit development in influencing the fruit yield, shelf life and quality Algarsamy and Neelakandan (2008) in Robusta, Madhu in banana cv. Grand Naine. (2013), Ramesh Kumar and Kumar (2007 and 2010) in cv. Ney Poovan and Ramesh Kumar *et al.* (2008) in cv. Robusta and Madhu (2013) in banana cv. Grand Naine. Beneficial effect of various plant growth regulators have been studied in banana after the last hand opening stage Among the PGR's, Gibberellic acid , 2,4-D, CPPU and BR are commonly used in banana, which have been shown to regulate several physiological processes (Athani*et al*., 1999; Jayakumar*et al*.,2010).

MATERIALS AND METHODS

The experiment was laid out in banana cv. Nendran (AAB) under two locations in split plot design with ten pre-harvest treatment combinations as bunch spray and replicated three times as detailed below:

Main plot treatments Sub plot treatments

S_1 - Without SOP **G_0** - Without growth regulator

Table 1: Details of the treatment combinations imposed during the experiment

Treatment	Components / materials
T_1 (S_1G_1)	Control
T_2 (S_1G_2)	Spray GA_3 at 50 ppm without SOP
T_3(S_1G_3)	Spray 2,4,D at 25 ppm without SOP
T_4 (S_1G_4)	Spray CPPU at 2 ppm without SOP
T_5 (S_1G_5)	Spray BR at 2 ppm without SOP
T_6 (S_2G_1)	Spray with 2% SOP alone
T_7 (S_2G_2)	Spray with 2% SOP + GA_3 at 50 ppm
T_8 (S_2G_3)	Spray with 2% SOP + 2,4,D at 25 ppm
T_9 (S_2G_4)	Spray with 2% SOP + CPPU at 2 ppm
T_{10} (S_2G_5)	Spray with 2% SOP + BR at 2 ppm

Table 1: Effect of pre harvest sprays of SOP and growth regulators on bunch weight (kg) of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	9.65	9.75	9.70	9.85	9.98	9.91	9.75	9.91
G_2	10.26	11.15	10.70	10.45	11.38	10.91	10.35	10.91
G_3	10.28	11.42	10.85	10.53	11.60	11.06	10.40	11.06
G_4	10.00	10.90	10.45	10.42	11.10	10.76	10.21	10.76
G_5	10.62	11.65	11.13	10.85	11.85	11.35	10.73	11.35
Interaction Mean	10.16	10.97	10.56	10.42	11.18	10.80		
Mean	S_1 (10.29)	S_2 (11.07)	G_1 (9.80)	G_2 (10.81)	G_3 (10.95)	G_4 (10.60)	G_5 (11.24)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.0116*	0.0317**	0.0502**	0.0338	0.0645	0.0710**	0.0710	
CD(0.05)	0.0520	0.0644	0.1018	NS	NS	0.1440	NS	

L_1- First Location L_2 -Second Location, S_1 - Without SOP spray S_2 – With SOP @
G_1- Without Growth regulator G_2- 50 ppm GA_3 G_3-25 ppm 2, 4-D G_4- 2 ppm CPPU
G_5- 2 ppm Brassinosteroid

S_2 – With SOP (2%) **G_1 -** GA_3 (50 ppm)
G_2 - 2, 4, D (25 ppm)
G_3 - CPPU (2 ppm)
G_4-Brassinosteriod (BR) (4 ppm)

The spraying was done twice, first immediately after last hand opening and second, twice after first spray at 15 days interval. Weight of the bunch was recorded including the peduncle up to first bract leaf node above the first hand and expressed in kilogram (kg). The middle fingers in the top and bottom rows of the second hand were selected as representative fingers (Gottreich*et al.*, 1964) to record average weight of the finger and expressed in gram (g). Fully ripe fruit was weighed and peeled. The peel was weighed and pulp weight was arrived by the difference between the two. The pulp-peel ratio was computed. The benefit – cost ratio for the different treatments was worked out based on the expenditure and return in order to study the economics of banana production.

RESULTS AND DISCUSSION

The bunch characters and fruit characters like bunch weight,finger weight,finger length,pulp weight and peel weight, pulp to peel ratio, total bunch yield and benefit: cost ratio were recorded after the harvest and the results are as follows.

The mean data on bunch weight at both locations are represented in **Table 1.** Among the SOP treatments, the S_2 treatment (SOP @ 2%)recorded the highest mean bunch weight (11.07 kg) and highly significant from S_1 (Without SOP) of 10.29 kg in location II. Spraying of growth regulators significantly influenced the mean bunch weight at both locations. However, application of brassinosteroid (G_5) registered significantly maximum bunch weight (11.24 kg) followed by 2, 4-D (10.95 kg) and minimum bunch weight was recorded in SOP alone (9.80 kg).

Bunch weight was significantly influenced by the interaction of SOP and growth regulators at both locations. SOP @ 2% + brassinosteroid combination (S_2G_5) recorded the higher mean bunch weight (11.35 kg) in location II than all other treatments. The lowest mean bunch weight (9.75 kg) was recorded in control at location I.

The finger weight was significantly influenced by various pre harvest treatments in both locations**(Table 2)**. The location II recorded the higher finger weight (189.94 g) and significantly different from Location I (185.95g).Among main effects, S_2 (with SOP @ 2%)recorded the highest finger weight (197.51g) and highly significant from S_1 (178.38 g) in location II.Whereas G_5 (Brassinosteroid @ 2 ppm) higher finger weight (202.45 g) followed by 2, 4-D (194.20 g) compared to control (167.09 g).Among the interactions, SOP @ 2% + brassinosteroid combination (S_2G_5) recorded the maximum bunch weight (215.40 g) in location II than all other treatments. The minimum bunch weight (162.62 g) was recorded in treatment combination of SOP @ 2 % alone + no growth regulator spray in location I.

The higher finger length (26.38 cm) was recorded in Location II and significantly different from location I (25.92 cm) (**Table 3**). Among main effects, S_2 recorded significantly

Table 2: Effect of pre harvest sprays of SOP and growth regulators on finger weight (g) of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	160.36	171.05	165.70	164.88	172.10	168.49	162.62	171.57
G_2	180.56	197.41	188.98	181.80	201.33	191.56	188.18	199.37
G_3	180.00	204.08	192.04	182.44	210.30	196.37	181.22	207.19
G_4	173.65	192.81	183.23	181.11	195.30	188.20	177.38	194.05
G_5	187.41	212.20	199.80	191.60	218.60	205.10	189.50	215.40
Interaction Mean	176.36	195.51	185.95	180.36	199.52	189.94		
Mean	S_1 (178.38)	S_2 (197.51)	G_1 (167.09)	G_2 (190.27)	G_3 (194.20)	G_4 (185.71)	G_5 (202.45)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.2240*	0.7326**	1.1583**	0.7661	1.4822	1.6381**	1.6381	
CD(0.05)	0.9642	1.4859	2.3494	NS	NS	3.3226	NS	

higher finger length (26.97 cm) compared to S_1 (25.33 cm) in II location. Finger length varied significantly due to application of growth regulators at both locations. The G_5 (Brassinosteroid @ 2 ppm) resulted in higher finger length (27.74 cm) followed by 2, 4-D (26.43 cm) and lowest finger length was recorded with treatment sprayed with SOP alone (24.12 cm). Among interaction effects, SOP @ 2% +Brassinosteroid (S_2G_5) combination recorded higher finger length (29.10 cm) in location II. However, the lowest finger length (24.00 cm) was recorded in S_1G_1 combination (SOP @ 2 % alone + no growth regulator) at location I.

The mean data on pulp weight at both locations were represented in **Table 4**.The location II recorded the maximum pulp weight (152.91g) and significantly different from Location I (145.85g).The S_2 treatment recorded the highest pulp weight (160.28 g) and highly significant from S_1 (138.48 g) and among growth regulators G_5 (Brassinosteroid @ 2 ppm) registered higher pulp weight (164.64 g) followed by 2, 4-D (156.63 g) and lowest pulp weight was recorded with SOP alone treatment (127.29 g). Among the interaction effects, SOP @ 2% + Brassinosteroid combination (S_2G_5) recorded the higher pulp weight (180.22 g) in location II than all other treatments.

The data on pulp to peel ratio revealed that, location II recorded the higher pulp to peel ratio (4.16) and significantly different in location I (3.68) (**Table 5**). The pulp to peel ratio was recorded highest (4.32) with the treatment S_2 (SOP @ 2 %) and lowest pulp to peel ratio was registered with S_1 (3.51) at location II. Among the different growth regulators, brassinosteroid @ 2 ppm (G_5) recorded higher pulp to peel ratio (4.40) followed by 2, 4-D (4.15). The interaction effect was found significant and the combination of SOP @ 2% along with brassinosteroid (S_2G_5) recorded higher pulp to peel ratio (5.13) in location II.

Table 3: Effect of pre harvest spray of SOP and growth regulators on finger length (cm) banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	24.32	24.60	24.46	23.68	24.95	24.31	24.00	24.77
G_2	25.30	27.10	26.20	25.52	27.80	26.66	25.41	27.45
G_3	25.36	26.00	25.68	25.83	27.28	26.55	25.60	26.64
G_4	24.90	26.80	25.85	25.69	27.00	26.34	25.29	26.90
G_5	26.10	28.80	27.45	26.68	29.40	28.04	26.39	29.10
Interaction Mean	25.19	26.66	25.92	25.48	27.28	26.38		
Mean	S_1 (25.33)	S_2 (26.97)	G_1 (24.12)	G_2 (26.38)	G_3 (26.43)	G_4 (26.0995)	G_5 (27.74)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.01432 *	0.06594**	0.10426**	0.06748**	0.14377**	0.14745**	0.09326**	
CD(0.05)	0.06159	0.13375	0.21148	0.13266	0.27259	0.29908	0.18915	

Table 4: Effect of pre harvest spray of SOP and growth regulators on pulp weight (g) of fruits of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	119.76	130.75	125.25	124.58	134.10	129.34	122.17	132.42
G_2	138.86	157.56	148.21	142.60	163.51	153.05	140.73	160.53
G_3	134.89	166.78	150.83	148.84	173.50	161.17	141.87	170.14
G_4	130.53	156.71	143.62	146.66	159.50	153.08	138.59	158.10
G_5	146.11	176.60	161.35	152.00	183.85	167.92	149.05	180.22
Interaction Mean	180.22	157.68	145.85	142.93	162.89	152.91		
Mean	S_1 (138.48)	S_2 (160.28)	G_1 (127.29)	G_2 (150.00)	G_3 (156.63)	G_4 (148.35)	G_5 (164.64)	
	L	S	G	L x S	L x G	S x G	L x S x G	
S Ed	0.28939*	0.50116**	0.79241**	0.57871**	1.04326**	1.12063**	1.12063**	
CD(0.05)	1.24518	1.01651	1.60725	1.50296	2.29865	2.27300	2.27300	

The mean data on total yield at both locations are represented in **Table 5**. Among the locations, the location II recorded the highest total yield (27.00 tonnes / ha) and significantly different from location I (26.40 tonnes/ ha). Among the SOP treatments, the S_2 treatment (SOP @ 2%)recorded the highest total yield (27.70 tonnes/ ha) and highly significant from S_1 (without SOP) of 25.50 tonnes per hectare in location II.

Spraying of growth regulators significantly influenced the total yield of banana at both locations. However application of brassinosteroid (G_5) registered significantly higher yield (28.10 tonnes) followed by 2, 4-D (27.30 tonnes) and lowest yield was recorded in SOP alone (24.50 ton). Total yield was significantly influenced due to the interaction of SOP and growth regulators at both locations. SOP @ 2% + brassinosteroid combination (S_2G_5) recorded the higher total yield (29.38 tonnes/ ha) in location II than all other treatments. The lowest yield was recorded in treatment combination of SOP @ 2 % alone + without growth regulator spray (24.38 tonnes/ ha) in location I.

The benefit cost ratio differed significantly due to pre harvest bunch spraying of SOP along with growth regulators in banana cv. Nendran and data is presented in **Table.6**. The maximum benefit : cost ratio (2.87) was obtained in the treatment (T_{10}) where, the bunches were treated with 2 per cent sulphate of potash and 2 ppm brassinosteroid, which was followed by (T_8) 2 per cent sulphate of potash and 25 ppm 2,4-D (2.83). Whereas, the minimum benefit cost ratio (2.50) was obtained in control (T_1).

The combination of SOP and growth regulators revealed significant influence on yield and quality attributes of cv. Nendran in the present study. The results obtained from the present investigation, on bunch yield revealed that the preharvest sprays with SOP and growth regulators influenced the bunch weight positively. The treatment combination of 2 % SOP and 2 ppm brassinosteroid(T_{10}) registered the highest mean bunch weight and total yield.Irrespective of the locations G_5*i.e.*,Brassinosteroids@ 2 ppm concentration was found to improve the plant yield attributing characters.

From results obtained it can be inferred that SOP and brassionsteroid can have a complementary role in improving bunch weight. Preharvest spraying SOP either alone or along with growth regulators did not have any significant influence with respect to the different finger characters like number of fingers per hand, number of hands per bunch and total fingers per bunch. This is mainly because of the imposition of treatments after flag leaf emergence or after last hand opening stage. By the time of spray, the actual differentiation of fingers and hands are well over and hence there is no likelihood of improving the numbers of hand or fingers. In earlier studies by Nandan*et al.* (2011),Madhu (2013) and Kaviarasu (2013) also there were no significant improvement in number of hands and fingers.

The field trials conducted in the present study in two locations clearly pointed out that, the increased total yield was mainly due to improvement in finger weight. The favourable influences on bunch traits by SOP can be because of the presence of sulphur or potassium or both in the SOP. Given as a foliar spray, the absorption of both sulphur and potassium could have played a key role in assimilate partitioning and diversion to the rapidly developing fingers.

Table 5: Effect of pre harvest sprays of SOP and growth regulators on total yield (ton/ha) of banana cv. Nendran (AAB)

Treatments	L_I			L_{II}			Mean	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1 x G	S_2 x G
G_1	24.13	24.38	24.38	24.62	25.00	24.80	24.38	24.70
G_2	25.65	27.88	25.88	26.12	28.50	27.30	25.89	28.20
G_3	25.46	28.55	25.85	26.23	29.00	27.60	25.85	28.78
G_4	25.00	27.25	25.70	26.38	27.75	27.10	25.70	27.50
G_5	27.84	29.12	26.83	27.12	29.63	28.38	26.84	29.38
Interaction Mean	26.39	27.43	26.40	26.10	28.00	27.00		
Mean	S_1 (25.70)	S_2 (27.70)	G_1 (24.50)	G_2 (27.00)	G_3 (27.30)	G_4 (26.60)	G_5 (28.10)	
	L	S**	G**	L x S	L x G	S x G	L x S x G	
S Ed	1..98*	5.17	8.17	6.02	11.2	11.5	8.2	
CD(0.05)	4.7200	10.4894	16.5850	NS	NS	23.45	NS	

Sulphur present in the sulphate of potash (SOP) is considered to play a crucial role in formation of ferridoxin (Iron-sulphur protein) in plants. Ferridoxin is known to have direct impact on metabolism of the plant by activating the catalase and perodoxidase enzymes. Presence of sulphur in SOP may also have a synergistic effect with zinc influencing carbon dioxide absorption and utilization, synthesis of RNA and auxin (Pandey and Sinha, 1999). SOP has been attributed to play major roles in energy transformation, nitrate assimilation, as a constituent of amino acid and protein production, binding of nucleic acid with proteins, activation of enzymes in carbohydrate metabolism subsequently resulting in greater partitioning of photosynthates in yield attributes of bananas (Ramesh Kumar and Kumar, 2007 and 2010).

Sulphur of potash is very well known to trigger nitrate reductase in the majority of growth stages. Since nitrate reductase is the key enzyme in the assimilation of nitrate, the maintenance of the high rate of enzyme activity is imperative for enhanced protein content of the plants. The higher yield and yield attributing parameters obtained in the study could have been also brought by the influence on soluble protein too.

The increase in bunch yield and finger weight due to SOP application in the present study is similar to the earlier findings of Algarsamy and Neelakandan (2008) in Robusta, Madhuin banana cv. Grand Naine. (2013), Ramesh Kumar and Kumar (2007 and 2010) in cv. Ney Poovan and Ramesh Kumar *et al.* (2008) in cv. Robusta and Madhu (2013) in banana cv. Grand Naine.

Brassinosteroid has multifunctional role in plants. It induces cell division, elongation and differentiation and stimulates photosynthetic activity by accelerating CO_2 fixation and further increasing protein biosynthesis. Besides, BRis known to promote nucleic acid level, nitrogen fixation and enhance soluble protein content and increase in DNA and RNA concentrations(Jayakumar *et al.*, 2010). Increase in leaf chlorophyll content, leaf area and leaf area index was brought out by Anitha by application of brassinosteroids (2007). Apart from these physiological responses, BR has growth promoting effects similar to auxin and gibberellins and found to have promising effects on total yield improvement (Vardhini and Rao1998). Similar results were revealed by Bhat *et al.* (2011) in grapes, Peng *et al.* (2004) in litchi and Gomez *et al.* (2006) in yellow passion fruit.

While the earlier studies in banana indicated the positive influence of SOP alone or brassinosteroid alone, in the present study the synergistic effect of both SOP and brassinosteroid could be visualised by the enhanced yields in the treatment combination S_2G_5 *i.e.*,2 % SOP and ppm brassinosteroid. The positive influence of SOP was seen to have been dynamically influenced further by the brassiosteroids as revealed by as high as 16 per cent in yield and 32 % in finger weight. The multifunctional physiological role of brassinosteroids could be due to improved photosynthetic processes and sink efficiency.

Among the two locations, the maximum bunch weight and highest total yield was observed in location II which might be attributed to the differences in soil factors, local weather parameters and differences in the approaches in field maintenance by the growers prior to the initiation of experiment.

Increase in length and girth may be also due to

Table 6: Cost economics of pre harvest application of SOP and certain growth regulators on banana cv. Nendran

Treatment	Cost of cultivation in Rs.per ha(excluding the treatment cost)	Treatment cost + labour cost (Rs.per ha)	Total cost of cultivation (Rs.per ha.)	Total yield (kg/ ha)	Gross income (Rs.per ha.)	Net income (Rs.per ha.)	Benefit : cost ratio
T1	90,000	0	90,000	24375.00	243,750	153,750	2.50
T2	90,000	12,500	102,500	25887.5	258,875	156,375	2.70
T3	90,000	9000	99,000	26012.50	260,125	161,125	2.62
T4	90,000	10,500	100,500	25525.00	255,250	154,750	2.53
T5	90,000	10,000	100,000	26837.50	268,375	168,375	2.68
T6	90,000	2000	92,000	24662.50	246,625	154,625	2.68
T7	90,000	13,500	103,500	28162.50	281,625	178,125	2.72
T8	90,000	10,000	100,000	28775.00	287,750	187,750	2.87
T9	90,000	11,500	101,500	27500.00	275,000	173,500	2.70
T10	90,000	12,000	102,000	29375.00	293,750	191,750	2.87

complementary action of sulphur on zinc to synthesize auxins which are responsible for the cell elongation by increasing the cell permeability to water and osmotic solutes of the cells. Besides, auxins are also responsible for inducing the synthesis of specific DNA dependent new m-RNA and specific enzymatic proteins causes increased cell plasticity and extension resulting ultimately in cell enlargement (Ahmed *et al.,* 1998). Increased finger length and girth due to SOP was also reported in studies by Madhu (2013), Mustaffa *et al*. (2004), Nandan *et al.* (2011) and Ramesh and Kumar (2007) in banana.

Increased finger lengths and girths due to the application of auxins (2, 4-D) and gibberellins as recorded in the present study were also reported in earlier studies by Xiao*et al.*(1997), Patil and Hulmani, (1998) Athani *et al.,* (1999) in banana.

With regard to the physical fruit quality parameters like pulp weight, peel weight, pulp-peel ratio and fruit volume, superior performance was registered by application of 2 % SOP and 2 ppm of BR as pre-harvest spray at two stages of bunch development. This can be due to efficient partitioning of carbohydrates and mobilisation in developing bunches resulting in good pulp recovery.The influence on filling of fingers by the element potassium in banana has been registered by earlier workers like Mustaffa *et al*. (2004). Higher pulp weight recorded in the treatment S_2G_5 can be further attributed to the accelerated rate of cell division and enlargement favoured by auxin biosynthesis prompted by sulphur and potsasium and as well as accelerated sink development aided by the brassinosteroids. A similar effect can be attributed to peel weight.

Peng *et al.* (2004) has described the role of BR's in influencing the finger characters by inducing cell division, elongation and differentiation. In addition, brassinosteroid stimulate the accumulation of photosynthates through increase carbohydrate assimilation and enhanced mobilization of metabolites to the fruits (Fujioka, 1997). The findings in the present study are in consonance with the findings of (Bhat *et al*. 2011) in grape and Gomez *et al.* (2006) in yellow passion fruit.

The rate of photosynthesis is high in plants receiving adequate amounts of potassium may be due to the positive effect of potassium ions on the transfer of the products of photosynthesis because it speed up the flow of assimilates as reported by Suseela and Mruthunjaya (2000). The present results are similar to the findings of Madhu (2013), Ramesh Kumar *et al*. (2008) and Ramesh and Kumar (2007 and 2010).

The increase in bunch weight, finger attributes and other bunch and finger parameters observed in the present study with the other growth regulators *i.e.,*2, 4-D, CPPU and GA_3 can be also attributed to their impact on cell development, cell division and mobilisation of photosynthetic assimilates to the developing fruits. Increased yield of banana due to application of these growth regulators have been observed by many workers.

The enhanced impact due to GA_3 was earlier observed by Chattopadhyaya and Jana, 1988; Pradhan *et al* , 1988; Mary and Sathiamoorthy, 1996; Kumar and Reddy, 1998; Athani, *et al.,* 1999; Balakrishnan *et al.*, 2002; Barman and Das, 2002; Sanna Ebeed, 2008). Similarly enhancement in yield was reported by Rao and Chundawat (1986). Significant enhancement in finger weight with increased pulp: peel ratio and TSS due to post shooting spray of 2,4-D was also observed by Tomi *et al.*

(1997), Patil and Hulmani, (1998), Athani *et al*., (1999), Barman and Das (2002), Tamilselvi *et al*. (2006). Kaviarasu (2012) reported that the bunch weight was significantly influenced by CPPU and 2, 4-D applications. The findings in the present study have similarity to the above findings and confirm that these growth regulators in combination with SOP can be employed for cv. Nendran for improving bunch yield.

REFERENCES

Kumar, A.R. and Kumar, N. 2008. Studies on the efficacy of sulphate of potash (SOP) on the physiological yield and quality parameters of banana cv. Robusta (Cavendish – AAA). **EurAsian J. Bio Sci.,2**(12):102-109.

Ananthi, S. 2002. Comparative efficacy of sulphate of potash and murate of potash on yield and quality of chilli (*Capsicum annum* L.) **M.Sc., Thesis,** Tamil Nadu Agricultural Univerisity Coimbatore-03

Anitha, R. and Jeyakumar, P. 2005. Effect of plant growth regulators and chemicals on morphological traits and yield of banana cv. Grand Naine. **Madras Agric. J., 95 (1-2):** 24-28.

Anitha. N. 1993. Synthetic Brassinosteroids: Its role in few plant growth processes. **Ph.D., Thesis,** UAS, Bangalore, India.

Antognozzi, E. A.; Battistelli, F. Famiani.; Moscatello S.; Stanica, F. and Tombesi, A. 1996. Influence of CPPU on carbohydrate accumulation and metabolism in fruits of Actinidiadeliciosa. **Scientia Horticulturae. 65**: 37-47.

Athani, S.I. and Hulamani, N.C. 1999. Pre-harvest treatment effect on crop maturity and yield of banana cv. 'Rajapuri' (Musa AAB). **Karnataka J. Agric. Sci., 12**(1-4): 234-235.

Athani, S.I.; Hulamani, N. C. and Shirol, A.M. 1999. Studies on yield and quality of banana cv. Rajapuri as influenced by pre harvest treatments. **South Indian Hort., 47(1/6):** 158-161.

Balakrisnan, K. and Rajangam, J. 2002. Studies on the effect of pre- harvest treatments on maturity, yield and quality of red banana, **Madras Agric. J., 89(7-9):**434-437

Barman, P. and Das, P.K. 2002. Effect of plant growth substances on growth and development of banana cv. Barjahaji (AAA group). **J. Agri. Sci. Soc., North-East India**, **15 (1)**: 38-45

Bhat, Z.A.; Reddy, Y. N. and Srihari, D. 2011. New Generation Growth Regulators - Brassinosteroids and CPPU Improve Bunch and Berry Characteristics in 'Tas-A-Ganesh'. Grape. **International Journal of Fruit Science. 11**:309–315.

Chattopadhyaya and Jana. 1988. Effect of growth substances on fruit growth and development of Gaint Governer Cavendish banana. **Prog. Hort., 20 (1-2):** 136-139

Deshmukh, V.N.; Warokar, R.T. and B. T. Kanakpure. 1992. Yield, quality and nutrient uptake by banana cv. Robusta as influenced by potash fertilization and time of application. **J. Potassium Res. 8(4):** 367-370.

Edward Raja, M. and Krishnamurty, P.N. 1999. Foliar nutrition as a tool to increase nutrient use efficiency and to reduce input cost of banana**. In:** Proc. of the seminar held at college of Horticulture, Kerala Agricultural University, Vellayani, *Hort. India.*, 224-225.

Habibi, H.K.; Gowda, N.V. and Jaganath, S. 2010. Effect of gibberellic Acid and brassinosteroid on bunch, berry character and yield of Bangalore Blue grapes, *Mysore Journal of Agriculture Science.* **44(4):**759-765.

Champa, H.; Mahajan, B.V.C. and N.K. Arora. 2014. Pre-harvest treatments of brassinosteroids on improving quality of table grapes (*Vitisvinifera* L.) cv. Flame Seedless, *Int. J. of Agri. Sci. and Vet Medicine***., 2:** 12-14.

Huanga. H.; Guoxing B.J.C. and Yueming J. 2014. The combined effects of phenylurea and gibberellins on quality maintenance and shelf life extension of banana fruit during storage. *Scientia Horticulturae***. 167:** 36–42.

Jeyakumar, P.; Amutha, R. and Balamohan, T.N. 2010. Nutrient-Bioregulator Interaction Effects on Banana. *Acta Hort***., 884:** 515-524.

Jeyakumar, P.; Kumar, R.A. and Kumar, N. 2010. Effect of Post shooting Spray of Potash (SOP) on Yield and Quality of Banana cv. Robusta (AAA- Cavendish). *Research Journal of Agriculture and Biological Sciences***. 4(6)**: 655-659.

Peng J.; Xudong T. and Feng, H. 2004. Effects of brassinolide on the physiological properties of litchi pericarp (*Litchi chinensis* cv. Nuomoci). *Scientia Horticulturae***.101:**407–416.

Kaviarasu, P. 2013. Chemical manipulation for improvement of yield and quality of banana cv. Grand Naine. M.Sc (Hort), Thesis, Tamil Nadu Agric. Uni., Coimbatore.

Kitren Glozer, U. and C. Davis. 2006. CPPU for harvest delay, improved fruit firmness and reduction of preharvest drop in *Prunus domestica* L. Physiological Responses and Fruit Retention of Carambola Fruit (Averrhoa carambola L.) Induced by 2, 4-D and GA_3. *Journal of Biosciences.* **16 (1):** 9-14.

Kotur, S.C. and Keshava Murthy, S.V. 2008. Enhancing the fruit yield of 'Robusta' banana (*Musa paradisiaca*) by de-navelling and feeding Nitrogen, Potassium and Sulphur through the distal stalk end of the bunch. *Indian J. Agric. Sci***., 78**(2):109-115.

Kotur, S.C. and Keshava Murthy, S.V. 2010. Enhancing fruit yield in 'Neypoovan' banana by de-navelling and feeding N, K and S through distal stalk – end of the bunch. *J. Hort., Sci.,* **5**(1): 53-56.

Lahav, E., 1975. Effect of potassium level on the content of free amino acids in banana suckers. *Agrochemical***. 19:** 319-325.

Kumar and Reddy. 1998. Effect of growth substances on fruit size, yield and quality of banana cv. Neypoovan. *Environment and Ecology***. 16(4):** 937-939.

Madhu, R. 2013. Effect of bunch spray of nitrogen and potassium on yield and quality of banana cv. Grand Naine under hill zone of Karnataka. M.Sc., (Hort) Thesis. UAS, Bangalore, India.

Mahalakshmi, M. and Sathiamoorthy, S. 1999. Effect of post shoot application of potassium on yield characters in banana cv. Rasthali (AAB). South Indian Hort., **47(1-6):**155-157.

Mignani, J.L.; Treccani, C.P. and Cocucci, S. 1995. Bitter pit incidence and changes in Ca^{2+} content in apple after postharvest dip in $CaCl_2$ or GA_3. *Scientia Horticulturae.* **19(3/4)**: 295-299.

Mishra, D.S.; Kumar, P. and Kumar, R. 2012. Effect of GA_3 and BA on fruit weight, quality and ripening of 'rose scented' litchi. *Hort Flora Research Spectrum*, **1(1):** 80-82.

Mustaffa, M.M.; Tanuja, B.; Sivakumar, K.C.; Kumar, V and Sathiamoorthy, S. 2004. Effect of preharvest treatments on bunch parameters, quality and shelf life of banana cv. Nendran. *In Banana: Technological Advancements***.** (Singh, H.P. and Uma, S. Eds), AIPUB, Trichy, PP.124-132.

Nandan, C.P.; Sathyanarayana, B.N.; Naresh, P. and Lakshmipathy, M. 2011. Effect of certain pre harvest treatments in improving the yield and quality of banana cv. Nanjangudu Rasabale. *Pl. Arc.* **11(2):**677-681.

NHB Data Base 2013. Published by National Horticulture Board Department of Agriculture and Co-operation Government of India.

Pandey, S.N. and Sinha, B.K. 1999. ***Plant Physiology***. Vikas Publ. House Pvt. Ltd., New Delhi.

Patil, S.N. and Hulamani, N.C. 1998. Effect of post harvest treatments on physical characters and shelf life of banana fruits. *Karnataka, J. Agric. Sci***., 11(2):** 535-537.

Peng, J.; Xudong T. and Huyuan F. 2004. Effects of brassinolide on the physiological properties of litchi pericarp (*Litchi chinensis* cv. Nuomoci). *Scientia Horticulturae.* **101:**407-416.

Pradhan, S.K.; Mishra, A. and Sen, S.K. 1988. Effect of growth regulators on fruit size, yield and quality of banana cv. Gaint Governer. *Prog. Hort***., 20**(3-4)326-330.

Rahman, A. and Moieza, A. 2013. Effect of Plant Biostimulants on Growth, Chlorophyll Content, Flower Drop and Fruit Set of Pomegranate Cv. Kandhari Kabuli. *Int. J. of Agri. Envt & Biotech***., 6(2)**: 305-309.

Kumar, A.R. and Kumar, N. 2007. Sulphate of potash foliar spray effects on yield, quality and post – harvest life of banana (India). *Better Crops***, 91**(2):22-24.

Kumar, A.R. and Kumar, N. 2007. Sulphate of potash foliar spray effects on yield, quality and post harvest life of Nendran banana (India). *The Asian J. Hort. Sci***., 28(2):** 22-24.

Kumar, A.R. and Kumar, N. 2010. Effect of post - shooting spray of certain nutrients on yield and quality of banana cv. Neypoovan (AB). *Agric. Sci. Digest*, **30 (2):**125-128.

Kumar, A.R.; Kumar, N. and Jeyakumar, P. 2008. Effect of post-shooting spray of sulphate of Potash (SOP) on yield and quality of banana cv. Robusta (AAA- Cavendish). *Res.J. Agri. Bio. Sci***., 4(6):**655-659.

Sanna, E.; Mustafa, E.A.M. and Sale, M.M.S. 2008. Effect of Gibberellic acid and male bud removal on yield and fruit quality of banana plants. *Res. J. Agri. Bio. Sci*., **4**(4):289-292.

Suhathiya, K. Singaravel, R. 2010, Influence of brassinosteroids and micronutrients on the yield and quality of tomato. *Plant Archives***. 10** (1).322-331.

Devi, J.S. and Mruthunjaya, S. 2000. Nutritional disorders and their management in fruit crops. *Krishivikas Publications*, 8-15.

Sushma, S. 1991. Effect of GA_3 and 2, 4-D on physiochemical properties of banana cv. Rastali. M.Sc. (Hort.) Thesis**,** Tamil Nadu Agricultural University, Coimbatore.

Tambe, T. B. 2002**.** Effects of Gibberellic acid in combination with brassinostroid on berry size, yield and quality of Thompson Seedless grape. *J. of Maharastra*, Agri. Univ., **27 (2):** 151-153.

Tamilselvi, C. 2006. Effect of certain plant growth regulator on growth parameters and fruit yield of banana cv. Ney Poovan. *South Indian Hort*., **54(1-6):**223-228, 2006.

Rao,V. 1998. Effect of brassinosteroids on growth, metabolite content and yield of *Arachishypogaea. Phytochemistery* **48**: 927-930.

Xiao, H.W., Jun-Xiang, H. Min, C. Shang- Xing and Guo- rong, F. 2007. Influence of CPPU on sugar and acidcontent of *Diospyros kaki cv*. Zenjimaru fruit. *Journal of Zhejiang Forestry Sci. and Tech***., 5:** 120-125.

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Effect of pruning severity on quality of grapes (*Vitis vinifera* L.) cv. Red Globe in winter season

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ABSTRACT

Effect of pruning severity on quality of grapes cv. Red Globe in winter season was studied at Horticultural Orchard, Tamil Nadu Agricultural University, Coimbatore during June, 2012. The vines were pruned at four different levels in a Randomized block design with five replications. Different pruning levels adopted are, I. Pruning all the canes to 2 bud level for vegetative growth. II. Pruning all the canes to 5-6 bud level for crop load. III. Pruning 33 per cent of the canes for vegetative growth (2 bud level) and remaining 67 per cent of the canes for crop load (5-6 bud level). IV. Pruning 50 per cent of the canes for vegetative growth (2 bud level) and 50 per cent of the canes for crop load (5-6 bud level). Observations such as TSS, TSS-acid ratio, titrable acidity, sugar-acid ratio, reducing, non-reducing and total sugars were determined. Results revealed that, all the vines which were pruned at 2 bud level for winter season crop registered highest TSS (16.25 ^{0}Brix), TSS/acid ratio (31.60), lower titrable acidity (0.51 per cent), whereas, the maximum reducing sugars (13.91 per cent), total sugars (15.26 per cent) and sugar-acid ratio (30.11) was observed in vines pruned to 50 per cent of the canes for vegetative growth and 50 per cent of the canes for crop yield for winter season crop was found to be better among different pruning intensities.

KEYWORDS: Grape, pruning, bud, TSS, acidity, sugars, winter season.

Grape (*Vitis vinifera* L.) is considered as one of the most important commercial fruit crops of temperate, tropical and sub-tropical regions of the world. Grape cultivation in India assumes great significance due to its high productivity (21.08 tonnes ha^{-1}) as compared to many other grape producing countries. The area under grape cultivation in the last three decades is increasing steadily with the introduction of exotic varieties. In India, grape is grown over an area of 0.118 million hectares with annual production of 2.48 million MT (NHB, 2013) and production share of 3.1 per cent among fruit crops. The major grape growing states of India are Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. Tamil Nadu is ranked third in the major grapes producing states in the country and accounts of 4.3 per cent of total production of Grapes in the country. The State produces 0.05 million MT of Grapes from an area of 0.003 million hectares with productivity of 19.30 tonnes ha^{-1} (NHB, 2013). Recently, the exotic cv. Red Globe, introduced from University of California, USA which is popular in USA, Australia, China and other grape growing countries, is also slowly gaining importance in India among the grape growers and consumer's preference is also much higher for this exotic variety. The vines of this cultivar are moderate in vigour but tend to produce more number of bunches with bigger sizes. Hence, optimum canopy size and bunch number per vine are to be maintained for achieving better fruit quality which calls for a proper balancing between vigour and capacity. Among different cultural practices, pruning is an effective tool used under frequent changes on climatic conditions as it helps to control the growth, crop load and also the quality of bunches (Reddy and Prakash, 1990). The time of pruning varies greatly with the variety and local climatic conditions in different grape-growing region in India. Generally growers adopt a pruning level of 4-5 buds/cane for pruning of all matured canes in cv. Muscat which results in more exploitation of reserve food material leading to the loss of vigour, quality and early setting of senility in the vines whereas, in cv. Red Globe it was unknown. In the present investigation, attempts were made to aim the quality bunches exclusively for winter by striking a balance between vigour and capacity through regulating the pruning intensities.

MATERIALS AND METHODS

The present investigation was undertaken at

Table 1: Effect of pruning severity on quality of grapes cv. Red Globe in winter season.

Treatments	TSS (^{0}Brix)	Titrable acidity (%)	TSS/acid ratio	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sugar-acid ratio
T_1	16.25	0.51	31.60	13.82	1.04	14.86	28.89
T_2	15.15	0.62	25.54	13.55	1.49	15.04	24.08
T_3	15.37	0.56	26.87	13.10	1.85	14.95	26.50
T_4	15.95	0.52	29.33	13.93	1.33	15.26	30.11
S.Ed	0.02	0.02	0.11	0.02	0.01	0.01	0.11
CD (0.05%)	0.05	NS	0.25	0.03	0.03	0.02	0.25

Treatment details

T_1: Pruning all the canes to 2 bud level (100 per cent) for vegetative growth.

T_2: Pruning all the canes to 6 buds level (100 per cent) for crop load.

T_3: Pruning 1/3rd or 33 per cent of the canes for vegetative growth (2 bud level) and 2/3rd or 67 per cent of the canes for crop load (6 bud level).

T_4: Pruning 50 per cent of the canes for vegetative growth (2 bud level) and 50 per cent of the canes for crop load (6 bud level).

Orchard, HC & RI, TNAU, Coimbatore during June, 2012 on eight year old grapevines which were trained on bower system spaced at 3.0 x 2.5 m apart. For winter season crop vines were pruned on 2nd fortnight of June, 2012 and harvested during the months of October-November, 2012 with four pruning intensities replicated five times in randomized block design. Different pruning levels adopted are, I. Pruning all the canes to 2 bud level for vegetative growth. II. Pruning all the canes to 6 bud level for crop load. III. Pruning 33 per cent of the canes for vegetative growth (2 bud level) and remaining 67 per cent of the canes for crop load (6 bud level). IV. Pruning 50 per cent of the canes for vegetative growth (2 bud level) and 50 per cent of the canes for crop load (6 bud level). Total of four vines were observed in each replication under each treatment for the collection of data. The soil samples collected from the experimental plot were analysed for organic carbon (0.85%), available N (390.67 kg/ha), P (35.43 kg/ha), K (809.13 kg/ha) before imposition of treatments. A nutrient dosage consisting of 5 kg FYM along with 0.75: 0.75: 0.50 kg NPK per vine was applied in 2 split doses, at vegetative and fruiting phase. Proper plant protection measures and cultural practices were also followed whenever needed.

Randomly selected 10 berries per replication in each treatment were used for assessing quality parameters. Observations such as TSS, TSS/acid ratio, titrable acidity, sugar-acid ratio, reducing, non-reducing and total sugars were determined. Total soluble solids in berry juice (T.S.S.) were determined by means of digital hand refractometer having a scale of 0-50^0 Brix and expressed as degrees Brix at 21^{0}C and titrable acidity was expressed as tartaric acid (%) according to (A.O.A.C., 1998). TSS/acid ratio was calculated by dividing TSS (^{0}brix) by acidity (%). The total sugars and reducing sugar were estimated as per the method suggested by Somogyi (1952) and expressed in percentage. The per cent non-reducing sugars were obtained by subtracting the values of reducing sugars from that of total sugars. Sugar-acid ratio was calculated by dividing total sugar content with acidity. Resulted data were subjected to statistical analysis as outlined by Panse and Sukhatme (1985). The various results were made after working out the standard errors and CD at 5 per cent level of significance.

RESULTS AND DISCUSSION

Fruiting is an exhaustive process and heavy crop load generally leads to depletion of nutrient reserves of the vine and quality bunches resulting in early senility. In grapes, particularly in table variety quality is more important to get better price in the market than yield. Quality is generally judged by chemical components of berries such as total soluble solids, titrable acidity, TSS/acid ratio, sugars (reducing, non-reducing and total sugars) and sugar-acid ratio etc. In the present study, invariably, severely pruned vines *i.e.*, pruning all the canes to 2 bud level aiming for winter season crop has produced with higher TSS (16.25 ^{0}Brix), TSS/acid ratio (31.60) and lesser acidity (0.51%) than less severely pruned vines (Table 1), it was followed by the vines which were pruned equal number of canes to 2 and 6 bud level *i.e.*, pruning 50% of canes for vegetative growth (2 bud level) and remaining 50% for crop load (6 bud level). This clearly indicates that crop load has a negative effect on the quality of bunches and we have to regulate the crop load in order to produce the quality bunches. The high TSS, TSS/acid ratio in severely pruned vines might be due to lesser competition for metabolites, among the limited number of bunches per vine, availability of more photosynthates consequent to better vigour and

Pruned grape vines

(A) Pruning at two bud level

(B) Pruning at six bud level

physiological activities induced in them. The predominant acids found in grapes *viz*., malic and tartaric acid are synthesized in leaves, these acids are translocated from leaves to bunch. This higher quantum of acids might have deposited in bunch during development and this resulted in higher acid content in less intensive pruning levels. These results are in conformity with earlier studies given by (Singh and Kumar, 1980; Joon and Singh, 1983; Brar *et al*., 1986; Sehrawat *et al*., 1998; Chougule, 2004 and Somkuwar and Ramteke, 2007). Among the pruning intensities, the vines which were pruned to 50% of canes for vegetative growth (2 bud level) and remaining 50% for crop load quality bunches (6 bud level) registered the maximum percentage of reducing sugars (13.93%), total sugars (15.26%) and sugar-acid ratio (30.11) (Table 1). The reason for accumulation of high reducing and total sugars in balanced pruning of vegetative and reproductive growth might be due to lesser competition of metabolites, limited number of bunches per vine, availability of more photosynthates consequent to better vigour and

physiological activity induced in them where source-sink relationship was well balanced. These results are in accordance with similar earlier results (Mohanakumaran *et al*. 1964 and Singh and Kumar, 1980). It was observed that among the different intensities of pruning *i.e*., pruning 50% of the canes for vegetative growth and 50% of the canes for crop load for quality bunches was found to be better.

REFERENCES

AOAC. 1998. *Official Methods of Analysis*. 16th edn., Association of Official Analysis Chemists, Washington, D.C.

Brar, S.S., Bindra, A.S., Singh, S. and Cheema, S.S. 1986. A note on the effect of crop load on yield and quality of grapes (*Vitis vinifera* L.) cv. Perlette has manifested on commercial scale. *Haryana J. Hort. Sci.*, **15(1-2):** 48-50.

Chougule, R.A. 2004. Studies on sub-cane pruning and cycocil application in relation to the canopy management in grapes. **M.Sc., Thesis** submitted to MPKV, Rahuri.

Joon, M.S. and Singh, I.S. 1983. Effect of intensity of pruning on ripening, yield and quality of Delight grapes. *Haryana J. Hort. Sci.*, **12(1-2):** 44-47.

Mohanakumaran, N., Krishnamurthi, S. and Rao, V.N.M. 1964. Influence of leaf area on yield and quality of some varieties of grapes. *South Ind. Hort.*, **12(2):** 29-49.

NHB, 2013. Grapes area, production and productivity. 2012. http://www.nhb.gov.in.

Panse, V.G. and Sukhatme, P.V. 1985. Statistical Methods for Agricultural Workers, ICAR. Pub. New Delhi, **115-130**.

Reddy, N.N. and Prakash, G.S. 1990. Effect of rootstock on bud fruitfulneess in Anab-e-Shahi grapes. J. Mah. Agric. Univ., **15:** 218-220.

Sehrawat. S.K., Daulta, B.S., Dahiya, D.S. and Bharadwaj, R. 1998. Effect of pruning on growth, yield and fruit quality in grapes (*Vitis vinifera* L.) cv. Thompson Seedless. *Intern. J. Trop. Agric.*, **16(1-4):** 185-188.

Singh, I.J. and Kumar, H. 1980. Yield and fruit quality of Anab-e-Shahi grape as influenced by severity of pruning. Haryana. J. Hort. Sci., **9:** 110-117.

Somkuwar, R.G. and Ramteke, S.D. 2007. Effect of bunch retention, quality and yield in Sharad Seedless. Annual Report 2006-07, National Research Center for Grapes, Pune. pp **20**.

Somogyi, N. 1952. Notes on sugar determination. *J. Biol. Chem.* **200(2):** 145-154.

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Study on propagation of carrizo rootstock through cutting

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ABSTRACT

Among the three types of cuttings studied during the investigations, softwood cuttings recorded maximum level of number of main shoots produced, which was to the tune of 2.78. In term of maximum length and diameter of main shoots, hardwood cuttings were found to produce 71.11cm & 1.12cm value of these parameters respectively. These were highest among all type of cuttings. Maximum number of sub-shoot to the tune of 10.78 was again produced by hardwood cuttings. All type of cuttings were found to be statistically at par regarding maximum sub-shoot length and diameter. Non-significant variation was also recorded in maximum root length and number of primary roots in all type of cuttings. Fresh and dry weight of the roots was higher in hardwood cuttings in comparison to other two types, though the variation here too was non-significant. In term of survival success, hardwood cuttings recorded maximum value to the tune of 22.23 percent and it was significantly higher than the success percentage recorded by semi-hardwood and softwood cuttings.

KEY WORDS: Carrizo Citrange, root, shoot, stem cuttings and survival success

Citrus cultivation in India occupies a prominent place. The fruits under this group are grown in diverse conditions over the sub-continent, right from arid and semi-arid areas to humid tropical areas (Chahal & Bal, 2012). Under Punjab conditions also Citrus is performing excellently and is dominant fruit crop of the region. Out of the total area under fruit crops in this state, around 65.75 percent is under citrus (Anonymous, 2014) and majority of the plantation is on rough lemon rootstock.

Citrus rootstocks have been used for a long time and their effects on the performance and characteristics of scion cultivars have been reported by many researchers. Rootstocks contribute largely to success and failures in citrus industry. It is just as important to use carefully selected rootstocks of superior performance as it is to use selected superior fruit varieties. However, the dominant citrus rootstock in Punjab, Rough lemon, having suitable characters like drought tolerance and extensive root system is susceptible to *phytophthora*. The newly recommended rootstock for this region, Carrizo Citrange is expected to overcome the problems emerging from *phytophthora* to some extent as it is considered to be tolerant against this disease (Rafael, 1987). Carrizo is a hybrid between sweet orange and trifoliate orange (*Citrus sinensis* [L.] Osbeck X *Poncirus trifoliata* [L.] Raf.). It is adaptable to all types of soils except those having high levels of available calcium. It has the ability to regenerate roots after *phytophthora* damage. However, not much research has been done under Punjab conditions on multiplication of this rootstock. Various trials on asexual methods of propagation in citrus, like in *Citrus jambhiri* Lush. (Kumar *et. al.*, 2012) and in *Citrus aurantifolia* Swingle (Kumar *et. al.*, 2011) have been done but such efforts to explore different methods of multiplication lack in case of Carrizo Citrange under Punjab conditions. Propagation through stem cuttings is an important method, particularly, in horticulture for mass production of improved materials within a short period of time and for perpetuating the characters of the parent plant (Hartmann *et. al.*, 1997). Keeping this in view, the experiment was planned to study the multiplication of Carrizo Citrange through stem cutting.

MATERIALS AND METHODS

The experiment was conducted at Punjab Agricultural University's Fruit Research Station, Jallowal-Lesriwal, Jalandhar (Latitude, 31° 29′ 38" N and Longitude, 75° 37′ 40" E). The station falls under the central fruit zone of Punjab and represent typical sub-tropical climatic conditions with annual average rainfall of 701 mm. The daily mean maximum temperature in Jalandhar is 40.75°C and the mean minimum temperature is 5.15°C (*Kahlon et. al.*, 2011). Cuttings of three types from Carrizo Citrange

Table 1: Effect of different type of cuttings on vegetative growth of Carrizo Citrange

Type of cutting	Number of main shoots	Maximum length of main shoots (cm)	Maximum diameter of main shoots (cm)	Number of sub shoots	Maximum length of sub shoots (cm)	Maximum diameter of sub shoots (cm)
Hardwood	2.56	71.11	1.12	10.78	24.37	0.40
Semi-hardwood	2.22	53.57	0.88	7.00	19.55	0.35
Softwood	2.78	56.44	0.88	7.89	20.00	0.36
C.D.	**NS**	**11.996**	**0.110**	**2.285**	**NS**	**NS**

plants were prepared for the trial in 2013. Hardwood cuttings, semi-hardwood cuttings and softwood cuttings were prepared in the month of February and planted on open beds. The cuttings were taken from Carrizo plants of well maintained rootstock block established in 2005 at Fruit Research Station, Jallowal-Lesriwal. This rootstock block was established by importing plant material from USA.

Data on different parameters of vegetative growth and percent success of the cuttings was recorded in February 2014. Number of main shoots was calculated by counting the shoots emerging from main cutting, while number of sub shoots was calculated by counting those emerging from main shoots. Maximum length of the main and sub-shoots was measured with the help of measuring tape in centimeters. It was worked out by identifying the shoot with maximum length. Diameter of main and sub shoot was measured with the help of digital Vernier Caliper. Maximum root length was measured in centimeters, while their fresh and dry weight was calculated in grams. Cuttings survival success was expressed in term of percentage.

RESULTS AND DISCUSSION

The data presented in Table-1 reveals that all the types of cuttings registered non-significant variation in producing number of main shoots. The maximum number of main shoots was recorded in softwood cuttings, which was to the tune of 2.78, while the minimum was in semi-hardwood cuttings (2.22). Significant variation was observed between hardwood cuttings and other type of cuttings in term of maximum shoot length. Hardwood cuttings registered this parameter to the tune of 71.11cm which was highest among all the cutting types. Non-significant variation was observed between semi-hardwood (53.57cm) and softwood cuttings (56.44cm). Similar trend was recorded in diameter of main shoots. Growth from hardwood cuttings resulted in main shoots with maximum diameter to the tune of 1.12cm, which was significantly higher than those produced by semi-hardwood and softwood cuttings.

The data regarding number of sub-shoots reveals that maximum number of sub-shoots was produced by hardwood cuttings which registered this parameter to the tune of 10.78. It was found to be significantly higher than those produced by other type of cuttings. Semi-hardwood cuttings produced minimum number of sub-shoots (7.00) but were at par with those produced by softwood cuttings (7.89). Maximum length of sub-shoots in all type of cuttings was found to be statistically at par. However, hardwood cuttings produced maximum level (24.37cm) of this parameter followed by softwood cuttings (20.00cm). Similar trend was recorded in case of sub-shoot diameter. Hardwood cuttings produced sub-shoots with diameter of 0.40cm, while semi-hardwood and softwood cuttings produced sub-shoot diameter of 0.35cm and 0.36cm respectively. Wood maturity of different type of cuttings might have resulted in reserve starch and sugar content variation (Singh *et. al.*, 2013) and hence would have affected growth of main and sub-shoots.

The data presented in table-2 reveals that all type of cuttings produced maximum root length, statically at par with each other. Longest roots were observed in hardwood cuttings, with value of 22.23cm. Root length recorded in case of semi-hardwood and softwood cuttings was

Table 2: Effect of different type of cuttings on rooting performance and survival success in Carrizo Citrange.

Type of cutting	Maximum root length (cm)	Number of primary roots	Fresh weight of roots (gm)	Dry weight of roots (gm)	Survival success (%)
Hardwood	22.23	6.19	3.89	2.68	22.23
Semi-hardwood	18.13	4.67	3.30	2.23	16.13
Softwood	16.17	3.33	2.88	1.72	10.17
C.D.	**NS**	**NS**	**NS**	**NS**	**2.74**

18.13cm and 16.17cm respectively. The data regarding number of primary roots showed that hardwood cuttings produced maximum level of this parameter (6.19) followed by semi-hardwood cuttings (4.67). Softwood cuttings produced minimum number of primary roots (3.33). However, all three types of cuttings were statistically at par with each other. Higher number of primary roots in hardwood cuttings may be result of larger rooting area provided by these type of cuttings. Singh *et. al.*, (2011) during his work on propagation of pear through cuttings observed that semi-apical cutting produced maximum number of primary and secondary roots. Highest level of fresh weight (3.89gm) of the roots was recorded in hardwood cuttings and was non-significantly higher than semi-hardwood (3.30gm) and softwood cuttings (2.88gm). Similar trend was observed in case of dry weight of the roots. Maximum dry weight of roots was found to be 2.68gm in hardwood cuttings, while it was 2.23gm and 1.72gm in case of semi-hardwood and softwood cuttings respectively. In both fresh and dry weight of the roots, non-significant relation was observed between all type of cuttings. Higher value of fresh and dry weight of roots in hardwood cuttings may be due to more length and number of primary roots in these type of cuttings in comparison to semi-hardwood wood and softwood cuttings. Rooting in stem cuttings of various citrus rootstocks have been reported by Bhusal *et. al.*, (2001).

The data regarding survival success of different type of cuttings was calculated by counting the number of sprouted cuttings that survived upto one year with regular growth. The percentage of such cuttings was calculated. Maximum rate of success was found to be 22.23 percent in case of hardwood cuttings. It was statistically higher than the success rate in case of semi-hardwood and soft wood cuttings. Semi-hardwood cuttings recorded success rate of 16.13 percent while it was 10.17 percent in case of softwood cuttings. Sprouting of Kagzi Lime (*Citrus aurantifolia* Swingle) stem cuttings and their survival has been reported by Diwaker and Katiyar in 2013.

From the foregoing discussion, inference can be drawn that hardwood cuttings are most suitable out of all type of cuttings studied during the investigation in term of survival success and growth. Semi-hard wood cuttings were the next best type in term of survival success. Little success was found in case of softwood cuttings in term of survival success but they produced maximum number of main shoots. Hardwood cuttings resulted in higher vegetative growth in term of length and diameter of shoots as well as length and weight of roots. The maximum level of the success in term of survival of cuttings was 22.23 percent, which invites further research in this field to explore the possibility of increasing the success rate.

REFERENCES

Anonymous, 2014. Package of Practices for cultivation of fruits. Punjab Agricultural University, Ludhiana.

Bhusal, R.C., Mazutani, F., Moon, Doo-Gyung and Rutto, K.L. 2001. Propagation of citrus by stem cuttings and seasonal variation in rooting capacity. *Pakistan Journal of Biological Sciences,* **4:** 1294-1298.

Chahal, T.S. and Bal, J.S. 2012. Effect of pre-harvest treatments of calcium salts on harvest maturity in kinnow mandarin. *HortFlora Research Spectrum*, **1(2)**: 153-157.

Diwaker and Katiyar, P.N. 2013. Regeneration of Kagzi Lime (*Citrus aurantifolia* Swingle) through stem cuttings with the aid of IBA and PHB. *HortFlora Research Spectrum*, **2(3)**: 270-273.

Hartmann, H.T., Kester,D.E., Davis Jr., F.T. and Geneve, R.L. 1997. Plant propagation, principles and practecies. *Prentice-Hall, Inc. Upper Saddle River, New Jersy, USA*, p. 239-385.

Kumar Raj, Kaul, M.K., Saxena, S.N., Bhargava, S. and Singh, S. 2012. Protocol standardization for micropropagation of *Citrus jambhiri* Lush. using nodal segments of nucellar seedlings. *Progressive Horticulture*, **44(1)**: 101 – 109.

Kumar, R., Kaul, M.K., Saxena, S.N., Bhargava, S., Singh, A.K. and Singh, J. 2011. Standardization of micro-propagation technique for acid lime (*Citrus aurantifolia* Swingle). *Progressive Horticulture*, **43(1):** 25 – 29.

Marte, Rafael (1987). Citrus propagation manual. *Miscellaneous Publication Series*, No.A2/BB-87-004,: 4.

Singh, S.K., Ranjan K., Singh, M. K., Chaubey, S.K. and Prasad, K.K. 2011. Studies on pear propagation through cuttings treated with Indole Butyric Acid under Ranchi condition. *Progressive Horticulture*, **43(1):** 121 – 125.

Singh, K.K., Choudhary, T. and Kumar P. 2013. Effect of IBA concentrations on growth and rooting of *Citrus limon* Cv. Pant Lemon cuttings. *HortFlora Research Spectrum*, **2(3)**: 268-270.

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Diversity in ber varieties in irrigated eco-system of northern India

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ABSTRACT

Ber occupies a significant position as a fruit crop in Indian subcontinent. Maximum number of ber varieties have been reported in China. But in India about 125 ber varieties are grown in different states which have been developed by selection. During the last three decades the cultivation of ber become very popular particularly in the arid and arid irrigated zones of Haryana, Punjab Rajasthan and Gujarat. There is lot of genetic diversity in the ber grown in different states. Thus, to optimize fruit yield and to improve income of the fruit growers a field gene bank was established at FRS Bahadurgarh in which more than 50 varieties were collected and out of which ten promising were evaluated for their fruit yield, quality and reaction to the powdery mildew disease. The internodal length was recorded maximum (7.25 cm) in Umran and minimum (3.75 cm) in Sanaur-2. Most of the varieties developed spreading habit of branching except in Wallaiti where the branches were erect. Least thorn length was noted in Umran and Selected Safeda. Different varieties develop variable fruit apex i.e. round in Umran, Sanaur-5, Illaichi, ZG2, Gola and Selected Safeda and slightly to medium pointed in Sanaur-2, Sanaur-3, Sanaur-4 and Wallaiti. In all varieties flowering commences from 1st September and completed utpo 25th September. Maximum average fruit weight (30.45 g/fruit) was recorded in Umran followed by Sanaur-2, whereas minimum fruit weight was recorded in Illaichi (4.60 g/fruit). Maximum fruit size in term of fruit length and breadth was recorded in Umran i.e. 5.11 x 3.49 cm followed by in Sanaur-2 i.e. 4.20 x 3.21 cm while among all the varieties it ranged from 2.17 x 1.01 cm to 5.11 x 3.49 cm respectively. The maximum fruit yield 195.9 kg/plant was recorded in Umran followed by in Sanaur-2. The picking of fruits starts from 10th February to 15th April. On the basis of picking of fruits these are classified as early (Gola, Selected Safeda), mid season (Sanaur-2, Sanaur-3, Sanaur-4, Sanaur-5, Wallaiti) and late (Umran, ZG-2 and Illaichi). The fruit colour was observed deep golden yellow in Umran which is more appealing to the consumers. Light golden yellow colour of fruits was noted in Sanaur-5 and Wallaiti. The fruits of Sanaur-2, Sanaur-3, Sanaur-4 and Gola attained light yellow colour at maturity. The total soluble solids ranged from 12.80 to 16.70 per cent among all the cultivars. The varieties were evaluated against the powdery mildew and it has been observed that Umran, Gola, Selected Safeda, Illaichi and Wallaiti were found highly susceptible whereas Sanaur-2, Sanaur-3, Sanaur-4, Sanaur-5 and ZG2 were found moderate to resistant to powdery mildew.

KEY WORDS: Ber, diversity, growth, yield, powdery mildew disease

The ber *(Ziziphus mauritiana lamk)* is an ancient and commercial fruits crop grown in arid and irrigated zones of Indian subcontinent. It has a long historic background mentioned in the earliest Sanskrit literature. Generally, the ber is called the poor man's fruit (Bal, 1979) although it is a very nutritious fruit and the grafted plants fetch a remunerative price in the market thus, ber is no longer the poor man's fruit. Its cultivation has been received a great impetus as a commercial crop in North India especially in the Punjab, Haryana and Rajasthan states, on accounts of its potential for high yield and good economic return to the fruit growers (Bal, 1999). China ranks first among ber growing countries of the world. The total area under ber growing in India is about ninety thousand hectares with annual production of about nine lakh tones. India is the second most important ber growing country in the world. The important states for ber cultivation in India are Maharashtra, Gujarat, Madhya Pradesh, Punjab, Haryana, Rajasthan, Bihar, Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Assam. Productivity of ber in India is 10 metric tonnes per hectare. The total area under ber in Indian Punjab is 2206 ha. The annual production of ber out of this area is 38189 mt and productivity is 16.6 mt/ha. In Punjab Sangrur, Bathinda, Ferozepur, Ludhiana, Patiala, Mukatsar, Mansa, Barnala and Faridkot are famous for ber growing. The ber fruit is known for its high nutritive value (Bal, 1992). Large number of varieties is available in India and some of them have been classified as early, mid

Table 1: Performance of the different varieties of the ber *(Ziziphus mauritiana)* in irrigated eco-system

Varieties	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	TSS (%)	Acidity (%)	Pulp (%)	Pulp stone ratio	Fruit yield (Kg)	Percent Disease index	Time of flowering	Time of ripening
Umran	30.45	5.11	3.49	15.25	0.25	94.77	18.15	195.9	55.25	10- 25th September	15th -7th April
Sanaur-2	21.93	4.20	3.21	14.28	0.44	92.33	12.05	180.20	3.75	1-10th September	7th -30th March
Sanaur-3	18.36	3.87	3.10	14.10	0.44	91.01	10.12	158.50	5.25	7 - 20th September.	7th -30th March
Sanaur-4	19.32	4.18	2.87	15.25	0.32	92.39	12.14	142.40	15.25	7-20th September	7th -30th March
Sanaur-5	20.80	4.10	2.81	15.27	0.56	92.30	12.0	150.50	22.50	7-20th september	7th -30th March
Wallaiti	17.42	4.20	2.47	14.89	0.38	91.67	11.01	123.13	7.0	10 -15thSeptember	10th -20th March
Ellaichi	4.60	2.17	1.01	16.70	0.25	88.54	12.14	92.80	1.25	10 -25th September	15th -5th April
ZG2	16.37	3.83	2.86	14.35	0.20	92.11	11.68	137.4	3.50	10th-25th September	15th -15th April
Gola	12.77	3.60	2.59	12.80	0.38	89.89	8.89	104.4	36.50	7 -25th September	10th -28th Feb
Selected Safeda	13.25	3.17	2.80	14.25	0.32	90.11	9.11	114.70	6.50	1 -15th September	10th -28th Feb

and late on the basis of their maturity. There is lot of genetic diversity in ber present in India and some of the promising varieties need to be identified that are resistant to various diseases having good shelf life and high yield potential having small stone and minimum spines, uniform ripening and juicy in nature that can be easily eaten by the old age people. So keeping in view the same, the study was carried out to evaluate performance of different varieties of ber *(Ziziphus mauritiana Lamk)* in irrigated eco-system of northern India.

MATERIALS AND METHODS

The study was carried out at Punjab Agricultural University, Regional Fruit Research Station, Bahadurgarh, Patiala. This experiment was planned in randomized block design. There are 50 varieties planted and out of which ten promising varieties i.e. Umran, Sanaur-2, Sanaur-3, Sanaur-4, Sanaur-5, Wallaiti, Ellaichi, ZG2, Gola, and Selected Safeda were under study. These are evaluated for fruit yield, quality and reaction to the Powdery mildew and vegetative growth. The trees were planted 11m x 11m apart in square system. The trees are fully grown and are maintained under uniform cultural operations throughout the period of the study. Yearly observations were recorded on the various physic-chemical characters of the fruit, viz, i.e. fruit weight, fruit length, fruit breadth, TSS, acidity, pulp percentage pulp stone ration, fruit yield, average leaf size in term of length and breadth, thorn length, time of flowering, branching habit, internodal length fruit apex, fruit color, fruit shape, orientation to thorns reaction to powdery mildew, percent disease index. Fruit and leaf size in terms of length and breadth was measured by Vermeer calipers. Yield data was recorded at the time of each picking. For determining average fruit weight, a representative sample of 25 fruits was taken. TSS was determined with the help of a Digital hand refractometer whereas acidity was estimated by titrating 2ml fruit juice against N/10 NaOH solution. Time of ripening of fruit was recorded on the basis of fruit colour.

RESULTS AND DISCUSSION

There is lot of genetic diversity in the ber grown in the country so to optimize fruit yield and to improve quality and subsequent increase in the income of fruit growers a field gene bank was established at RFRS Bahadurgarh in which more than 50 varieties were collected from various sources and out of which ten promising were evaluated for fruit yield, quality and reaction to the Powdery mildew

Table 2: Performance of the different varieties of the ber (*Ziziphus mauritiana*) in irrigated eco system

Varieties	leaf length (cm)	Leaf width (cm)	Internodal length (cm)	Branching habit	Fruit apex	Fruit colour	Fruit shape	Orientation of thorns	Thorn length (cm)	Reaction to Powdery Mildew
Umran	7.65	5.55	7.25	Spreading	Round with depression	Deep golden yellow	Oval	Up and down	0.33	Susceptible
Sanaur-2	7.48	5.53	3.75	Spreading	Slightly pointed	Light yellow	Oval oblong	Up&down	0.6	Resistant
Sanaur-3	6.60	3.50	5.00	Spreading	Medium pointed	Light yellow	Beaked	Up&down	0.5	Moderate
Sanaur-4	7.35	6.10	5.00	Spreading	Medium pointed	Light yellow	Beaked	Up&down	0.5	Resistant
Sanaur-5	6.60	4.91	4.67	Spreading	Round with depression	Light golden yellow	Oval	Up&down	0.4	Resistant
Wallaiti	6.40	3.82	5.00	Erect	Slightly pointed	Light golden yellow	Oval	Up&down	0.65	Susceptible
Ellaichi	7.37	4.11	4.50	Spreading	Round	Ligth Brown	Ovalate	Up&down	0.4	Susceptible
ZG2	5.75	5.28	5.00	Spreading	Round with depression	Greenish yellow	Ovalate roundish	Up&down	0.8	Moderate
Gola	8.34	5.4	4.83	Spreading	Round	Light yellow	Round	Up&down	0.65	Susceptible
Selected Safeda	8.20	5.05	4.75	Spreading	Round	Yellowish green	Round	Up&down highly curve	0.35	Susceptible

the most serious disease. The results of the experiment presented in Table (1) revealed that maximum fruit weight (30.45 gm) was recorded in cultivar Umran followed by Sanaur 2 i.e. 21.93 gram and 20.80 gram in Sanaur-5. Whereas minimum fruit weight 4.60 gram was recorded in Ellaichi followed by Gola 12.77gram. The fruit weight among all varieties ranged from 4.60 to 30.45 gm. The fruit size in terms of length and breadth was recorded in all the varieties and maximum fruit size (5.11 X 3.49 cm) was recorded in Umran followed by Sanaur-2 i.e. 4.20 x 3.21 cm. and minimum i.e. smallest fruit was recorded in Ellaichi 2.17 x 1.01 cm. While among all the varieties it ranged from 2.17 x1.01 cm to 5.11 x 3.49 cm. respectively. The pulp percentage in all varieties ranged from 88.54 to 94.77%. The maximum pulp percentage (94.77%) was recorded in Umran followed by Sanaur-4 i.e. 92.39. The pulp stone ratio in different varieties ranged from 8.89 to 18.15 percent. The maximum pulp stone ratio was recorded in Umran & minimum in Gola variety. The total soluble solid (TSS) ie index of sweetness was ranged from 16.70 to 12.80% i.e. maximum16.70 % was observed in Ellaichi followed by Sanaur-5 and Umran. The titratable acidity ranged from 0.20 to 0.56 among all the varieties under evaluation. The Umran cultivar proved very commercial variety as it yield maximum fruit yield 195.9 Kg/ plant/ year followed by Sanaur-2 i.e.180.20 Kg/ plant/ year. The maximum leaf length 8.34 cm was recorded in cultivar Gola followed by Selected Safeda whereas leaf width 6.1 cm was recorded in Sanaur-4 followed by Umran and Sanaur No.2. The maximum internodal length 7.25 cm. recorded in cultivar Umran and minimum 3.75 cm was recorded in Sanaur No.2 that constitutes the bushiness in the cultivar Sanaur No.2. The orientation of the thorns in all the varieties is up and down. The thorns that interfere in the harvesting operation are an important parameter. The length of the thorns is the deciding factor in the easiness of harvesting. The length of the thorns in all the varieties ranged from 0.33 to 0.8 cm. The maximum length of the thorns (0.8 cm) was recorded in ZG-2 followed by Wallaiti and Gola whereas shortest thorn 0.33 cm. was recorded in Umran. In Selected Safeda the thorns are highly curved. The reaction to the powdery mildew in all the varieties was recorded and Sanaur -2, Sanaur-4, Sanaur-5 were found resistant whereas Umran, Illaichi, Gola, Selected Safeda were found susceptible. The picking of fruits starts from 10th February to 15th April. On the basis of picking of fruits these are classified as Early (Gola, Selected Safeda) mid season (Sanaur-2, Sanaur-3, Sanaur-4, Sanaur-5and Wallaiti where as Umran, ZG-2 and Illaichi are late. Gupta (1977) reported that the largest fruit size in Umran followed by Sanaur -2. Sriharibabu and Kumar(1988) reported that the flowering in the different variety in Andhra Pradesh start in the month of May and completed in the month June i.e. the flowering in the northern India vary from southern India. No off-season flowering was observed in any variety except in the Sanaur 2 In all the varieties and flowering commences from 1st September and completed up to 25th September. Randhawa and Biswas (1966) also stated that ber flower from May to July in Southern India. On the other hand ber in the subtropical climate of the northern India flowers from September to November .This variation is due to prevailing tropical climatic conditions of south India. These varieties are also evaluated against the Powdery mildew and it has been observed that Umran and Gola were found highly susceptible where as Sanaur-2, Sanaur-3 Selected Safeda, ZG-2 and Illachi and Wallaiti were found tolerant to powdery mildew. The percent disease index (PDI) ranged from 1.25 to 55.25 percent among all the varieties under study. Aulakh *et. al* (2000) studied three variety of the ber in foothill area of the kandi and reported maximum fruit yield 32.3 kg per plant in the Sanaur -2 followed by Umran and similar trend was recorded in the plant spread stem girth, and spread etc. Tomar and Singh (1987) studied the performance of the six promising cultivar in the arid zone of the Punjab. The heaviest fruit weight and large size of fruits was in Umran have been reported by Gupta (1977) and Tomar and Singh (1987). The fruit of Gola require less degree days for their maturity. This could be the reason for early maturity of Gola fruits (Singh *et. al* 1998)

REFERENCES

Bal, J.S. 1979. Ber the poor man's fruit. *Science Reporter*, **16(2)**: 126-27.

Bal, J.S. 1992. Ber for health and profit. *The Tribune*, **112(84)**: 6.

Bal, J.S. 1999. Grow ber successfully. *The Tribune*, **119(2 Jan.)**: 13.

Randhawa, G.S. and Biswas, G.S. 1966. Studies on the morphology and chemical composition of some jujube varieties *Indian J Hort.*, **22**: 101-10.

Gupta, M. R.1977. Physical chemical character of the some promising ber cultivars grown at Bahadurgarh Patiala *Punjab Hort. J.*, **17**: 131-134

Aulakh, P.S. 2000. Performance of ber varieties grown under rainfed conditions In Punjab. *Indian J. Hort.* **5792**: 123-124.

Singh R.S.V. and Parsad, R.N. 1998. Micrometeorology of ber *(Ziziphus mauritiana Lamk)* orchard grown under rainfed arid conditions. *Indian J. Hort.* **55(2)**: 97-107.

Tomar, N.S. and Singh, R. 1987. Performance of the six promising ber cultivars grown at Bhatinda. *Haryana J.Hort.* Sci.**16**: 52-58.

Sriharibabu, R. and Sampath, P.K. 1988. Studies on the growth and flowering of certain cultivars of *ber (Ziziphus mauritiana)*At Hyderabad *Haryana J. Hort. Sci.* **17(1-2)**: 24-27.

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Production and quality assessment of onion under influence of transplanting dates and sulphur fertilization

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ABSTRACT

The response of three different planting dates and forms of sulphur fertilization on physico-chemical traits of 'Pusa Red' cultivar of onion (*Allium cepa* L.) were assessed in a field experiment during *rabi* season of 2013-14. The experiment comprises three planting dates namely, 15th November 2013, 15th December 2014 and 15th January 2014, and three doses of elemental sulphur and gypsum each 20kg/ha, 40kg/ha and 60kg/ha, respectively. The experiment was laid out in factorial randomized block design with three replications. The data clearly revealed that early date of planting *i.e.* 15th November with 40 kg/ha of elemental sulphur significantly influenced the growth, yield and yield attributing characters i.e. plant height, number of leaves, neck thickness, bulb length, bulb diameter, bulb size and bulb weight of onion compared to other two planting dates, sulphur and gypsum levels. However, it was at par with early date of planting *i.e.* 15t1h November with 60kg/ha elemental sulphur. Similarly, higher TSS and ascorbic acid content in bulb were recorded in early planting (15th November with 60kg/ha and 40kg/ha), respectively and significantly higher reducing sugar, non-reducing sugar and total sugars were obtained with early planting *i.e.* 15th November with 20kg/ha of elemental sulphur, while higher content of pyruvic acid was found in late planting (15th January with 60kg/ha of elemental sulphur) of the crop.

KEY WORDS: Onion, Planting dates, Elemental Sulphur, Gypsum, Pyruvic acid.

Onion is one of the most important commercial vegetable crops grown in rabi season. It is an important crop used as a vegetable and spice as well all over the world. It is extremely important vegetable crop not only for internal consumption but also as highest foreign exchange earner among the fruits and vegetables. The productivity of onion 13.20 tonnes per ha in the country is very low compared to world average productivity *i.e.*19.10 tons per hectare. The reasons for low productivity are mainly attributed to improper planting schedule and inadequate supply of balanced nutrients, particularly sulphur. Onion is a temperature and photoperiod sensitive crop. Early transplanting results in higher yield but majority of the bulb undergoes to bolting due to low temperature during the early stage of its development, while later transplanting results in low yield. Bolted onion decreases the marketable value of the bulbs. So, it requires a proper time adjustment of their transplanting without affecting the yield. Sulphur deficiency in Indian soils adversely affects crop production besides recommended dose of NPK fertilizers application. Today, the use of gypsum as a source of sulphur fertilization not only harm the soil but also unavailable to the crop because of its low solubility in the soil. Elemental sulphur (S°) has the advantages of ready supply, lower production costs and, because of its high analysis, lower transportation cost and fewer drill fills during field operations. Yearly and regional variation in the flavor potential of onion can be a problem for growers wishing to produce a consistent product and for the consuming public. Though, the limits of flavor potential are ultimately determined by genetics, multiple environmental factors can act to influence flavor within physiological limits. The purpose of this research was to determine how different transplanting time, two form of sulphur (elemental sulphur and gypsum) and their interaction influenced the flavor development in onion.

MATERIALS AND METHODS

To standardize the planting time and evaluate the optimum dose of two forms of sulphur on the quality attributes in onion a field experiment was conducted at the Babasaheb Bhimrao Ambedkar University, Lucknow, U.P. India, during 2013-14. Pusa Red cultivar of onion

Table 1: Effect of planting dates and forms of sulphur on growth and yield of onion bulb (2013-14)

Treatments	Plant height (cm)	No. of leaves	Neck thickness (cm)	Bulb weight (g)	Bulb length (cm)	Bulb diameter (cm)	Bulb size (cm^2)	Bolting percentage (%)	Yield/plot (kg)	Yield (q/ha)
Planting time										
Nov 15, 2013	73.50	10.40	2.53	77.52	6.30	6.94	42.66	6.28	5.27	351.7
Dec 15, 2013	65.01	8.84	2.37	67.94	5.70	6.15	34.27	4.90	4.71	314.3
Jan 15, 2014	61.07	7.21	2.24	56.12	5.07	5.52	27.45	0.04	3.88	259.9
C.D. (P=0.05)	1.93	0.18	0.04	1.74	0.15	0.11	1.19	0.51	0.06	0.43
SE(d)	0.95	0.09	0.02	0.86	0.07	0.05	0.59	0.25	0.03	0.21
Two-form of sulphur doses										
RDF (control)	63.92	7.32	2.19	53.93	4.08	5.11	24.26	3.66	4.25	283.7
S^0 20 Kg/ha	66.17	8.51	2.36	65.52	5.85	6.03	33.62	3.88	4.59	306.0
S^0 40 Kg/ha	68.99	10.13	2.54	75.91	6.17	6.80	40.68	3.11	4.93	329.1
S^0 60 Kg/ha	68.03	9.45	2.45	71.07	5.92	6.59	38.47	3.44	4.74	318.1
Gy 20 Kg/ha	64.72	8.15	2.29	62.47	5.41	6.04	33.12	4.55	4.43	295.5
Gy 40 Kg/ha	67.38	9.46	2.46	72.61	5.93	6.51	37.72	4.00	4.75	317.0
Gy 60 Kg/ha	66.46	8.71	2.38	68.81	5.75	6.33	35.69	3.55	4.67	311.1
C.D. (P=0.05)	2.95	0.27	0.07	2.66	0.23	0.17	1.82	0.78	0.09	0.66
SE(d)	1.45	0.13	0.03	1.31	0.11	0.08	0.90	0.38	0.04	0.33

was opted because it is a less bolting type variety. The experiment was conducted in factorial RBD design with three replications having three transplanting dates (November 15, December 15 and January 15) as one factor and different doses of gypsum and elemental sulphur (20 kg/ha, 40 kg/ha and 60 kg/ha) as another factor. Seedlings of same age (8 weeks-old) were transplanted with a spacing of 15x10 cm. Recommended dose of fertilizer (150:60:60) in the form of Urea, Single Super Phosphate and muriate of potash was applied to grow the crop. Urea was applied in three split doses, first along with phosphorus and potash at the time of land preparation and remaining 2/3rd in later stages. Data were recorded after harvesting on plant height (cm), number of leaves, neck thickness (cm), bulb weight (g), bulb length (cm), bulb diameter (cm), bulb size (cm^2), bolting percentage (%), yield per plot (kg), yield per hectare (q), total soluble solids (^{0} Brix), ascorbic acid (mg/100g), pyruvic acid (µm/g), total sugars (%), reducing sugar (%) and non- reducing sugar (%). TSS were analysed by Hand Refractrometer, Indophenol method was used for the determination of Ascorbic acid. Pyruvic acid analysis was performed according to Schwimmer and Weston (1961) and total, reducing and non-reducing sugars were analysed by Lane and Eynon Method (1923).

RESULTS AND DISCUSSION

It is clearly revealed from the data that there was a significant effect of different planting dates on the vegetative growth of the crop (Table. 1). Maximum plant height (73.50 cm), number of leaves (10.40), neck thickness (2.53 cm), bulb weight (77.52 g), bulb length (6.30 cm), bulb

Table 2: Effect of planting dates and forms of sulphur on quality (bio-chemical) attributes of onion bulb (2013-14)

Treatments	TSS (^{0} Brix)	Ascorbic acid (mg/100g)	Pyruvic acid (µm/g)	Total Sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)
Planting dates						
Nov 15, 2013	15.42	12.64	4.74	11.59	5.07	6.06
Dec 15, 2013	13.78	11.62	5.47	11.08	4.31	6.80
Jan 15, 2014	12.40	8.27	6.78	9.10	2.74	6.38
C.D. (P=0.05)	0.11	0.39	0.11	0.07	0.17	0.08
SE(d)	0.05	0.19	0.05	0.03	0.08	0.04
Two-form of sulphur doses						
RDF (control)	12.20	8.85	4.02	9.69	3.41	5.88
S^0 20 Kg/ha	13.48	10.25	5.50	11.50	4.57	6.96
S^0 40 Kg/ha	14.48	11.96	6.19	10.87	4.22	6.60
S^0 60 Kg/ha	15.39	11.58	6.72	10.21	4.06	6.17
Gy 20 Kg/ha	12.88	10.56	5.13	11.09	4.35	6.81
Gy 40 Kg/ha	14.21	11.76	5.75	10.66	3.95	6.32
Gy 60 Kg/ha	14.44	10.98	6.32	10.12	3.71	6.14
C.D. (P=0.05)	0.17	0.59	0.18	0.10	0.26	0.13
SE(d)	0.08	0.29	0.08	0.05	0.12	0.06

Table 3: Interaction effects of different planting dates and forms of sulphur on growth and yield of onion bulb (2013-14)

Parameters / Treatment combinations		Plant height (cm)	No. of leaves	Neck thick-ness (cm)	Bulb weight (g)	Bulb length (cm)	Bulb diameter (cm)	Bulb size (cm^2)	Yield /plot (kg)	Yield (q/ha)	Bolting percent-age (%)
Planting dates	Sulphur doses										
Nov 15, 2013	RDF (Control)	70.98	8.70	2.35	60.87	5.23	5.91	30.50	4.91	328.6	6.33
	RDF + S^0 20 Kg/ha	73.67	9.86	2.52	77.56	6.56	6.95	43.14	5.27	351.4	5.66
	RDF + S^0 40 Kg/ha	**76.12**	11.53	2.70	87.55	6.79	7.59	49.05	5.67	378.3	5.33
	RDF + S^0 60 Kg/ha	74.61	11.23	2.61	82.01	6.65	7.32	46.74	5.42	361.4	6.66
	RDF + Gy 20 Kg/ha	71.28	9.76	2.43	68.73	5.78	6.49	39.62	5.02	334.6	7.33
	RDF + Gy 40 Kg/ha	74.81	11.13	2.59	84.78	6.62	7.21	45.33	5.35	356.5	6.66
	RDF + Gy 60 Kg/ha	73.02	10.60	2.52	81.11	6.51	7.13	44.26	5.27	351.2	6.00
Dec 15, 2013	RDF (control)	62.54	7.06	2.20	51.89	4.82	4.82	22.50	4.24	282.8	4.33
	RDF + S^0 20 Kg/ha	64.82	8.43	2.33	62.69	5.86	5.84	31.67	4.68	311.9	6.00
	RDF + S^0 40 Kg/ha	67.62	10.50	2.52	78.29	6.14	6.74	40.49	5.03	335.2	4.00
	RDF + S^0 60 Kg/ha	66.63	9.46	2.46	73.93	5.91	6.61	38.52	4.83	322.4	3.66
	RDF + Gy 20 Kg/ha	63.74	8.06	2.27	65.22	5.52	6.20	33.48	4.49	299.2	6.33
	RDF + Gy 40 Kg/ha	65.18	9.90	2.48	74.38	5.90	6.50	37.51	4.91	327.5	5.33
	RDF + Gy 60 Kg/ha	64.58	8.46	2.37	69.17	5.76	6.31	35.71	4.82	321.5	4.66
Jan 15, 2014	RDF (control)	58.24	6.20	2.02	49.03	4.37	4.61	19.79	3.59	239.7	0.33
	RDF + S^0 20 Kg/ha	60.04	7.23	2.23	56.33	5.14	5.29	26.03	3.82	254.6	0.00
	RDF + S^0 40 Kg/ha	63.23	8.36	2.41	61.89	5.59	6.06	32.49	4.11	273.9	0.00
	RDF + S^0 60 Kg/ha	62.85	7.66	2.28	57.26	5.21	5.85	30.15	3.96	270.6	0.00
	RDF + Gy 20 Kg/ha	59.15	6.63	2.18	53.48	4.93	5.44	26.26	3.79	252.8	0.00
	RDF + Gy 40 Kg/ha	62.17	7.36	2.32	58.67	5.28	5.82	30.33	4.00	267.0	0.00
	RDF + Gy 60 Kg/ha	61.80	7.06	2.26	56.17	5.00	5.56	27.12	3.92	260.6	00.0
C.D(P=0.05)		NS	0.48	NS	4.61	0.39	0.30	NS	NS	NS	NS
SE (d)		2.52	0.23	0.08	2.27	0.19	0.15	1.56	0.08	0.57	0.66

diameter (6.94 cm), bulb size (42.66 cm^2), bolting percentage (6.28 %), yield per plot (5.27 kg) and yield per hectare (351.7 q/ha) were recorded in early planting date i.e. 15th November which was followed by planting date of 15th December (65.01 cm, 8.84, 2.37 cm, 67.94 g, 5.70 cm, 6.15 cm, 34.27 cm^2 4.90 %, 4.71 kg and 314.3 q/ha respectively). Minimum figure were recorded for these parameters i.e. plant height (61.07 cm), number of leaves (7.21), neck thickness (2.24), bulb weight (56.12 g), bulb length (5.07 cm), bulb diameter (5.52 cm), bulb size (27.45), bolting percentage (0.04 %), yield per plot (3.88 kg) and yield per hectare (259.9 q/ha) in late planting i.e. 15th January. These results are might be due to low average temperature while early transplanting and gradual increase in average temperature during delayed transplanting results decreased yield (Al-Rehim, 1997). The latest planting date showed that the lowest growth parameters values may be due to the short period allowed for growth which is also in conformity of the findings of (Sawant *et al*., 2002) who reported that early planting showed significantly higher growth values than the later planting in the two growing seasons .Similarly, chemical properties were significantly influenced by the planting dates (Table 2). Early planting (15thNovember) resulted in higher content of TSS (15.42^{0}Brix), ascorbic acid (12.64 mg/100g), total sugars (11.59%) and reducing sugar (5.07 %) followed by second planting date (15th December) having TSS (13.78^{0}Brix), ascorbic acid (11.62 mg/100g), total sugars (11.08%) and reducing sugar (4.31 %). The minimum values for these traits (TSS, ascorbic acid, total sugars and reducing sugar) were recorded (12.40^{0}Brix, 8.27 mg/100g, 9.10% and 2.74%, respectively) in late planting (15th January). In contrast to these observations, maximum pyruvic acid (6.78µm/g) was recorded in late planting date (15th January) and non-reducing sugar (6.80 %) was in second planting date (15th December). The soluble solid content of mature bulbs had a negative linear response to increasing temperature. Total sugars and reducing sugar were decreased with delay in planting. Total sugars and reducing sugar content was highest at low temperature and exceptionally low at high growing temperature. Non-reducing sugar content decreased at late planting this might be due to inversion of non-reducing sugar to reducing sugar because of increase in respiration due to high temperature. Pyruvic acid content is highest at temperature condition 20^{0}C because biosynthesis of cysteine activates effectively at temperature condition of 20^{0}C (Lee and Suh, 2009). Maximum content of ascorbic acid in early planting might be due to maximum sugar synthesis (reducing sugar) during photosynthesis which is responsible for the synthesis of ascorbic acid (Stone, 1972).Interaction between different planting times and sulphur forms and their doses had significant effect

Table 4: Interaction effect of planting dates and forms of sulphur on quality attributes of onion bulb (2013-14)

Treatment combinations / Parameters		TSS (^{0}Brix)	Ascorbic acid (mg/100g)	Pyruvic acid (µmol/g)	Total sugars (mg/100g)	Reducing sugar (%)	Non-reducing sugar (%)
Planting dates	Sulphur doses						
Nov 15, 2013	RDF (Control)	13.85	10.17	3.11	10.57	4.31	5.50
	RDF + S^0 20 Kg/ha	14.96	12.12	4.82	12.52	5.74	6.78
	RDF + S^0 40 Kg/ha	15.91	14.02	5.20	11.79	5.37	6.32
	RDF + S^0 60 Kg/ha	16.87	13.71	5.71	11.25	5.23	5.81
	RDF + Gy 20 Kg/ha	14.56	12.18	4.25	12.10	5.32	6.63
	RDF + Gy 40 Kg/ha	15.76	13.71	4.76	11.61	4.81	5.77
	RDF + Gy 60 Kg/ha	16.06	12.60	5.32	11.33	4.69	5.62
Dec 15, 2013	RDF (control)	12.03	9.06	4.15	10.03	3.71	6.28
	RDF + S^0 20 Kg/ha	13.55	10.79	5.23	12.06	4.78	7.30
	RDF + S^0 40 Kg/ha	14.63	12.42	5.90	11.42	4.53	6.93
	RDF + S^0 60 Kg/ha	15.23	12.08	6.48	10.79	4.32	6.55
	RDF + Gy 20 Kg/ha	12.94	11.87	4.90	11.62	4.59	7.12
	RDF + Gy 40 Kg/ha	13.98	13.02	5.42	11.21	4.21	6.84
	RDF + Gy 60 Kg/ha	14.11	12.14	6.23	10.43	4.03	6.57
Jan 15, 2014	RDF (control)	10.73	7.32	4.81	8.48	2.21	5.85
	RDF + S^0 20 Kg/ha	11.93	7.83	6.44	9.92	3.21	6.81
	RDF + S^0 40 Kg/ha	12.89	9.44	7.48	9.38	2.78	6.55
	RDF + S^0 60 Kg/ha	14.08	8.97	7.97	8.58	2.63	6.15
	RDF + Gy 20 Kg/ha	11.14	7.62	6.25	9.56	3.14	6.68
	RDF + Gy 40 Kg/ha	12.91	8.55	7.08	9.15	2.85	6.37
	RDF + Gy 60 Kg/ha	13.15	8.19	7.43	8.60	2.41	6.23
C.D. (P=0.05)		0.30	1.03	0.31	0.18	NS	0.23
SE (d)		0.14	0.50	0.15	0.09	0.22	0.11

on the growth and bulb yield of the crop (Table. 3). Maximum number of leaves (11.53), bulb weight (87.55 g), bulb length (6.79 cm), bulb diameter (7.59 cm) were found in early planting i.e. 15th November with application 40 kg/ha elemental sulphur which is at par with 15th November planting with gypsum 40 kg/ha for bulb weight (84.78 g) and 15th November planting with elemental sulphur 60 kg/ha for number of leaves (11.23), neck thickness (2.61 cm), bulb length (6.65 cm) and bulb diameter (7.32 cm), while there was a non-significant interaction found in other parameters. Quality traits of the bulb were also significantly affected by the interaction between three planting dates and three doses of two form of sulphur (Table 4). The maximum TSS (16.87 ^{0}Brix) and ascorbic acid (14.02 mg/100g) was found in 15th November planting with $S^0$60 kg/ha and 15th November planting with $S^0$40 kg/ha, respectively which was significantly higher than all other treatments, while minimum TSS (11.14 ^{0}Brix) and ascorbic acid (7.62 mg/100g) were recorded in 15th January with Gy 20 kg/ha among other treatment combinations except control. The highest content of pyruvic acid (7.97 µmol/g) was found in 15th January with S^0 60 kg/ha. Similarly, maximum total sugars (12.52 %) was found in 15th November with S^0 20 kg/ha and non-reducing sugar (7.30 %) was found in 15th December with S^0 20 kg/ha. Similar results were previously found by (Bharti and Ram, 2014). Application of elemental sulphur up to 40 kg/ha significantly increased the plant growth, yield and other bio-chemical parameters as compared to gypsum mediated sulphur fertilization. This might be due to low solubility of gypsum in the soil and as in turn less availability of SO_2^{-4} for crop because of leaching loss (Singh, 2008).

It is concluded after overall interpretation of the findings that early planting (15th November) along with application elemental sulphur 40 kg/ha is much more economical to get higher bulb yield and exhibited better quality of bulbs in comparison to rest of the treatments of delayed planting and gypsum fertilization along with higher doses. So, higher yield and quality of bulbs can be obtained by proper nutrient balance and optimum time adjustment of transplanting.

REFERENCES

1. Bharti, N. and Ram, R.B. 2014. Estimating variation in the production, quality and economics of onion in response to transplanting dates and sulphur fertilization. *Europeon Academic Research*. **2(4)**: 4831-4843.
2. El-Rehim, G. H. A.; Ahmed, F. A.; Shalaby, G. I. and Waly, A. A. 1997. Effect of transplanting date and planting density on bulb yield and quality of Giza 20 onion in upper Egypt. *Egyptian Journal of Agricultural Research*. **75(3)**:681-695.
3. Lane and Eynon 1923. Determinations of sugars by fehling solution with methylene blue as a indicator. *J. Soc. Chem.* Ind. 42:32.

4. Lee, E. J. and Suh, J. K. 2009. Effect of temperature on growth, pyruvic acid and sugar contents in onion bulbs. *Kor. J. Hort. Sci. Technol*. **27(4)-**554-559.

5. Sawant, S. V.; Ingavale, M. T.; Mangave, K. K.; Wath, B. K. and Bhat, N. R. 2002. Effect of date of planting on growth, yield and quality of onion (*Allium cepa* L.). *Vegetable Science*. **29(2):**164-166.

6. Schwimmer, S. and Weston, W. J. 1961. Enzymatic development of pyruvic acid in onion as a measure of pungency. *J. Agric. Food Chem*. 9:301-304.

7. Singh, S. 2008. Effect of sulphur on yields and S uptake by onion and garlic grown in acid alfisol of Ranchi. *Agri. Sci. Digest*. **28 (3):**189-191.

8. Stone, I. 1972. The natural history of ascorbic acid in the evolution of the mammals and primates and its significance for present day man. *J. Orthomolecular Psychiatry*, **1(2-3):** 82-89.

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Effect of cushioning and wrapping materials during post harvest storage for extending shelf life of mango (*Mangifera indica* L.)

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ABSTRACT

The effect of different wrapping materials on post harvest decay loss of mango fruits under ambient conditions (17–25°C (RH 70–80%) was studied. Results revealed that post harvest decay loss can be minimized significantly through proper wrapping of fruits during storage. The main aim of study was to find out the suitable low cost wrapping and cushioning materials for mango fruits such as wrapping of fruits with tissue paper, wrapping of fruits with cling wrap, wrapping of fruits with banana leaves, wrapping of fruits with teak leaves, cushioning of fruits with neem leaves, cushioning of fruits with rice straw, cushioning of fruits with bamboo leavesand control. Above wrapping and cushioning materials were replicated three times under ambient conditions. Observations for all the parameters of these treatments were taken at zero day, four days and seven days after harvesting. The results showed that there was no significant effect of different wrapping and cushioning materials on size of fruits whereas fruit weight and fruit volume were significantly affected by treatments. Minimum per cent loss in weight was recorded from the fruits which were wrapped in cling wrap. There was significant effect of treatments on chemical parameters like TSS, sugar, ascorbic acid and pectin content. Maximum retention of ascorbic acid and pectin was recorded from the fruits which were wrapped in cling wrap. Cling wrap showed better results for chemical parameters followed by wrapping of Teak leaves. In overall quality, cling wrap showed best results accept in organoleptic evaluation while wrapping of Teak leaves showed better results in all treatments including organoleptic rating. Fruits without wrapping and cushioning showed poor results for all parameters.

KEY WORDS: Mango, cushioning, wrapping, shelf life.

Mango is recognized as one of the choicest and is well accepted fruit all over the world and also acknowledged as the king of fruit. In India mango is considered to be the best of all indigenous fruits because of its excellent flavour, attractive fragrance, beautiful shades of colour, delicious taste and nutritional value. Like many other fruits, mango is highly perishable in nature. The fruits undergo many physiological and biochemical changes that lead toripening and senescence. Shelf life of mango might beextended by stopping or slowing down thesephysicochemical changes. Due to lack of properpreservation technology, the post harvest loss of mangodue to decay is considerable. To reduce this loss and toincrease the shelf life, efforts are need to develop postharvest technologies which are not health hazardousand would suit climatic and socio-economic conditionsof India. Recently, Hassan (2010) reported thatthe postharvest loss of mango in supply chain was 27%. Hence, adequate measures should be taken to prolongshelf life of mangoes. Due to mishandling, inadequatestorage or lack of postharvest technical knowledge, producers and traders have to face about 27% losses (Hassan, 2010), and loss of this perishable commodity is estimated up to 320.7 thousand tons annually with avalue of 3,000 lakh in the country (Haq, 2002). Use of proper packaging and cushioning materials help a great extent to enhance shelf life of fruits. Different cushioning materials have different capacity toabsorb the moisture and gases evolved from fruits and thus alter shelf life of fruits. Cushioning of fruits is also helpful to protect the fruits from physiological losses during transportation. Use of carbohydrate and lipid based edible waxes for skin coating and individual shrink wrapping (ISW) are some of the recent approaches proved to be effective in preventing change during storage (Dinamarca *et al*., 1987). Packaging used for fresh fruits and vegetables must meet some of the

most demanding conditions of any type of export packaging. In many cases, it must be able to control environmental factors such as temperature, vapour pressure, relative humidity, atmospheric composition and exposure to light. Temperature management is one of the most critical factors for such exports. Among the marketing considerations that are particularly important in choosing the right packaging for distribution organization, shelf-life, turnover rate of the produce, space limitations in the sales outlets and requirements for effective presentation of the produce to consumers (Anonymous, 1988). The use of proper packaging materials to extend the shelf life of fruits is very important. Total soluble solids, acidity and ascorbic acid content of the fruits were not affected by any of the packing materials. Chlorophyll a, b and carotenoid contents of fruit were highest in fruits packed in polyethylene bags. These fruits also showed the lowest rate of respiration. Firmness decreased with increasing period of storage in all fruits packed in different cushioning materials, resulting in fruit softening. Fruits packed in polyethylene bags were firmer indicating that these fruits had a slow rate of ripening (Sharma *et al*., 1994)

Different type of packaging can be used depending upon the requirement of the produce and the target market. For developing country like India, it is necessary to find out cheap and effective packaging material to increase shelf life of fruits. The existing methods of packaging and storage are costly and not ease for farmers and sometime they increase cost of cultivation. Thus we are in need of such material which is low in cost, easily available as well as eco friendly.

MATERIALS AND METHODS

An experiment was carried out at Post Graduate Laboratory, Department of Horticulture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, district- Udhamsingh Nagar (Uttarakhand) in the year 2011 on mango variety namely Dashaheri collected from Horticulture Research Centre, Patharchatta. Maturity of mango was identified when the shoulderswere in line with the stem end and the colour wasgreen. The experiment was laid out in Completely Randomized Design (CRD) with 3 replications. Each replication consisted of 5 fruits. The harvested fruitswere cushioning and wrapped with new paper, cling wrap, banana leaves, teak leaves, neem leaves, rice staw and bamboo leaves separately. Fruits afterwrapping were stored at room temperature forobservation and data collection. The procedure explained by Koolpluksee *et al*. (1993) was followed.

Data on the following parameters were recorded. Eachfruit was observed at 4 days interval to record thecolour of the peel by estimation. Days required fromharvesting to softening fruits and shelf life of mangofruits as influenced by different postharvest treatmentswas calculated by counting the days required to ripenfruits as to retaining optimum marketing and eatingqualities. When the fruits were reached at pre-ripe, ripeand over ripe stage, general appearance and eatingquality (taste and flavour) was assessed fororganoleptic evaluation. Fruitsweight was recorded at 4 days interval and then weightloss was calculated and expressed as percentage. Total soluble solids (TSS) content of mango pulp was estimated using Abbe's Refractometer. A drop of mangojuice squeezed from the fruit pulp was placed on the prism of the refractometer, and TSS was recorded as % Brix from direct reading of the instrument. Temperature corrections were made using thetemperature correction chart.

RESULT AND DISCUSSION

Data presented in Table 3 showed that packaging

Table 3: Effect of wrapping and cushioning materials on fruit volume

Treatments	Fruit Volume (cc.)		
	At fully ripe stage	After 4 days	After 8 days
T1 (Fruits cushioning with New paper)	168.33	158.99	144.66
T2 (Fruits cushioning with cling wrap)	179.32	170.66	158.33
T3 (Fruits cushioning with banana leaves)	162.33	149.92	135.66
T4(Fruits cushioning with teak leaves)	175.34	163.98	158.00
T5(Cushioning of fruits with neem leaves)	173.00	162.45	156.66
T6(Cushioning of fruits with rice straw)	172.33	160.33	150.00
T7(Cushioning of fruits with bamboo leaves)	166.66	157.69	140.00
T8 (Control)	169.00	160.35	151.66
S. Em.±	1.21	1.02	0.98
C.D. at 5%	3.67	3.34	2.89

Table 5: Effect of wrapping and cushioning materials on loss in fruit weight (%)

Treatments	Loss in fruit weight (%)		
	At fully ripe stage	After 4 days	After 8 days
T1 (Fruits cushioning with New paper)	0.00	8.55	19.05
T2 (Fruits cushioning with cling wrap)	0.00	6.55	15.45
T3 (Fruits cushioning with banana leaves)	0.00	13.18	29.05
T4(Fruits cushioning with teak leaves)	0.00	11.62	21.73
T5 (Cushioning of fruits with neem leaves)	0.00	13.44	23.55
T6(Cushioning of fruits with rice straw)	0.00	10.58	22.56
T7(Cushioning of fruits with bamboo leaves)	0.00	12.94	24.76
T8 (Control)	0.00	14.32	29.32
S. Em.±	0.00	1.68	1.29
C.D. at 5%	0.00	NS	NS

materials had significant effect on fruit volume during storage. Fruit volume influenced significantly with storage period during storage. Maximum fruit volume was recorded in wrapping of fruits with Cling wrap (T_2) after 4 and 7 days of storage while at 4 and 7 days of storage minimum volume was recorded from wrapping of fruits with Banana leaves (T_3).

Volume of the fruit decreased consistently with the increase in storage period. However, the ratewas slower in the fruits which are wrapped. The wrapping of fruits with cling wrap, resulted in minimum volume loss of the fruits during storage. Lesser rate of reduction in volume loss of the fruits in wrapped may be due to retardation of the process of respiration and transpiration or rate of the moisture loss from the fruits (Khedkar*et al*., 1982).

It is evident from the data presented in Table 5 that packaging materials had significant effect on change in fruit weight during storage. Per cent loss in weight was not significantly affected by treatments upto 4th day of storage while significant effect of wrapping and cushioning was observe after seven days of storage. Among the packaging materials, maximum fruit weight loss during storage was shown by control. Minimum fruit losswas recorded in wrapping of fruits with Cling wrap (T_2), wrapping of fruits with Tissue paper (T_1) and wrapping of fruits with Teak leaves (T_4),materials as compared to control. Among the different treatments used, minimum loss in fruit weight was observed with the application of cling wrap as wrapping material followed by tissue paper wrapping and cushioning of rice straw and maximum loss in fruit weight was found with control after 7 days of storage. Minimum loss in weight might be due to reduction in respiration by modified atmosphere inside the cling wrapping. These results are in close conformity with the finding of Baviskar*et al*. (1995) as they reported maximum per cent loss in fruit weight from control fruits while polythene packed fruits showed minimum loss and Golomb*et al*. (1984) reported polyethylene film packaging has been to greatly reduced fruit weight loss under room condition. Similar results were also reported by Kumar *et al*. (2003) as they recorded significantly less PLW than the control when they packed fruits in modified atmosphere storage with individual paper wrapping and paper lining.

Careful analysis of data presented in Table 8 reflects that packaging materialshad no significant effect on total titratableacidity of the fruits during storage. Maximum total titratable acidity was recordedwhen fruits at zero day of storage. Acidity was gradually decreasing with storage period. Minimum acidity was recorded after 8 days of storage. After 4 and 8 days of storage maximum acidity (0.13, 0.14 per cent respectively) were recorded in wrapping of fruits with cling wrap (T_2) while minimum acidity was observed in control.

Acidity of the fruits decreased continuously in storage at room temperature. Maximum acidity was found when fruits are harvested. Minimum decrease in acidity was recorded from fruits which were wrapped in cling wrap followed by wrapping of fruits with Teak leaves whereas maximum decrease was recorded from control. The decrease in acidity during storage might be due to conversion of acids into salts and sugars by the enzymes particularly invertase. These findings are in close conformity with Agarwal*et al*. (2002) as they reported that titratable acidity decreased with advancing maturity.Similar findings as decrease in acidity during storage as a result of conversion of acids into salts and sugar have also been reported in mango (Mukherjee, 1972) and in Banana (Srivastava*et al*. 1972

Table 7: Effect of wrapping and cushioning materials on acidity

Treatments	Acidity (%)		
	At fully ripe stage	After 4 days	After 8 days
T1 (Fruits cushioning with New paper)	0.18	0.10	0.08
T2 (Fruits cushioning with cling wrap)	0.13	0.9	0.06
T3 (Fruits cushioning with banana leaves)	0.12	0.10	0.07
T4(Fruits cushioning with teak leaves)	0.11	0.8	0.09
T5(Cushioning of fruits with neem leaves)	0.11	0.6	0.05
T6(Cushioning of fruits with rice straw)	0.12	0.5	0.04
T7(Cushioning of fruits with bamboo leaves)	0.11	0.8	0.05
T8 (Control)	0.25	0.3	0.02
S. Em.±	0.017	0.011	0.09
C.D. at 5%	NS	NS	NS

A perusal of data presented in Table12 revealed that effect of packaging material on ascorbic acid content was found significant during storage. Higher retention of ascorbic acid content was found in fruits which were packed in different wrapping and cushioning materials while less retention of ascorbic acid content was found in control fruits during storage. Ascorbic acid content was found maximum at the zero day of storage and minimum ascorbic acidAfter 4 and 7 days of storage maximum fruit diameter (6.49 and 6.02, respectively) was found in wrapping of fruits with Cling wrap (T_2). Minimum fruit diameter (6.06 cm) was recorded in wrapping of fruits with teak leaves(T_4).

Study revealed that the ascorbic acid content of the guava fruit decreased from first day to last day of storage. Fruits wrapped in cling wrap retained higher content of ascorbic acid during storage. Cling wrap probably retard several process and hence the rate of conversion of L-ascorbic acid into dehydro ascorbic acid is slowed down.These results are in accordance with the finding ofKenawi*et al.* (1992)as they reported that ascorbic acid content of all produce decreased during storage, packing and storage at low temperature together reduced ascorbic acid loss. Similar result was reported by Srivastava*et al.* (1962) that decreasing trend of ascorbic acid during storage of guava fruits.

From the data presented in table 16 revealed that organoleptic rating was reduced with storage time. After 4th day of storage of fruits at wrapping of fruits with tissue paper(T_1) and fruits of control shown high organoleptic ratings (6.78, 6.33 respectively). Wrapping and cushioning materials had significant effect on organoleptic quality. After 7 days of storage poor organoleptic rating was recorded from all treatments. wrapping of fruits with cling

Table 11: Effect of wrapping and cushioning materials on ascorbic acid

Treatments	Ascorbic acid content (mg/100g)		
	At fully ripe stage	After 4 days	After 8 days
T1 (Fruits cushioning with New paper)	16.58	14.56	12.75
T2 (Fruits cushioning with cling wrap)	16.84	13.05	11.83
T3 (Fruits cushioning with banana leaves)	16.96	15.45	14.64
T4(Fruits cushioning with teak leaves)	17.28	15.38	14.04
T5(Cushioning of fruits with neem leaves)	17.51	16.01	11.46
T6(Cushioning of fruits with rice straw)	16.59	15.98	10.39
T7(Cushioning of fruits with bamboo leaves)	16.56	14.88	12.15
T8 (Control)	18.44	17.15	15.04
S. Em.±	0.18	0.15	0.13
C.D. at 5%	0.57	0.51	0.48

Table 15: Effect of wrapping and cushioning materials on Organoleptic rating

Treatments	Organoleptic rating		
	At fully ripe stage	After 4 days	After 8 days
T1 (Fruits cushioning with New paper)	7.20	6.25	4.70
T2 (Fruits cushioning with cling wrap)	7.13	5.84	4.20
T3 (Fruits cushioning with banana leaves)	6.95	6.06	4.29
T4(Fruits cushioning with teak leaves)	7.07	6.78	4.45
T5(Cushioning of fruits with neem leaves)	6.75	6.25	4.04
T6(Cushioning of fruits with rice straw)	6.61	5.83	3.49
T7(Cushioning of fruits with bamboo leaves)	6.92	5.80	3.67
T8 (Control)	7.52	6.20	3.69
S. Em.±	0.17	0.33	0.12
C.D. at 5%	0.51	0.99	0.37

wrap(T_2) showed poor organoleptic rating throughout the storage period.

Present finding revealed that the edible quality of guava fruit was decreasing with storage period. The organoleptic quality of the fruit was best maintainedin case of wrapping of fruits with teak leaves (T_4) during storage. Wrapping of fruits with cling wrap (T_2) which was superior in most of parameters showed a poor organoleptic rating.The reduction in moisture in fruits causing shrinkage, dullness in skin and loss of turgidity observed in control.Siddiqui and Gupta (1997) were also reported that the organoleptic quality was better in wrapped guava fruits as compare to unwrapped control fruits except polythene wrapped fruits which showed poor organoleptic rating throughout the storage.

It is evident from data presented in Table 11 showed that the effect of wrapping and cushioning materials were found significant in total sugar content during storage. Maximum total sugar content was found in control during early days of storage while minimum content was recorded from wrapping of fruits with Teak leaves (T_4) and wrapping of fruits with Cling wrap (T_2).

Results revealed that total sugars content of guava fruit increased with high rate up to 4th day of storage and then rate was decreased thereafter. Initially higher per cent of total sugar was recorded from control.The increase in total sugar during storage might be because of an increase in reducing sugars and non-reducing sugars resulting conversion of starch into simple sugar and later on reduction in rate was due to utilization of sugar in thewrapping of fruits with Teak leaves (T_4). Maximum retention of pectin was reported in wrapping of fruits with cling wrap (T_2). Minimum pectin content was found incontrol. Fruit firmness is closely related with the pectin content of the fruit. Pectin content of the guava fruit decreased progressively during storage. The reduction in pectin content during storage might be due to degradation of insoluble protopectin by the enzymes such as pectin methyl esterase enzyme and activity of enzyme increased as ripening advanced in guava. These findings are in accordance with the results of Chaitanya (1984) in guava

Table 10: Effect of wrapping and cushioning materials on total sugar

Treatments	Total sugar (%)		
	At harvest	After 4 days	After 8 days
T1 (Fruits cushioning with New paper)	16.58	17.48	15.28
T2 (Fruits cushioning with cling wrap)	15.84	16.14	14.14
T3 (Fruits cushioning with banana leaves)	16.96	17.86	15.16
T4(Fruits cushioning with teak leaves)	14.28	17.18	13.22
T5(Cushioning of fruits with neem leaves)	17.51	18.41	14.31
T6(Cushioning of fruits with rice straw)	16.59	15.49	13.39
T7(Cushioning of fruits with bamboo leaves)	16.56	14.36	12.66
T8 (Control)	18.44	18.94	16.54
S. Em.±	0.18	0.19	0.15
C.D. at 5%	0.57	0.60	0.54

Table 6: Effect of wrapping and cushioning materials on TSS

Treatments	TSS (^{0}brix)		
	At fully ripe stage	After 4 days	After 8 days
T1 (Fruits cushioning with New paper)	16.56	17.80	12.80
T2 (Fruits cushioning with cling wrap)	16.53	18.36	13.20
T3 (Fruits cushioning with banana leaves)	15.23	18.26	13.13
T4(Fruits cushioning with teak leaves)	17.50	19.30	15.16
T5(Cushioning of fruits with neem leaves)	17.43	19.93	13.53
T6(Cushioning of fruits with rice straw)	18.53	20.50	16.16
T7(Cushioning of fruits with bamboo leaves)	18.20	20.00	17.27
T8 (Control)	15.13	13.80	11.13
S. Em.±	0.14	0.15	0.12
C.D. at 5%	0.44	0.49	0.40

as he reported minimum retention of pectin from unwrapped fruit

Perusal of data Table 7 showed that packaging material had significant effect on total soluble solids of the fruit during storage. Maximum TSS (14^{0}brix) was found in bamboo leaves as cushioning material (T_7) after 4 days of storage while after 7 days of storage neem leaves as cushioning material (T_5) showed maximum TSS (13.55^{0}brix). Minimum TSS was recorded from wrapping with cling wrap (T_2) after 4 and 7 days of storage. Storage period also had pronounced effect on the TSS of the fruits. Maximum TSS was found after7th day of storage and minimum TSS was found at zero day.

Total soluble solids (TSS) of the fruits increased during storage. TSS content of guava fruits increased initially up to 4th day of storage and decreases thereafter. Maximum increase in TSS was observed in cushioning of fruits with neem leaves (T_5) and wrapping of fruits with teak leaves (T_4). Fruit wrapped in cling wrap showed the slowest rate of TSS increase. The slow increase in TSS might be mainly due to slow conversion of starch into sugars. Increase in total soluble solids during storage may be due to the breakdown of complex polymers into simple substances by hydrolytic enzymes which might be further metabolized during respiration and thus the level got decreased during subsequent storage. According toMapson, (1970) the increase in TSS was mainly due to the reduction in activities of various enzymes and thereby delaying senescence, disorganization of cellular structure and checking of microbial activities . Sharma *et al.* (2002) also found similar results as they reported that newspaper packed fruits of guava cv. Sardar recorded the maximum increase in TSS. Above results were in close conformity with the findings of Garg and Ram (1974) in guava and Bassily (1968) in peach as they reported similar trend of increase and decrease in TSS of fruits during storage.

On the basis of above results, it can be concluded that for most of parameters, cling wrap showed good results. Teak leaf wrapping had good effect on many parameters. Fruits wrapped in banana leaves showed growth of fungus in some fruits. Effect of different cushioning materials on physical and chemical parameters are satisfactory up to some extent. Fruits without wrapping and cushioning had poor physical and chemical properties. In organoleptic ratings fruits wrapped in teak leaves showed best results while poor rating was recorded in cling wrap. In overall cling wrap was considered as a good wrapping material for guava fruits followed by wrapping with teak leaves. Among the naturally available materials, teak leaves showed best results.

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Studies on development and storage of value added Bael syrup beverages incorporated with Aloe

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ABSTRACT

Bael (*Aegle marmelos* Correa) and Aloe (*Aloe barbadensis* Miller.) are rich in medicinal and nutritional properties. Five blend combinations were made by blending Bael pulp and Aloe Vera gel in different ratios *viz.* 100% Bael pulp + 0% Aloe Vera gel, 0% Bael pulp + 100% Aloe Vera gel, 50% Bael pulp + 50% Aloe Vera gel, 75% Bael pulp + 25% Aloe Vera gel and 25% Bael pulp + 75% Aloe Vera gel. The syrups were prepared using 65 per cent sugar, 1.25 per cent acidity and 25 per cent blend from each blend combination. The syrup developed from 65 per cent sugar, 1.25 per cent acidity and 25 per cent blend (consisting 50% Bael pulp + 50% Aloe Vera gel) was found the best among the all blend combinations during organoleptic test by the panel of semi trained judges on 9-point Hedonic Scale. The total soluble solids, acidity, reducing sugar, total sugars and browning were increased whereas Vitamin C, non-reducing sugar and organoleptic quality decreased continuously during storage. The blended syrup was found acceptable up to five months when stored at ambient conditions. The findings suggests that Bael and Aloe Vera can be utilized for commercial processing of blend syrup using 65 per cent sugar, 1.25 per cent acidity and 25 per cent blend consisting 50% Bael pulp and 50% Aloe Vera gel, which can be useful for growers, processors as well as consumers by the taste, flavour, nutritive and medicinal properties of both the plants. The developed product can also be stored for five months at ambient temperature.

KEY WORDS: Bael, Aloe Vera, Syrup, Pulp, Gel, Biochemical

Bael (*Aegle marmelos* Correa.) fruit is also called as *Bengal quince*, *Indian quince*, *Golden apple*, *bel*, *sirphal* and *holy fruit*. It is very important, underutilized, ancient and indigenous fruit which belongs to the family Rutaceae. Bael cultivation is found in India, Pakistan, Burma and Bangladesh. In India Bael is cultivated in U.P., Orissa, Bihar, W.B. and M.P. in wild form. The chemical composition of fresh fruit comprises of carbohydrate, protein, fat, minerals, carotene, thiamine, riboflavin, niacin and vitamin C (Rakesh *et al.*, 2005).The ripe Bael fruits are sweet, aromatic, cooling, febrifuge, laxative, good tonic for heart and brain and are also useful in dyspepsia. It is also used for digestive, stomachic, intestinal ailments, digestive complications and ulcer cure. Bael is not popular as dessert but the processing of the unripe and ripe Bael fruits into many quality value added products like, preserve, candy, powder and beverages is only solution for its proper consumption (Chand *et al*., 2007). The extracted Bael pulp was improved by adjusting the TSS and acidity by addition of sugar and citric acid respectively (Chand and Gehlot, 2006).

Aloe (*Aloe barbadensis* Miller.) is old as civilization and throughout history it has been used as popular folk medicine. It is also known by several vernacular names like lily of the dessert, plant of immortality, *Kumara*, *Ghritkumari* and *Mussavar*. Aloe Vera is grown in South Texas, USA, Mexico, India, Australia and Africa. In Aloe Vera leaves aloin is the chief constituent which contains 4.5 to 25 per cent aloin. It has been also used in medicine preparation as a source of drug 'aloin' and for developing liquors by flavouring. It is believed to be effective in treating stomach ailments, gastrointestinal problems, skin diseases, for its anti-inflammatory effect, for wound healing and burns, as an anti-ulcer and diabetes. Only plant species Aloe *barbadensis* (a tropical or subtropical plant) is used for making beverages (Eshun and He, 2004). There is a wide range of products containing Aloe Vera such as Aloe

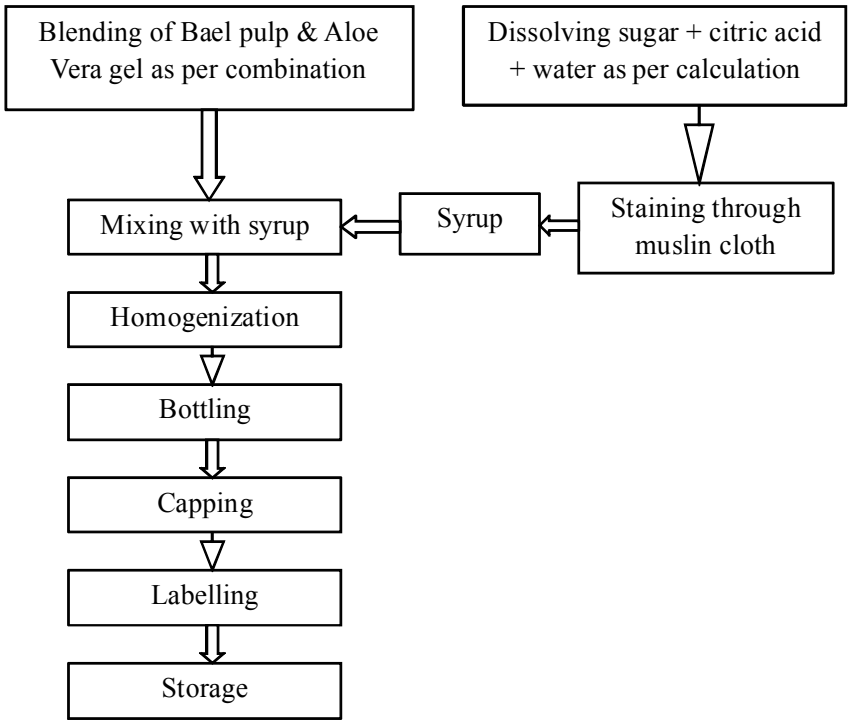

Fig. 1: Flow sheet for preparation of Bael-Aloe Vera blended Syrup

juice, Aloe jam and jelly (Niramon *et al*., 1996), cheese (Steinka, 2001), infant formula (Benward and Benward, 2002), chewing gum (Jenkins, 2003) and beverages of orange, grape, cranberry, strawberry, raspberry, pineapple (Malhotra *et al*., 2010). Aloe Vera processed products have long been used in health foods, medicinal and cosmetics purposes (Morton, 1961). The Aloe Vera gel cannot be consumed raw because of its astringent taste. Physiological benefits and basic nutrition from food or beverage for the reduction of risk of chronic diseases that's why is being preferred now days. Value added products are beneficial for prevention of various diseases *viz.* heart diseases and cancer and also help in keeping oneself healthy. (Syed *et al*., 2010).

Hence the present investigation was conducted to standardize the blending ratio of Bael pulp and Aloe Vera gel for preparation of blended syrup and the storage studies of prepared syrup.

MATERIALS AND METHODS

The experiment was conducted at Department of Horticulture, N.D. University of Agriculture and Technology, Faizabad, U.P. The ripe Bael fruits of cultivar Narendra Bael-9 and mature Aloe Vera leaves were collected from the main experiment station of the university.

Ripe Bael fruits were collected from the main experiment station of the university and washed properly in fresh water. Fruits were broken by striking against hard object and the fruit pulp along with its seeds and fibres was extracted with the help of spoon. Collected pulp was passed through pulper machine by adding water in the ratio of 1:1 and this was then heated at 70^0C for a minute. After cooling the fresh pulp (seed and fibre free) was collected by using muslin cloth and kept it in glass bottles for further uses.

Mature leaves of Aloe Vera were from the main experiment station of the university and keep it vertically for 24 hours for removing the toxic substance aloin. Cold extraction method was used to extract the Aloe Vera gel and prepared it into juice as per the method suggested by (Ramachandra and Srinivasa, 2008). Mature Aloe Vera leaves were freshly harvested and dipped into 500 ppm KMS (Potassium metabisulphide) solution and washed properly in fresh running water. Washed leaves were kept for flash cooling at 5^0C for gel stabilization. Leaves were then cut into two half vertically and extracted the gel by using stainless steel knife. Extracted gel was allowed to settle for 12-15 hrs and then passing through a mixer grinder for homogenization and treated with 1% pectolytic enzyme at 50°C for 20 minutes. After that filter the gel and to control the browning adjusts the pH of gel by adding

Table 1: Evaluation of blends of Bael pulp and Aloe Vera gel through organoleptic quality for the development of blended Syrup.

Treatments (Recipe) No.	Different combinations of blends		Organoleptic quality	
	Bael pulp (%)	Aloe Vera gel (%)	Score	Rating
1	100	Nil	7.86	Like moderately
2	Nil	100	6.28	Like slightly
3	50	50	8.14	Like very much
4	75	25	8.00	Like very much
5	25	75	7.28	Like moderately
CD at 5%			0.99	

citric acid and ascorbic acid to. Then obtained juice was pasteurized, cooled and stored in refrigerator for further use.

Five blend combinations were made by blending Bael pulp and Aloe Vera gel in different ratio (100% Bael pulp+0% Aloe Vera gel, 0% Bael pulp+100% Aloe Vera gel, 50% Bael pulp+50% Aloe Vera gel, 75% Bael pulp+25% Aloe Vera gel and 25% Bael pulp+75% Aloe Vera gel in Treatment No.1,2,3,4 and 5 respectively), consisting 25 per cent blend, 65 per cent sugar and 1.25 per cent acidity. The syrup of different blends shown in table-1 were prepared and evaluated organoleptically on 9-point Hedonic scale to find out the best blending ratio for palatable syrup. Syrup was prepared as per technique shown in fig. with 25 per cent blend (50% Bael pulp and 50% Aloe Vera gel), 65 per cent sugar and 1.25 per cent acidity which was filled into Syrup bottles of 750 ml. Capacity leaving 2 cm head space, capped and put for storage studies.

Best combination of blend comprising 50 per cent Bael pulp and 50 per cent Aloe vera gel was used for the preparation of syrup and prepared syrup was put for storage study at ambient condition.

Total soluble solids was measured with ERMA made hand refractometer at ambient temperature with 20^0C correction temperature (Ranganna, 2010). The mean value was expressed as per cent TSS.

The total titrable acidity was observed by titrating a known volume of sample against 0.1N NaOH solution using phenolphthalein as an indicator and expressed in per cent (Ranganna, 2010). The mean value was expressed as per cent acidity.

The estimation of vitamin C was carried out by using 3 per cent metaphosphoric acid and titrateted against 2, 6 dichlorophenol indophenols (dye) solution (A.O.A.C., 2000). The Vitamin C was expressed as mg per 100g of sample.

The reducing sugar, non-reducing sugar and total sugars were analyzed by using Fehling's solution A and B. 5 ml sample was taken and volume made up to 100 ml with distilled water. Aliquot was taken into conical flask and 5 ml of each Fehling's solution 'A' and 'B' were mixed with aliquot. A blank sample was also prepared and titrated against 1% glucose (Dextrose) using methylene blue as an indicator (Lane and Eynon, 1923).

Non-enzymatic browning was determined by preparing sample in ethanol alcohol and measuring optical density (O.D.) at 440 nm by **ELICO** made spectrophotometer (Rangana, 2010).

A panel of 9 semi trained judges evaluated syrup for its organoleptic quality on 9.0 point Hedonic scale. The organoleptic evaluation for assessing the colour, flavour and texture of syrup (Amerine *et al*., 1965).

RESULTS AND DISCUSSION

In present study 25 per cent blend (consisting 50 per cent Bael pulp and 50 per cent Aloe Vera gel) with 65 per cent sugar and 1.25 per cent acidity scored maximum (8.14) for the preparation of quality syrup. Rongshu *et al*. (2005) reported a composite Rose-Aloe suspended beverage had an acceptable quality, Nidhi *et al.* (2007) blended squash of Bael and Guava, Boghani *et al.* (2012) blended RTS of Papaya-Aloe Vera and Nath *et al.* (2005) squash prepared from mixing Mandarin and Ginger.

Studies on changes during storage of Bael pulp and Aloe Vera gel blended Syrup indicated that the quality and storability. Observations were recorded at monthly intervals during the storage period are discussed below and shown in Table 2.

Total soluble solids increased gradually after one month of storage. An increase in total soluble solids content during storage was probably due to the conversion of polysaccharides into sugar (Jakhar and Pathak, 2012).

Table 2: Changes in biochemical properties and organoleptic quality of blended syrup during storage

Storage period (months)	TSS (%)	Acidity (%)	Vitamin C (mg/100g)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)	Browning (OD)	Organoleptic quality	
								Score	Rating
0	65.00	1.25	4.35	6.23	57.58	63.81	0.80	8.28	LVM
1	65.00	1.29	4.24	7.69	56.70	64.39	0.80	8.14	LVM
2	65.00	1.30	4.11	8.46	56.46	64.32	0.81	8.10	LVM
3	66.00	1.34	4.02	9.59	55.98	65.57	0.82	7.95	LM
4	66.10	1.36	3.93	10.83	55.30	66.13	0.84	7.80	LM
5	66.30	1.38	3.85	12.35	54.85	67.20	0.86	7.28	LM
CD at 5%	NS	0.07	0.27	1.37	1.59	1.76	0.06	0.58	

LVM= Like very much, LM= Like moderately.

Similar trends were reported by Nidhi *et al.* (2007) in Bael-Guava blended RTS and Squash, Boghani *et al.* (2012) in blended RTS of Papaya-Aloe Vera, Pandey (2004) in Guava RTS and squash and Prasad and Mali (2006) in Bael squash.

In present findings total acidity increased gradually during the storage period. Degradation of pectic substances into soluble solids might have contributed towards an increase in the acidity of products (Conn and Stumf, 1976). Similar trends were reported by Pandey (2004) in Guava RTS and squash, Nidhi *et al.* (2007) in Bael-Guava RTS and squash, Boghani *et al.* (2012) in Papaya-Aloe Vera blended RTS, Kenghe *et.al* (2009) in Bael squash and Deen and Singh (2012) in Karonda squash.

Results indicated that Vitamin C content of blended Syrup decreased gradually during storage period. The reduction may be due to oxidation of ascorbic acid into dehydro ascorbic acid by oxygen. Several workers (Tiwari, 2000, Deka *et al*., 2005, Nidhi *et al*., 2008 and Deen and Singh, 2012) have also reported losses of vitamin C in different fruits based beverages.

The total sugars and reducing sugar increased continuously during storage of blended syrup. Similar trend were also observed by the several workers like Wasker and Khurdiya (1987) in Phalsa squash, Prasad and Mali (2006) in Bael squash and Deen and Singh (2012) in Karonda squash. The increase in reducing and total sugars of syrup could be due to inversion of non-reducing sugars into sugars. Non-reducing sugars of blended syrup decreased continuously throughout the entire period of storage which might be because of inversion of non-reducing sugar. Similar observations were observed by Wasker and Khurdia (1987) in Phalsa squash, Wasker and Deshmukh (1995) Pomegranate juice and Deen and Singh (2012) in Karonda squash.

A progressive increase in browning of blended syrup was observed during storage. This could be mainly due to the non-enzymatic reaction (Maillard reaction) such as organic acid reaction with sugars and amino acids which leads to the formation of brown pigments. This observation was also supported by Deka et al., (2005) Mango-Pineapple spiced beverages and Deen and Singh (2012) in Karonda squash.

Organoleptic score of blended syrup decreased with the storage period at room temperature. The acceptability of syrup was maintained upto five months of storage under ambient condition. Some biochemical changes and temperature are responsible for the development of off flavour as well as discolouration and thus masking the original colour and flavour of the syrup. Similar trend were reported by Boghani *et al.* (2012) in blended RTS of Papaya-Aloe Vera, Tandan *et al.* (2007) in Bael and Papaya blended beverages, Irfan *et al*. (2008) in Papaya and Guava blended beverages and Deen and Singh (2012) in Karonda Squash, these reported observations support the present findings.

25 per cent of blend combination of 50 per cent Bael pulp and 50 per cent Aloe Vera gel were found as the best for the development of blended syrup with 65 per cent sugar and 1.25 per cent acidity. The observations observed under changes during storage were TSS, acidity, reducing sugars, total sugars and browning of blended increased gradually. However, vitamin C, non-reducing sugar and organoleptic quality decreased continuously during storage period. The blended syrup was found to be acceptable upto five months of storage under ambient temperature. Development of blended syrup with Bael pulp and Aloe Vera gel would encourage the consumption of Bael fruit and Aloe Vera and the consumers would also be beneficial from nutritive, medicinal and therapeutic values of both the plants.

REFERENCES

A.O.A.C. 2000. Official method of analysis. Association of Official Agricultural Chemist, Washington, D.C., 17th Edition.

Amerine, M.A., Pangborn, R.M. and Roessler, E.B. 1965. Principles of sensory evaluation of food. *Academic Press*, London.

Benward, M.E. and Benward, W. 2002. Healthy body infant formula beverage and healthy body toddler formula beverage. US; United States Potent (US 6063433).

Boghani, A.H., Raheem, A. and Hashmi, S.I. 2012. Development and Storage Studies of Blended Papaya-Aloe vera Ready to Serve (RTS) Beverage. *J. Food Proces. & Tech.* 3:185.

Chand, T. and Gehlot, R. 2006. Utilization of bael (*Aegle marmelos* Correa.) for preparation and preservation of pulp. *Res Crops.* **7** (3):887-890.

Chand, T., Gehlot, R., Singh, R., Siddiqui, S. and Rana, M.K. 2007. Studies on physico-chemical composition of bael fruit and changes in chemical composition of its pulp and jam during storage. *Haryana J. Hort. Sci.,* **36** (1/2): 49-51.

Conn, E.E. and Stumf, P.K. 1976. Outlines of Biochemistry, Wiley Eastern Ltd., New Delhi.

Deen, B. and Singh, I.S. 2012. Development of Karonda (*Carissa carandas* L.) squash, *Beverages and Food World,* **39** (2): 37-39.

Deka, B.C., Sethi, V. and Saikia, A. 2005. Changes in quality of mango-pineapple spiced beverage during storage. *Indian J. Hort.,* **62** (1): 71-75.

Beg, I., Gaur, G.S., Angraj, A. and Siddiqui, M.Z. 2008. Changes in quality of papaya based mixed fruit RTS beverage during storage. National Seminar on "Sustainable Horticultural Research in India: Perspective, Priorities and Preparedness" held at Lucknow (14-15th April).

Jakhar, M.S. and Pathak, S. 2012. Studies on the preparation and storage stability of blended ready-to-serve from ber (*Zizyphus mauritiana* Lamk.) and jamun (*Syzigium cuminii* skeels.) pulp. *Plant Archives* **12**: 533-536.

Jenkins, J. 2003. Nutrition Chewing gum. US; United States Patent Application (US 2003/0157213 Al) Publication.

Eshun, K. and He, Q. 2004. Aloe vera: a valuable ingredient for the food, pharmaceutical and cosmetic industries - a review. *Crit. Rev. Food Sci. Nutr.* **44:** 91-96.

Kenghe, R.N., Unde, P.A. and Potdar, S.N. 2009. Processing of wild bael (*Aegle marmelos* Corr.) fruit for value addition. *Journal of Maharashtra Agricultural Universities,* **34** (1): 65-67.

Lane and Eynone, L. 1923. Determination of reducing sugars by means of Fehling solution with methylene blue indicator as an internal indicator. *J. Soc. Chem. India.* **42**: 32.

Malhotra, R., Tyagi, S.M. and Saini, P. 2010. Studies on Aloe Vera- A component of functional foods. *Beverage and Food World,* **37** (7): 36-39.

Morton, J.F. 1961. Folk uses and commercial exploitation of *Aloe* leaf pulp. *Econ. Bot.*, 15: 311-319.

Nath, A., Yadav, D.S., Sarma P. and Dey, B. 2005. Standardization of ginger-kinnow squash and its storage. *J. Food Sci. Technol.*, **42** (6): 520-522.

Gehlot,. N.R., Singh, R. and Rana, M.K. 2008. Changes in chemical composition of Ready-to-serve of bael-guava blended beverages during storage. *J. of Food and Tech.* **45** (4): 378-380.

Gehlot,. N.R., Singh, R.; Siddiqui, S. and Rana, M.K. 2007. Changes in chemical composition of bael-guava blends ready-to-serve beverage and squash during storage. *Haryana J. Hort. Sci.,* **36** (1/2): 46-48.

Niramon, U., Pannee, I. and Ekachai, S. 1996. Development of orange Aloevera Jam. Lampang Agriculture Research and Training Centre (Thailand) [Processing of the 13th Rajmangla Institute of Technology Annual Conference. *Food Science and Home Economics.* **94:** 39-45.

Pandey, A.K. 2004. Study about the storage stability of guava beverages. *Prog. Hort.,* **36** (1): 142-145.

Prasad, R.N. and Mali, P.C. 2006. Studies on changes in physico-chemical characteristics of bael squash during storage. *Scientific Horticulture,* **10**; 171-174.

Rakesh, Dhawan, S. S. and Arya, S.S. 2005. Product Development: Processed Products of Bael. *Processed Food Industry*, **8** (10): 25-27.

Ramachandra. C.T. and Srinivasa, P.R. 2008. Processing of Aloe Vera Leaf Gel: A Review. *American Journal of Agricultural and Biological Sciences* **3:** 502-510.

Rangana, S. 2010. Handbook of Analysis and quality control for fruit and vegetable products, Tata Mc Grow-Hill Ltd., New Delhi.

Rongshu, W., Wen Ming, D. and Xiao Feng, Z. 2005. The development of composite rose- aloe suspended beverage. *Journal of Yunnan Agricultural University,* **20** (2): 304-307.

Steinka, I. 2001. Possibility to apply Aloe Vera solution to optimize the quality of the lactic acid cheese. 8th optimize the quality of the lactic acid cheese. 8th Egyptian Conference of Dairy Science and Technology held at the International Agriculture Centre, Cairo, Egypt, 235-242.

Syed, I.H., Satwadhar, P.N., Khotpal, R.R., Deshpande, H.W. and Syed, K.A. 2010. Rapeseed meal nutraceuticals. *Journal of Oilseed Brassica.* 1: 43-54.

Tandon, D.K., Kumar, S., Dikshit, A. and Shukla, D.K. 2007. Storage study on bael-papaya blended RTS beverage. *Ind. Fd. Pack.,* 173: 91.

Tiwari, R.B. 2000. Studies on blending of guava and papaya pulp for RTS beverages. *Ind. Fd. Pack.*, **54** (2): 68.

Waskar, D.P. and Deshmukh, A.N. 1995. Effect of packaging containers on the retentions of pomegranate juice. *Indian Fd. Packer,* **41**(5):5-8.

Waskar, D.P. and Khurdia, D.S. 1987. Processing and storage of phalsa beverages. *Indian Fd. Packer.* **41**(5):7-11.

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Storage performance of hot water and sodium bicarbonate treated Kinnow mandarin fruits under ambient conditions

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ABSTRACT

The present study was conducted at All India Co-ordinated Research Project on Tropical Fruits Laboratory of Department of Fruit Science, Punjab Agricultural University, Ludhiana during the years 2011 and 2012. The fruits were subjected to hot water treatments at different temperature (45, 50 and 55°C), sodium bicarbonate at different levels (2%, 3%) and their combinations. The control fruits were kept untreated and all the fruits were stored at room temperature for 0-21days. Fruit weight loss, TSS and disease incidence increased significantly but the acid content declined thereafter. Hot water (50°C) alone and in combination with sodium bicarbonate (2%) retarded the changes associated with the storage duration in Kinnow mandarin, but exposure to high temperature (55°C) reversed the beneficial effects and enhanced the decline in physical and chemical quality attributes of fruits.

KEY WORDS: Hot water, Sodium bicarbonate, Storage, Rotting, Quality

Citrus fruits are non-climacteric having low respiration rate. Citrus fruits have a relatively short post-harvest life in stark contrast to the climacteric fruits like mango, banana and sapota, which can be harvested before ripening. Due to its short shelf life, Kinnow fruits exhibit changes in fruit texture, colour, aroma and biochemical attributes besides, fruit quality parameters like fruit weight, fruit colour, taste, TSS, acidity and sugar are highly affected with storage, leading to lowering of fruit quality and resulted in post-harvest losses. The improper storage results in rapid loss of sugars, ascorbic acid (Maleki and Sarkissian,1967) and enhances weight loss (McGornack, 1975). Low temperature storage is generally used to slow down the deterioration in citrus fruits during storage but these are chilling sensitive and hence may be injured by chilling temperatures (Purvis, 1985 and Couey, 1989).In a developing country like India, post-harvest losses of citrus fruits are in the range of 25-30 per cent as against 5-10 per cent in developed citrus growing countries like Brazil, USA, Australia, Spain, Italy and Israel. Postharvest green mold, caused by *Penicillium digitatum* and post-harvest blue mold, caused by *Penicillium italicum* Wehmer, are the most economically important postharvest diseases of Kinnow. Currently, both diseases are primarily controlled by application of synthetic fungicides. The use of synthetic chemicals on harvested fresh produce is becoming more difficult to justify due to the concerns about human health risks associated with chemical residues, widespread occurrence of pesticide-resistant microbes, environmental problems associated with disposal of water used in packing operations and a lack of approved fungicides for the control of rots. Hence, there is an urgent need to develop alternative technologies to control decay in citrus, which should be safe to consumers, workers, and the environment (Palou *et al* 2002 and Venditti *et al* 2005). Several alternatives show promise post-harvest treatments like hot water treatments (Gautam *et al* 2003 and Rodov *et al* 2000), hot water and sodium bicarbonate treatments (Larrigaudiere *et al* 2002), are emerging technologies in reducing post-harvest losses.

The US Department of Agriculture has classified many carbonates and bicarbonates as approved ingredients on products labelled "organic" (Smilanick *et al* 1999). Treating produce with bicarbonates and carbonates is inexpensive and less sophisticated. Furthermore, the chemical is easily available and the control measures can be implemented without much professional expertise. Heat treatment technology is a safe and environmentally-friendly procedure with increasing acceptability in commercial operations. It is used successfully to control the incidence of postharvest disease in several commodities (Fallik 2004). Heat treatments in the form of either moist hot air or hot water dips have had some commercial application for the control of post-harvest wastage in fruits. The advantage of hot water dipping is that it can control surface infections as well as infections that have penetrated the skin, without leaving no chemical

Table 1: Effect of different treatments on physiological loss in weight (%) of Kinnow mandarin stored under ambient condition

Treatments	Storage intervals (days)							
	2011				2012			
	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean
Sodium bicarb. (2%)	2.34	4.41	6.81	4.52	2.33	4.36	6.79	4.49
Sodium bicarb. (3%)	2.38	4.45	6.87	4.57	2.37	4.39	6.83	4.53
Hot Water (45°C)	2.18	4.21	6.56	4.32	2.16	4.18	6.52	4.29
Hot Water (50°C)	2.15	4.18	6.52	4.28	2.13	4.16	6.48	4.26
Hot Water (55°C)	2.23	4.24	6.61	4.36	2.20	4.20	6.57	4.32
Hot Water (45°C) + Sodium bicarb. (2%)	2.38	4.46	6.87	4.57	2.34	4.41	6.84	4.53
Hot Water (50°C) + Sodium bcarb. (2%)	2.36	4.43	6.85	4.55	2.33	4.37	6.78	4.49
Hot Water (55°C) + Sodium bicarb. (2%)	2.40	4.50	6.92	4.60	2.38	4.45	6.87	4.57
Hot Water (45°C) + Sodium bi carb. (3%)	2.42	4.49	6.93	4.61	2.39	4.46	6.88	4.58
Hot Water (50°C) + Sodium bicarb. (3%)	2.40	4.46	6.90	4.59	2.37	4.41	6.83	4.54
Hot Water (55°C) + Sodium bicarb. (3%)	2.44	4.56	6.96	4.65	2.39	4.49	6.89	4.59
Control	2.50	4.69	7.15	4.78	2.46	4.63	7.10	4.73
Mean	**2.35**	**4.42**	**6.83**		**2.32**	**4.38**	**6.78**	
CD (p=0.05)	Storage interval 0.09				Storage interval 0.06			
	Treatment 0.18				Treatment 0.13			
	Storage interval x Treatment 0.31				Storage interval x Treatment .23			
Initial Value	0.00				0.00			

residues on the produce (Fallik *et al* 2000). The principal benefit of hot water (or air) treatments is that they can kill the organisms on and below the fruit surface. Postharvest fungicides only kill surface pathogens. The heat may affect ripening behavior by slowing it, which could be good or bad (Fallik *et al* 2001). Postharvest heat treatment also can reduce chilling injury in many wounds of fruits during subsequent low temperature storage as well as reduce pathogens level and disease development. Heat treatment is also known for its effects on the fruit surface, such as melting of cuticular wax covering the natural openings, obstructing possible entry sites for pathogens and acting as a physical barrier against infection (Hatton and Cubbedge 1983, Rodov *et al* 1995, Schirra *et al* 1997, Gonzalez-Aguilar *et al* 1997 and Fallik 2004). The present study, therefore, was initiated to evaluate the effects of hot water, sodium bicarbonate and their combination on the physico-chemical quality attributes of Kinnow stored at room temperature.

MATERIALS AND METHODS

Fruits were randomly divided into twelve treatment groups, each of 75 fruits. The first group was used as the control, without any treatment, second group was dipped in sodium bicarbonate solution having a final concentration of 2% (w/v) for 2 minutes, third group was dipped in sodium bicarbonate solution having a final concentration of 3% (w/v) for 2 minutes, fourth group was dipped in hot water at 45°C for 2 minutes, fifth group was dipped in hot water at 50°C for 2 minutes, sixth group was dipped in hot water at 55°C for 2 minutes, other six groups were treated with combination of hot water (HW) at three temperatures [45, 50 and 55°C] and sodium bicarbonate (2 and 3% w/v) for 2 minutes each. All these treatments were followed by a gentle breeze from a fan to remove the surface water. These were then packed in cardboard boxes (530 x 200 x 200 mm) having 5% holes on each side for ventilation. The fruits were then stored at room temperature and data was recorded on physico-chemical quality attributes of fruits at 7 days interval for 21 days. Biochemical quality attributes such as total soluble solids (TSS), acidity, TSS:acid ratio, reducing and non-reducing sugars and ascorbic acid content were determined according to AOAC (1990). The data calculated on different parameters were subjected to Analysis of Variance (ANOVA) technique by using completely randomized design (Panse and Sukhatame, 1976) to observe the difference between the different treatments as well as their interactions.

RESULTS AND DISCUSSION

Storage performance of Kinnow after being treated with hot water and sodium bicarbonate at room temperature was conducted at All India Coordinated

Table 2: Effect of different treatments on rotting percentage of Kinnow mandarin stored under ambient conditions.

Treatments	2011				2012			
	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean
Sodium bicarb. (2%)	0.00	1.33	2.67	1.33	0.00	0.00	2.67	0.89
Sodium bicarb. (3%)	0.00	2.67	4.00	2.22	0.00	2.67	4.00	2.22
Hot Water (45° C)	0.00	4.00	6.67	3.56	0.00	4.00	5.33	3.11
Hot Water (50° C)	0.00	4.00	5.33	3.11	0.00	5.33	6.67	4.00
Hot Water (55° C)	4.00	10.67	12.00	8.89	5.33	10.67	13.33	9.78
Hot Water (45° C) + Sodium bicarb. (2%)	0.00	2.67	6.67	3.11	0.00	2.67	5.33	2.67
Hot Water (50° C) + Sodium bicarb. (2%)	0.00	2.67	5.33	2.67	0.00	5.33	6.67	4.00
Hot Water (55° C) + Sodium bicarb. (2%)	1.33	6.67	9.33	5.78	2.67	6.67	8.00	5.78
Hot Water (45° C) + Sodium bicarb. (3%)	0.00	4.00	8.00	4.00	0.00	5.33	6.67	4.00
Hot Water (50° C) + Sodium bicarb. (3%)	0.00	5.33	8.00	4.44	0.00	6.67	8.00	4.89
Hot Water (55° C) + Sodium bicarb. (3%)	2.67	8.00	10.67	7.11	4.00	9.33	10.67	8.00
Control	0.00	6.67	9.33	5.33	0.00	6.67	8.00	4.89
Mean	**0.67**	**4.89**	**7.33**		**1.00**	**5.45**	**7.11**	
CD (p=0.05)	Storage interval 0.92 Treatment 1.90 Storage interval x Treatment NS				Storage interval 0.82 Treatment 1.70 Storage interval x Treatment NS			
Initial Value	0.00				0.00			

Research Project on Tropical Fruits Laboratory, Department of Fruit Science, Punjab Agricultural University, Ludhiana during 2011 and 2012. The data regarding quality attributes of Kinnow are discussed below.

The weight loss is a result of direct water loss from the fruit tissue and partially due to respiration process. The physiological loss in weight was significantly affected by heat treatment and storage duration (Table 1).The above data indicate that the mean minimum loss in weight (4.28 and 4.26% in 2011 and 2012, respectively) was observed in fruits treated with hot water (50°C) dipping. The mean maximum PLW was recorded in control (4.78 and 4.73% in 2011 and 2012, respectively) followed by hot water (55°C) + sodium bicarbonate (3%), hot water 45°C + sodium bicarbonate (3%), hot water (55°C) + sodium bicarbonate (2%).There was a continuous increase in mean weight loss with increase in storage duration. The weight loss was increased significantly from the minimum (2.35 and 2.32% in 2011 and 2012, respectively) after 7 days of storage to 4.42 and 4.38 per cent in 2011 and 2012 respectively after 14 days of storage and maximum weight loss (6.83 and 6.78% in 2011 and 2012, respectively) was observed after 21 days of storage.

The combined influence of treatments and duration of ambient storage had a significant reflection on physiological loss in weight. Our results are in agreement with those of Schirra *et al* (2008) who reported that the rate of weight loss of Valencia oranges was significantly increased by sodium bicarbonate treatment after 20 days at 17°C and 90% relative humidity after 1 min dip in an aqueous mixture of sodium bicarbonate at 0.5, 1 or 2 per cent (weight / volume) at 20 or 40°C. Similarly, fruits dipped in hot water at 50°C for 5 min had a shelf life of up to 14 days with a minimum weight loss of 13% even on the 15thday of storage (Vijayalakshmi *et al* 2004). Khasi mandarin fruits were placed in hot water at 50°C by Deka *et al* (2006).They observed the lowest physiological weight loss up to 29 days at ambient temperature. Similarly, Zhang *et al* (2008) concluded that hot water treatment did not impair weight loss in peach fruits which were stored at 20°C for 7 days.

Hot water dip might be beneficial or harmful depending upon the treatment temperature. Among the hot water treatments, fruit treated with hot water (50°C) significantly reduced PLW. Above and below this temperature, water loss in Kinnow mandarin was found to have increased. The mode of action of hot water dip in reducing percentage of loss in fruit weight could be due to the melting of fruit epicuticular waxes which covers and seal the stomata and cracks on fruit surface. Similarly, decrease in physiological loss of weight in Clementine with hot water dip and sodium bicarbonate was also reported by Larrigaudierre *et al* (2002). It was also observed that sodium bicarbonate and its combination with hot water at different temperature exhibited greater loss as compared to treatment without sodium bicarbonate might be due to residue of sodium bicarbonate on the fruit which lower the osmotic potential of fruit, restricting water availability

Table 3: Effect of different treatments on juice percentage of Kinnow mandarin stored under ambient conditions

Treatments	2011				2012			
	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean
Sodium bicarb. (2%)	46.82	45.34	44.21	45.46	46.79	45.26	44.14	45.40
Sodium bicarb. (3%)	46.66	44.32	44.18	45.05	46.60	44.23	44.10	44.98
Hot Water (45° C)	47.24	45.62	44.37	45.74	47.15	45.58	44.28	45.67
Hot Water (50° C)	47.38	45.66	44.38	45.81	47.27	45.62	44.30	45.73
Hot Water (55° C)	46.82	45.65	44.40	45.62	46.73	45.60	44.36	45.56
Hot Water (45° C) + Sodium bicarb. (2%)	47.34	45.00	44.53	45.62	47.27	45.62	44.39	45.76
Hot Water (50° C) + Sodium bicarb. (2%)	47.41	45.82	44.56	45.93	47.34	45.76	44.51	45.87
Hot Water (55° C) + Sodium bicarb. (2%)	47.11	45.80	44.49	45.80	47.00	45.74	44.44	45.73
Hot Water (45° C) + Sodium bicarb. (3%)	47.21	45.63	42.42	45.09	47.13	45.59	44.36	45.69
Hot Water (50° C) + Sodium bicarb. (3%)	47.32	45.67	44.47	45.82	47.28	45.72	44.49	45.83
Hot Water (55° C) + Sodium bicarb. (3%)	46.92	45.60	44.43	45.65	46.87	45.53	44.37	45.59
Control	45.62	43.36	41.85	43.61	45.57	43.18	41.73	43.49
Mean	**46.99**	**45.29**	**44.02**		**46.92**	**45.29**	**44.12**	
CD (p=0.05)	Storage interval 0.82 Treatment NS Storage interval x Treatment NS				Storage interval 0.46 Treatment 0.96 Storage interval x Treatment NS			
Initial Value	48.04				47.84			

and leading to an osmotically imposed drought (Smilanick *et al* 2002).

The mean minimum rotting percentage (1.33 and 0.89% in 2011 and 2012, respectively) was observed in fruit treated with sodium bicarbonate (2%) followed by sodium bicarbonate (3%) (2.22% during both the seasons) in ascending order and both these treatments differed significantly from each other (Table 2). The maximum rotting percentage was recorded in fruits treated with hot water (55°C) (8.89 and 9.78% in 2011 and 2012, respectively) followed by hot water (55°C) + sodium bicarbonate (3%), hot water (55°C) + sodium bicarbonate (2%). The rotting percentage increased significantly from the minimum (0.67 and 1.00% in 2011 and 2012, respectively) after 7 days of storage at ambient temperature to 4.89 and 5.45 per cent in 2011 and 2012, respectively after 14 days of storage. The maximum rotting percentage (7.33 and 7.11 in 2011 and 2012, respectively) was observed after 21 days of storage. There was a continuous increase in rotting percentage with increase in storage duration. It might be due to the weakening of the defense system against fungal attack. The combined influence of treatments and duration of ambient storage had a significant reflection on physiological loss in weight. Our results are in agreement with the findings of Ratnayake *et al* (2009) who observed that sodium bicarbonate treatment controlled the decay by 100 % in wood apple. Studies of Ben-Yehoshua *et al* (2000) also lend support to the present findings, they also reported that the effective temperature range for 2 minute grapefruit dip treatments was between 51 and 54°C, as temperatures above 54°C caused brown discoloration of the peel and temperatures below 51°C were not effective in reducing decay.

The inhibitory effect of sodium bicarbonate on post harvest decay of citrus was significant, when compared with the control. In contrast, hot water treatments at 55°C did not control the decay and did not improve the sodium bicarbonate treatment. Exposure to high temperature, however, increased disease incidence, probably damaging waxy layer and rind tissue (Yousaf and Hashim 1992 and joyce *et al* 2003). The effect of hot water treatment on citrus fruit may be associated with melting and redistributing of natural epicuticular wax on the fruit surface, plugging numerous microscopic cuticular cracks and stomata to adapt physical barriers to pathogen penetration (Porat *et al* 2000). It was also observed that hot water and its combination with sodium bicarbonate exhibited greater rotting percentage as compared to treatment with sodium bicarbonate alone. It might be due to residue of sodium bicarbonate on the fruit which had a fungistatic character (Smilanick *et al* 2002). The results obtained in the present studies are in agreement with the findings of Pimenta *et al* (2010) where oranges were treated with sodium bicarbonate salt, a generally regarded safe substance at different concentrations (1, 2 and 5%) and it was observed that sodium bicarbonate reduced the decay severity by 19.8 %. Similarly, the potential of using hot water (2.5 min at 45°C), 2% sodium carbonate or 2% sodium bicarbonate

Table 4: Effect of different treatments on TSS (°Brix) of Kinnow mandarin stored under ambient conditions

Treatments	2011				2012			
	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean
Sodium bicarb. (2%)	9.27	9.32	9.47	9.35	9.23	9.25	9.34	9.27
Sodium bicarb. (3%)	9.28	9.39	9.52	9.40	9.24	9.27	9.37	9.29
Hot Water (45°C)	9.23	9.29	9.36	9.29	9.21	9.24	9.31	9.25
Hot Water (50°C)	9.21	9.27	9.31	9.26	9.19	9.22	9.29	9.23
Hot Water (55°C)	9.31	9.52	9.68	9.50	9.26	9.34	9.62	9.41
Hot Water (45°C) + Sodium bicarb. (2%)	9.24	9.30	9.39	9.31	9.21	9.25	9.33	9.26
Hot Water (50°C) + Sodium bicarb. (2%)	9.22	9.28	9.35	9.28	9.2	9.23	9.30	9.24
Hot Water (55°C) + Sodium bicarb. (2%)	9.33	9.54	9.71	9.53	9.28	9.47	9.68	9.48
Hot Water (45°C) + Sodium bicarb. (3%)	9.26	9.33	9.43	9.34	9.22	9.30	9.40	9.31
Hot Water (50°C) + Sodium bicarb. (3%)	9.25	9.31	9.40	9.32	9.21	9.27	9.38	9.29
Hot Water (55°C) + Sodium bicarb. (3%)	9.36	9.6	9.76	9.57	9.30	9.52	9.74	9.52
Control	9.30	9.50	9.67	9.49	9.25	9.34	9.6	9.40
Mean	**9.27**	**9.39**	**9.50**		**9.23**	**9.31**	**9.45**	
CD (p=0.05)	Storage interval 0.03 Treatment 0.06 StorageintervalxTreatment 0.10				Storage interval 0.04 Treatment 0.09 Storage interval x Treatment NS			
Initial Value	9.23				9.20			

solutions alone or combined with hot water, was investigated on commercially ripe Clementines by Larrigaudiere *et al* (2002). It was revealed that both carbonate and bicarbonate solutions effectively control decay during two month storage but hot water did not.

The mean maximum juice percentage (45.93 and 45.87% in 2011 and 2012, respectively) was noticed in hot water (50°C) + sodium bicarbonate (2%) and it was closely followed by hot water (50°C) + sodium bicarbonate (3%) where mean juice percentage was found to be 45.82 and 45.83 in 2011and 2012, respectively (Table 3).The latter two treatments were at par in the year 2011 and differed significantly in 2012.The mean minimum juice percentage (43.61and 43.49 in 2011 and 2012, respectively) was recorded in control. The remaining treatments had less reductive effect on juice percentage as compared with control. The perusals of data indicate that juice percentage of fruit decreased significantly with the advancement of storage period in all the treatment. The mean maximum juice percentage (46.99 and 46.92 % in 2011 and 2012, respectively) was recorded after 7 days and minimum (44.02 and 44.12 % in 2011 and 2012, respectively) after 21 days of ambient storage. The interaction between treatment and storage interval was found to be non-significant during both the years.

From the experiment, it was found that all the treatments resulted in higher juice content than control. It was specially due to increase permeability in cell wall with heat treatment. The significant decrease in juice percentage with prolongation of storage may be due to continous dehydration of peel and juice. Similar, results were reported previously by Ozyka and Dundar (2012) in Star Ruby grapefruit and Larrygaudiere *et al* (2002) in Clementines. However, Obeed and Harhash (2006) reported that increase in juice content occured in Maxican lime with increase in storage period.

The mean total soluble solids after all storage interval was recorded maximum TSS (9.57and 9.52°Brix in 2011 and 2012, respectively) in hot water (55°C) + sodium bicarbonate (3%) followed by hot water (55°C) + sodium bicarbonate (2%) where TSS was found to be 9.53 and 9.48 °Brix in 2011 and 2012, respectively (Table 4). The mean minimum TSS (9.26 and 9.23 °Brix in 2011 and 2012, respectively) was recorded in hot water (50°C) treatment. The perusal of data indicates that total soluble solids of fruit increased significantly with the advancement of storage period in all the treatments. The mean maximum TSS (9.51 and 9.45 °Brix in 2011 and 2012, respectively) was recorded after 21 days and minimum TSS (9.27 and 9.23 °Brix in 2011 and 2012, respectively) after 7 days of ambient storage. It was also observed that hot water (55°C) and its combination with sodium bicarbonate (2% or 3 %) exhibited increase in °Brix as compared to other treatments as well as control. This might be due to the alteration in cell wall structure and breakdown of complex carbohydrate into simple sugars during storage. It was also concluded that hot water up to 50°C exhibited the decrease in TSS initially may be due to more utilization of

Table 5: Effect of different treatments on acidity (%) of Kinnow mandarin stored under ambient conditions

	2011				2012			
	7 days	14 days	21 days	Mean	7 days	14 days	21 days	Mean
Sodium bicarb. (2%)	0.63	0.61	0.59	0.61	0.65	0.63	0.62	0.63
Sodium bicarb. (3%)	0.62	0.60	0.58	0.60	0.64	0.61	0.61	0.62
Hot Water (45°C)	0.64	0.62	0.61	0.62	0.65	0.64	0.62	0.64
Hot Water (50°C)	0.65	0.63	0.62	0.63	0.67	0.65	0.62	0.65
Hot Water (55°C)	0.63	0.62	0.64	0.63	0.63	0.62	0.65	0.63
Hot Water (45°C) + Sodium bicarb. (2%)	0.64	0.62	0.61	0.62	0.65	0.63	0.61	0.63
Hot Water (50°C) + Sodium bicarb. (2%)	0.66	0.64	0.62	0.64	0.68	0.66	0.63	0.66
Hot Water (55°C) + Sodium bicarb. (2%)	0.62	0.61	0.63	0.62	0.64	0.63	0.64	0.64
Hot Water (45°C) + Sodium bicarb. (3%)	0.64	0.62	0.60	0.62	0.65	0.64	0.63	0.64
Hot Water (50°C) + Sodium bicarb. (3%)	0.64	0.63	0.61	0.63	0.66	0.65	0.63	0.65
Hot Water (55°C) + Sodium bicarb. (3%)	0.61	0.59	0.63	0.61	0.63	0.62	0.64	0.63
Control	0.60	0.58	0.57	0.58	0.62	0.60	0.58	0.60
Mean	**0.63**	**0.61**	**0.61**		**0.65**	**0.63**	**0.62**	
CD (p=0.05)	Storage interval			0.017	Storage interval			0.010
	Treatment			NS	Treatment			0.021
	Storage interval x Treatment –			NS	Storage interval x Treatment			NS
Initial Value	0.67				0.69			

sugars than conversion of complex carbohydrates into simple sugars by the fruit to fulfill energy demand. Heat treatment seems to delay the development of TSS, since heat treatments slow down the ripening process. A gradual decrease in TSS was observed in all samples during storage, although a typical phenomenon would be a general increase in the solute concentration due to the water loss. This result may have been related to the persistent consumption of sugars and organic acids for plant tissue metabolism, rather than the solute concentration effects during long-term storage. The results obtained in the present studies are in agreement with the findings of Khan *et al* (2007) who studied on ambient storage of sweet orange cv. Blood Red after subjecting to heat treatments for 0, 5, 10 and 15 minutes in water at 50°C revealed that total soluble solids content increased with increasing storage duration up to 45 days, but decreased when storage period was prolonged up to 60 days and heat treatments delayed TSS increase. Fruits of peach (cv. Flordasun) were subjected to hot water (immersed in a tank containing water at 40 ± 2°C for 10, 20 and 30 minutes) stored at room temperature. In their study on Valencia orange and Marsh Seedless grapefruit, Mohamed *et al* (2003) mentioned that Sodium carbonate (2 or 4%) did not affect TSS content as compared to control up to 112 days of storage (13°C and 90-98% relative humidity) in Valencia orange and Marsh Seedless grapefruit . According to Alawami *et al* (2007) immersion of peach fruits in hot water at 46 or 50°C for 2.5 min. caused reduction in TSS content as compared to control fruits.

The mean acidity after all the storage intervals was recorded maximum (0.64 and 0.66 % in 2011 and 2012) respectively) in hot water (50°C) + sodium bicarbonate (2%) and mean minimum (0.58 and 0.60 % in 2011 and 2012, respectively) acidity was recorded in control (Table 5). The perusal of data indicate that acidity of fruits decreased significantly with the advancement of storage period in all the treatments except in hot water (55°C) and its combination with sodium bicarbonate (2% or 3%) where acidity was found to be increased after 14 days of storage might be due to the fermentation of sugars resulting in production of acids. Fruits those dipped in hot water at 55°C and its combination with sodium bicarbonate (2% or 3%) however, developed off-flavor, which was probably due to the increased ethanol level. The mean maximum acidity (0.63 and 0.65% in 2011 and 2012, respectively) was recorded after 7 days and minimum acidity (0.61 and 0.62% in 2011 and 2012 respectively) after 21 days of ambient storage. The difference between storage intervals was also found to be significant. The interaction between treatment and storage interval was found to be non-significant during both the years. It was observed that percent titratable acidity had decreasing trend during 21 days of storage period that might be due to the degradation of citric acid which could be attributed to increased activity of citric acid glyoxylase during ripening or reduction in acidity may be due to its conversion into sugars and their further utilization in metabolic process of the fruit.

The results obtained in the present studies are in agreement with the findings of Obaid *et al* (2010) who

reported a significant decrease in acidity (0.90-0.68 %) in hot water dipped Blood Red orange fruits at different temperatures (45, 50, 55 and 60°C). In contrast, SeokIn *et al* (2007) mentioned hot water treatment also had no adverse effects on titratable acidity in Satsuma mandarins (*Citrus unshiu* Marc cv. Gungchun) of an early harvesting cultivar after treated by hot water dipping at 52°C for 2 min, 55°C for 1 min, and 60°C for 20 s, and then stored at 5°C for 3 weeks and subsequently at 18°C for 1 week (simulated shelf-life). Also, Cruz *et al* (2010) treated mangoes (*Mangifera indica*) cv. Tommy Atkins immersed in sodium bicarbonate solution of 3% (v/v) and stored under ambient conditions (26±2°C and RH 90±5%). They recorded reduction of the acidity in treated fruits as compared to control. The perusal of data indicate that acidity of fruit decreased significantly with the advancement of storage period in all the treatments except in hot water (55°C) and its combination with sodium bicarbonate (2% or 3%) where acidity was found to be increased after 14 days of storage might be due to the fermentation of sugars resulting in production of acids. The decrease in titratable acids during storage may be attributed to utilization of organic acid in pyruvate decarboxylation reaction occuring during the ripening process of fruits (Pool *et al* 1972). The findings of these results coincided with those of Gowda and Huddar (2001) who reported the similar pattern in different varieties of mango fruit stored at 18-34°C under gone a series of physico-chemical changes during ripening and the major changes were considerable increase in pH from 2.85 to 4.38 and decreased in acidity from 2.71 to 0.04 per cent during ripening. The acidity in most of the mandarins has been reported primarily due to two compounds, the citric and iso-citric acids (Cancolon and Xu 2002). The reduction in the titrable acidity during storage has been noticed by Kaushal and Thakur (1996).

Hot water dip might be beneficial or harmful depending upon the treatment temperature. Heat treatment seems to delay the development of TSS, since heat treatments slow down the ripening process. Exposure to high temperature (55°C), however, increased disease incidence, probably damaging waxy layer and rind tissue. Titratable acidity had decreasing trend during 21 days of storage period in all treatments except in hot water (55°C) and its combination with sodium bicarbonate (2% or 3%) where acidity was found to be increased after 14 days of storage might be due to the fermentation of sugars resulting in production of acids. Hot water (50°C) and Hot water (50°C) + sodium bicarbonate (2%) proved to be better treatment in improving the overall quality and extending the shelf life of fruits.

REFERENCES

Alawami, A.M. El., Samra, I.A., Hussein, A.M. and Shama, S.M. 2007. Efficiency of dipping in hot water or ethanol on reducing postharvest fungal decay of peach fruits. *Proceedings of International Congress* **pp** 172-9, Bologna, Italy.

Al-Obeed, R.S. and Harhash, M.M. 2006. Impact of postharvest treatments on storage life and quality of Mixican lime. *Journal of Advances Agricultural Research* **11**: 533 - 49.

AOAC 1990. Official and Tentative Methods of Analytical Chemists, Washington DC, USA 14th edition.

Ben-Yehoshua, B., Peretz, S. J., Rodov, V., Nafussi, B., Yekutieli, O., Wiseblum, A., Regev, R. and Herregods, M., Nicolai. M., Jager, A. and Roy, S.K. 2000. Postharvest application of hot water treatment in citrus fruits: the road from the laboratory to the packing-house. *Acta Horticulture* **518**: 19-28.

Cancolon, P.F. and Xu, Y. 2002. Changes in organic acid composition of citrus juices during the 2000-2001 season. *Proceedings of Florida State Horticulture Society* **115**:37-41.

Couey, H.M. 1989. Heat treatment for control of postharvest diseases and insect pests of fruits. *Horticulture Sciences* **24**(2):198-202.

Cruz M J, da S Clemente E, Cruz M E, da S Mora F, Cossaro L and Pelisson N. 2010. Effects of bioactive natural compounds on the postharvest conservation of mango fruits cv. Tommy Atkins. *Cienciae Agrotecnologia* **34**: 428-33.

Deka, B.C., Sharma, S. and Borah, S.C. 2006. Postharvest management practices for shelf life extension of Khasi mandarin. *Indian Journal of Horticulture* **63**: 251-55.

Fallik, E., Aharoni, Y., Copel, A., Rodov, R., Tuvia-Alkalai, S., Horev, B., Yekutieli, O., Wiseblum, A. and Regev, R. 2000. A short hot water rinse reduces post-harvest losses of 'Galia' melon. *Plant Pathology*. **49**: 333-38.

Fallik, E., 2004. Prestorage hot water treatments (immersion, rinsing and brushing).*Postharvest Biology and Technology* **32**:125–34.

Fallik, E., Tuvia-Alkalai, S., Feng, X., Lurie, S., 2001. Ripening characterisation and decay development of stored apples after a short pre-storage hot water rinsing and brushing. *Innovative Food Science and Emerging Technologies* **2**: 127–32.

Gautam, B., Sarkar, S.K. and Reddy, Y.N. 2003. Effect of postharvest treatments on shelf-life and quality of Banganapalli mango. *Indian Journal of Horticulture* **60**:135-39

Gonzalez Aguilar, G.A., Zacarias, L/, Mulas, M. and Lafuente, M.T. 1997. Temperature and duration of water dips influence chilling injury, decay and polyamine content in 'Fortune' mandarins. *Postharvest Biology and Technology* **12**: 61–69.

Gowda, I.N.D. and Huddar, A.G. 2001. Studies on the effects ripening changes in mango (*Mangifera indica* L.) fruits. *Journal of Food Science and Technology,* Mysore **38:** 135-37.

Hatton, T.T. and Cubbedge, R.H. 1983. Temperature for pre storage conditioning of 'March' grapefruit to prevent chilling injury at low temperature. *Horticulture Sciences* **18:** 721–22.

Joyce, D.C., Hockings, P.D., Mazucco, R.A., Shorter, A.J. and Brereton, I.M. 2003. Heat treatment injury of mango fruit revealed by non-destructive magnetic resonance imaging *Postharvest Biology and Technology* **3**: 305-11.

Kaushal, B.B.L. and Thakur, K.S. 1996. Influence of ambient and evaporative cool chamber storage conditions on the quality of polyethylene packed Kinnow. *Advances in Horticulture Science* **10**:179-84.

Khan, G.A., Rab, A., Sajid, M. and Salimullah 2007. Effect of heat and cold treatments on post harvest quality of sweet orange cv. blood red. *Sarhad Journal of Agriculture* **23**: 39-44.

Larrigaudiere, C., Pons, J., Torres, R. and Usall, J. 2002. Storage performance of clementines treated with hot water sodium carbonate and sodium bicarbonate dips. *Journal of Horticulture Science and Biotechnology* **77:** 314-19.

Maleki, M. and Sarkissian, L. 1967. Effect of canning and storage on the chemical composition and organoleptic quality of juices of different varieties oranges grown in Lebanan. *Journal of Food Science and Agriculture.***18**: 501-04.

McCornack, A.A. & Hayward, F.W. 1968. Factors affecting decay control of Dowcide Ahexamine treated citrus fruit. *Proceeding of Florida State Horticultural Society*, **81:** 290-93.

Mohamed, M.A.A., Abdel Hafeez, A.A. and Mehaisen, S.M.A. 2003. Effect of post-harvest treatments with some safe compounds on fruit properties of Valencia orange and Marsh Seedless grapefruit fruit during storage. *Annals of Agriculture Sciences,* Moshtohor **41**: 1253-67.

Obaid, J., Khalil, S.A., Khattak, A.B., Khan, M. and Ayub, M. 2010. Effect of hot water dipping on the postharvest life of blood red oranges. *Advances in Food Science* **32**: 82-87.

Panse, V.G. and Sukhatame, P.V. 1976. *Statistical method for agricultural workers* ICAR, New Delhi.

Palou, L., Usall, J., Munoz, J.A., Smilanick, J.L. and Vinas, I. 2002. Hot water sodium carbonate and sodium bicarbonate for the control of postharvest green and blue moulds of Clementine mandarins. *Postharvest Biology and Technology* **24**: 93-96.

Pimenta, R.S., Silva, J.F.M., Coelho, C.M., Morais, P.B., Rosa, C.A. and Correa, J.A. 2010. Integrated control of *Penicillium digitatum* by the predacious yeast *Saccharomycopsis crataegensis* and sodium bicarbonate on oranges. *Brazilian Journal of Microbiology* **41**: 404-10.

Pool, K.M., Weaver, R.J. and Kliewer, K.M. 1972. The effect of growth regulators on the changes in fruits of Thompson seedless during cold storage. *Journal of American Society of Horticulture Science* **97**: 67-70.

Poppe, L., Meziane, H., Vanhoutte, S. and Hofte, M. 2002. Modes of action of *Pantoea agglomerans* CPA2 an effective antagonist against postharvest pathogens on fruits. *Bulletin* **225** : 2-7.

Porat, R., Pavoncello, D., Peretz, J., Ben-Yehoshua, S. and Lurie, S. 2000. Effects of various heat treatments on the induction of cold tolerance and on the postharvest qualities of Star Ruby grapefruit. *Postharvest Biology and Technology*. **18**: 159–65.

Purvis, A.C. 1985. Relationship between chilling injury of grape fruit and moisture loss during storage. Amelioration by polyethylene shrink film. *Journal of American Society of Horticulture Science* **110**: 385-388

Ratnayake, R.M.R.N.K., Sumithra, H.J., Fernando, M.D. and Palipane, K.B. 2009. Effect of GRAS compounds on Aspergillus rot of woodapple (*Feronia limonia*). *Phyto parasitica* **37**: 431-36.

Schirra, M., Aquino, D.S., Palma, A., Angioni, A. and Cabras, P. 2008. Factors affecting the synergy of thiabendazole sodium bicarbonate and heat to control postharvest green mold of citrus fruit. *Journal of Agriculture Food Chemistry* **56**: 10793-98.

SeokIn, H., Hyun, H.L. and Dong, M.K. 2007. Effects of hot water treatment on the storage stability of satsuma mandarin as a postharvest decay control. *Post harvest Biology and Technology* **43**(2): 271-79.

Smilanick, J.L., Aiyabei, J., Gabler, F.M., Doctor, J., Sorenson, D. and Mackey, B. 2002. Quantification of the toxicity of aqueous chlorine to spores of *Penicillium digitatum* and *Geotrichum citriaurantii*. *Plant Disease* **86(5)**: 509-14.

Venditti, M.G., Molinu, A., Dore, M. and D'Hallewin, G. 2005. Sodium carbonate treatment induces scoparone accumulation, structural changes, and alkalinisation in the albedo of wounded citrus fruit. *Journal of Agriculture Food Chemistry* **53**: 3510–18.

Vijayalakshmi, D., Bangarusamy, U. and Vijayakumari, R.M. 2004. Post-harvest treatments to extend the shelf life of sapota fruit cultivars Co 1 and Co 2. *Crop Research Hisar* **27**(2/3): 219-26.

Yuosaf, S. and Hashim, H. 1992. Hot water dip versus vapour heat treatment and their effects on guava (*Psidium guajava*) fruits. *Acta Horticulture* (ISHS) **292**:217-222.

Zhang, H.Y., Wang, S.Z., Huang, X.Y., Dong, Y. and MaLong, C. 2008. Control of blue mold disease and natural decay of postharvest peaches by hot water treatment. *Transactions of the Chinese Society of Agricultural Engineering* **24(8):** 294-97.

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Effect of organic manures and inorganic fertilizers on growth and flowering in gladiolus cv. Tiger Flame

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ABSTRACT

The experiment was conducted in Randomized Block Design (RBD) with three replications. A field experiment was conducted to assess the effect of vermi compost 5t/ha, 10t/ha 15t/ha, and F.Y.M. 10t/ha, 20t/ha, 30t/ha, NADEP compost 10t/ha, 20t/ha, 30t/ha and NPK 120:60:120kg/ha on vegetative and flowering growth in Gladilous cv. Tiger Flame. Application of 15t/ha vermi compost increasing flowering character like spike length, no. of florets / spike, no. of spike / plant, size of florets and height of plants and vegetative characters like – number of leaves per plant, number of corm per plant. N.P.K. 120 : 60 : 120 kg/ha showed the maximum plant height.

KEY WORDS: Gladiolus corm, Organic manures and Inorganic fertilizers.

Among the leading cut flower crop in the international trade, gladiolus occupies a prime position. The market loss of cut flowers due to inefficient post harvest management in India is estimated to be around 30-45 per cent. The immense commercialization of agriculture has a very negative impact on the environment. It also affects the health of farm workers and florists who are dealing with them biofertilizers and organic farming have the capability to take care of each of these problems. Besides this, organic culture also has good impact on the quality flower production. It can also greatly help a farmer to become self sufficient in his requirement for agro-input. Hence, in the present organic era, there is an urgent need for effective increase in the production and improvement in the quality and longevity of flowers through organic culture.

MATERIALS AND METHODS

The present investigation was carried out at Horticulture Garden Janta College Bakewar, Etawah (U.P.) during year 2012-2013, to find out the effect of organic manures and inorganic fertilizers on vegetative growth and flowering parameters. Organic manures used were farm yard manure (FYM), vermicompost (VC) and NADEP compost (NC). The data were recorded for number of days taken for corm germination, number of leaves per plant, number of tillers per plants, number of days taken for opening of first floret, size of first florets. Number of florets per spike, number of days taken for opening last florets, length of spike (cm), period of flowering, number of days taken for senescence of last florets, length of rachis (cm). Variety Tiger Flame selected for investigation. The experiment was laid out in a randomized block design with 11 treatments and three replications. Statistical analysis were done as per the procedure given by Panse and Sukhatme (1989).

RESULTS AND DISCUSSION

The minimum number of days taken for germination (11.53 days) was recorded in T_3 (F.Y.M 30t/ha) followed by (12.66 days) with T_9 (V.C. 15t/ha) while maximum number of days taken for germination was recorded under control (23.43 days). The maximum number of tillers per plant (2.86) was recorded in treatment T_9 and T_6 (V.C.15t/ha) and (N.C 30 t/ha) followed by (2.53) with T_5 (N.C.) 20 t/ha) but the minimum number of tillers per plant (1.33) was recorded under control. The result are in conformably with the finding of (Nazir *et al*. 2007). Number of leaves per plant range between 8.13 and 9.20. The maximum number of leaves (9.20) was recorded under T_9 (VC 15t/ha) while minimum number of leaves per plant (8.13) under T_1 (F.Y.M. 10t/ha) and control. Maximum height of plant (127.73 cm) was recorded in T_{11} (N.P.K. standard dose) followed by (123.53 cm) with T_3 (F.Y.M. 30 t/ha) and T_6 (N.C. 30 t/ha). The effect of organic and inorganic fertilizers on height of plant (72.88cm) at 45 days after planting, number of leaves (5.13) at 30 days after planting (Gangadharan and Gopinath, 2000). The minimum plant height was recorded under control (102.53cm), Table 1.

Table 1: Effect of organic manures and inorganic fertilizers on vegetative growth of gladiolus cv. Tiger Flame

Treatment	Characters			
	No. Days taken for corm germination	No. of tillers /plant	No. of leaves/plant	Height of plant (cm)
T_1- F.Y.M. 10 t/ha	15.80	1.93	8.13	115.86
T_2- F.Y.M. 20 t /ha	14.56	2.00	8.60	119.86
T_3-F.Y.M. 30 t /ha	11.53	2.46	8.93	123.53
T_4-N.C. 10 t /ha	19.06	2.40	8.60	115.46
T_5-N.C. 20 t /ha	17.53	2.53	8.80	119.33
T_6-N.C. 30 t /ha	17.33	2.46	9.00	123.53
T_7-V.C. 5 t /ha	13.93	2.00	8.66	108.20
T_8-V.C. 10 t /ha	13.13	2.46	8.86	117.36
T_9-V.C. 15 t /ha	12.66	2.86	9.20	117.86
T_{10}- Control	23.43	1.33	8.13	102.53
T_{11} -N.P.K. – 120:60: 120 kg/ha	15.80	2.26	8.80	127.73
CD-at 5%	1.67	0.31	0.38	5.97

The maximum number of days (106.66) taken for spike initiation was recorded under control followed by (98.04 days) taken for spike initiation under T_7 (V.C. 5t/ ha). The maximum number of spikes per plant (3.00) was produced in T_9 (V.C. 15t/ ha) followed by (2.53) in T_8 (V.C. 10t/ ha). The minimum number of spikes per plant (1.20) were produced in control. Maximum number of days for openings of first floret was (117.00) taken by plants under control. The minimum days (103.84 days) was recorded for T_3 (F.Y.M. 30t/ ha) followed by (104.60 days) T_9 (V.C. 15t/ ha). The maximum size of first floret (18.35cm) was recorded under T_9 (V.C. 15t/ ha) followed by (11.99cm) T_8 (V.C.10t/ ha). The minimum size of first floret was recorded under control (10.95cm) The minimum size of third floret (11.81cm) was recorded with T_9 (V.C.15t/ ha) followed by (11.38cm) with T_8 (V.C.10t/ ha), minimum size of third floret (10.15cm) was recorded under control. Nazir *et al.* (2007), they reported that organically grown gladiolus producing more number of florets per spike and diameter of floret per spike, diameter is also maximum. Maximum

Table 2: Effect of organic manures and inorganic fertilizers on flowering parameters of gladiolus cv. Tiger Flame

Treatments	Characters										
	Number of days taken for Spike Initiation	Number of spike per plant	No. of days taken for opening of Ist floret	Size of Ist floret (cm)	Size of IIIrd floret (cm)	No.of floret /spike	No. of days taken for opening of last floret	Length of spike (cm)	No. days taken for sene-scence at last floret	Period of flowe-ring	Length of Rachis (cm)
T_1-F.Y.M. 10 t/ha	96.93	1.60	105.33	11.32	10.74	14.10	117.93	70.03	124.20	18.86	52.66
T_2- F.Y.M. 20 t/ha	95.73	1.66	105.06	11.41	11.03	14.43	117.40	75.40	125.00	19.93	55.46
T_3- F.Y.M. 30 t/ha	93.66	2.06	103.84	11.62	11.16	14.66	117.40	76.26	126.00	22.29	59.00
T_4- N.C. 10 t /ha	97.10	2.08	107.66	11.67	10.74	13.33	118.73	69.13	127.00	19.33	51.93
T_5- N.C. 20 t /ha	97.06	2.30	105.93	11.75	10.90	13.86	118.33	70.88	126.93	20.86	52.93
T_6- N.C. 30 t /ha	94.86	2.48	104.96	11.89	11.12	14.46	118.33	76.48	126.26	21.46	57.00
T_7- V.C. 5 t /ha	98.04	1.80	105.73	11.79	11.14	14.53	117.26	72.68	125.93	20.20	54.26
T_8- V.C. 10 t /ha	96.22	2.53	105.00	11.99	11.38	15.93	116.93	75.37	125.40	20.40	56.13
T_9- V.C. 15 t /ha	94.60	3.00	104.07	12.35.	11.81	15.26	116.66	76.60	126.66	22.06	59.06
T_{10}- Control	106.66	1.20	117.00	10.95	10.15	13.06	123.93	66.63	135.33	18.33	49.40
T_{11}- N.P.K. – 120:60: 120 kg/ha	96.33	2.00	107.46	11.32	10.67	14.60	118.73	77.26	126.06	19.26	59.86
CD at 5%	2.00	0.26	1.68	0.34	0.39	1.01	0.92	2.60	1.67	2.07	4.11

Note:

NC - Nadep Compost VC - Vermi Compost FYM - Farm Yard Manure

number of florets per spike (15.93) was recorded under T_8 (V.C. 10t/ha) followed by (15.16) florets per spike under T_9 (V.C. 15t/ha). Similar results of increased maximum number of per spike with the vermi compost (8t/ha), azotobacter and PSB@25kg/ha (Godse *et al.* 2006). The minimum number of spikes per plant (13.06) was recorded under control. Average number of days taken for opening of last floret ranged between 116.67 T_9 (V.C.15t/ha) and 123.93 days under control. Maximum length of spikes was recorded (77.26cm) under the treatment T_{11} (N.P.K. standard dose) followed by (76.60cm) with T_9 (V.C.15t/ha). The minimum length of spikes were produced under control (66.63cm). These results corroborate with results of (Sharma and Singh *et al.* 2007), who reported that the application of N_{40}, P_{20}, K_{20} g/m^2 significantly increases spike length. The maximum number of days required for senescence of first floret was recorded 126.06 days under control followed by 119.66 days with T_5 (N.C. 20t/ha). Where as minimum number of days 115.93 required for senescence under T_8 (V.C. 10t/ha). The maximum average number of days taken for senescence of last floret was recorded 135.35 days under control followed by 127.00 days under the, treatment T_4 (N.C.10t/ha) where as minimum number of 124.20 days required for senescence under T_1 (F.Y.M.10t/ha). These finding nearly corroborate with (Thangam *et al.* 2007). The plant treated (F.Y.M. 30t/ha) with T_3 recorded maximum period of flowering (22.29 days) followed by (V.C.15t/ha) with T_9 (22.06 days). The maximum length of rachis (59.86cm) was recorded in T_{11} (N.P.K. standard dose) followed by 59.06 cm with T_9 (V.C.15t/ha). The minimum length of rachis was recorded under control (49.40cm) Table 2.

Studies thus suggested that application of 15 t/ha Vermin compost was found most effective treatments. For increasing the flower yield, vegetative growth and corm production in gladiolus, C.v. "Tiger Flame" as compared to other organic and inorganic fertilizers.

REFERENCES

Gangadharan, G.D. and Gopinath, G. 2000. Effect of organic and inorganic fertilizers on growth flowering and quality of gladiolus Cv. White Prosperty. *Karnatka journal of Agriculuture sciences*. **13(2)**: 401 – 405, 4 Ref.

Godse, S.B., Golliwar, V.J., Chopde, N., Bramhankar, K.S. and Korel, M.S. 2006. Effect of organic manures and bio-fertilizers with reduced doses of inorganic fertilizers on growth, yield and quantity of gladiolus. *J. Soils and Crops*. **16(2)**: 445 – 449.

Nazir, M. and Bhat, K.L. 2007. Exploring export potential of gladiolus from Jammu & Kashmir, *Indian Horticulture* **48**:1-20.

Panse, V.G. and Sukhatme, P.V. 1989. stastical method for agricultural workers. ICAR, New Delhi.

Sharma, G. and Singh P. 2007. Response of N, P and K on vegetative growth, flowering and corm production in gladiolus under mango orchard. Journal of Ornamental Horticulture, **10(1)**: 52 -54.

Thangham, M. and Ramchandraudu, K. 2007. Response of plant growth regulators coconut water and cow urine on vegetative growth, flowering and corm production in gladiolus, *Journal of Ornamental Horticulture*, **10(1)**: 38-41.

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Influence of nitrogen and potassium on growth and yield of gladiolus corms

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ABSTRACT

A field experiment on influence of nitrogen and potassium on growth and yield of gladiolus corm was conducted at Horticulture Section, College of Agriculture, Nagpur (M.S.) during 2012-2013 with sixteen treatment combinations in factorial randomized block design. The treatment comprised of four levels of nitrogen (0, 150, 300 and 450 kg ha^{-1}) and four levels of potassium 90, 75, 150 and 225 kg ha^{-1}). The results of the experiment revealed that, plant height, shoots plant^{-1}, number of cormels plant^{-1}and ha^{-1}, diameter of corm, weight of corms plant^{-1} and weight of cormels plant^{-1} were recorded significantly higher with 450 kg nitrogen ha^{-1} and 225 kg potassium ha^{-1}. However, in respect of corm yield, the treatment combination of 300 kg ha^{-1} of nitrogen with 225 kg ha^{-1} of potassium produced significantly maximum number of corms plant^{-1}and ha^{-1}.

KEY WORDS: Corms,Cormels,Gladiolus, Growth, Nitrogen, Potassium.

Gladiolus is very popular and important bulbous ornamental flowering plant of the world. It is known as queen of bulbous flowers. It belongs to the family Iridaceae and is a native of Mediterranean region. It is excellent for cut flowers as it lasts long in flower vase and has magnificent inflorescence with variety of colours. Production of healthy and vigorous corms and cormels depend on many factors, of which nutrient supply is an important one. Gladiolus requires nutrients throughout the period of growth, corm development and flowering. So, application of nutrients in an optimum level is essential. There is a good scope of increasing the yield and vigorous corms and cormels production ofgladiolus by the use of appropriate amount of nitrogen and potassium under the agro-ecological conditions of Vidarbha region. Keeping these in view, the present study was undertaken to investigate the effects of nitrogen and potassium on yield and quality of gladiolus corms and cormels.

MATERIALS AND METHODS

A field experiment was conducted at Farm No. 16, Horticulture Section, College of Agriculture, Nagpur (Maharashtra) India during 2012-2013. The experiment was laid out in factorial randomized block design with three replications. Four nitrogen levels were used *viz.*, 0 kg N ha^{-1}, 150 kg N ha^{-1}, 300 kg N ha^{-1} and 450 kg Nha^{-1} and four levels of potassium i.e. 0 kg K_2O ha^{-1}, 75 kg K_2O ha^{-1}, 150 kg K_2O ha^{-1} and 225 kg K_2O ha^{-1}. After preparing the land, the field was laid out with the beds of 45 cm spaced ridges and furrows and the rested, cold stored, best quality and uniform sized corms of gladiolus variety 'American Beauty' were planted after treating with fungicide for 20 minutes at a spacing of 45 x 15 cm. Fertilizer dose of nitrogen, phosphorus and potassium was applied in the form of urea, single super phosphate and muriate of potash, respectively. A recommended dose of phosphorus i.e. 200 kg ha^{-1} was applied for all the treatment plots as a full dose at the time of bed preparation before planting. The dose of potassium was applied as per the treatment as a full dose at the time of bed preparation, however, the dose of nitrogen was splitted in three equal splits and was applied at 2 leaf, 4 leaf and 6 leaf stages as per the treatment, respectively. The recommended cultural and plant protection measures were followed.

RESULTS AND DISCUSSION

Growth parameters *viz.* plant height and shoots plant^{-1} (Table 1) were significantly influenced by nitrogen and potassium levels. Significantly maximum height of plant and shoots plant^{-1}were found with 450 kg nitrogen ha^{-1} which was statistically at par with 300 kg nitrogen ha^{-1}, however, height of plant and shoots plant^{-1} were noted minimum with 0 kg nitrogen ha^{-1}. The favorable effect of higher levels of nitrogen i.e. 450 and 300 kg N ha^{-1} in promoting height of plant and shoots plant^{-1} might be due to the fact that the increase in nitrogen level enhanced the chlorophyll formation and thereby increased photosynthesis and synthesis of reserve food material

Table 1: Growth and yield of corms and cormelsin gladiolus as influenced by nitrogen and potassium

Treatment	plant height (cm)	shoots plant^{-1}	Corms plant^{-1}	Corms ha^{-1} (lakh)	Cormels plant^{-1}	Cormels ha^{-1} (lakh)	Diameter of corm (cm)	Weight of corms plant^{-1} (g)	Weight of cormels plant^{-1} (g)
Nitrogen (N)									
N_0-0 kg N ha^{-1}	50.40	2.70	2.02	2.30	23.85	27.26	3.68	53.02	6.05
N_1-150 kg N ha^{-1}	52.35	2.90	2.30	2.63	26.12	30.76	4.18	60.11	6.99
N_2-300 kg N ha^{-1}	55.51	3.37	2.90	3,31	29.37	33.56	4.45	63.71	7.76
N_3-450 kg N ha^{-1}	56.68	3.62	3.06	3.50	31.73	36.27	4.63	66.48	8.04
F test	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**
SE (m) ±	1.40	0.11	0.07	0.08	0.97	1.11	0.14	1.59	0.31
CD at 5%	4.04	0.30	0.21	0.24	2.81	3.21	0.41	4.58	0.88
Potassium(K)									
K_0-0 kg K_2O ha^{-1}	51.16	2.63	2.14	2.45	24.83	28.38	3.83	51.33	6.31
K_1-75 kg K_2O ha^{-1}	52.56	3.05	2.40	2.74	26.18	29.92	4.08	59.39	6.89
K_2-150 kg K_2O ha^{-1}	53.49	3.32	2.75	3.14	28.92	33.05	4.30	63.60	7.35
K_3-225 kg K_2O ha^{-1}	57.63	3.58	2.98	3.41	31.93	36.49	4.73	68.99	8.29
F test	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**
SE (m) ±	1.40	0.11	0.07	0.08	0.97	1.11	0.14	1.59	0.31
CD at 5%	4.04	0.30	0.21	0.24	2.81	3.21	0.41	4.58	0.88
Interaction effect (N x K)									
F test	**NS**	**NS**	**Sig.**	**Sig.**	**NS**	**NS**	**NS**	**NS**	**NS**
SE (m) ±	2.80	0.21	0.14	0.16	1.95	2.22	0.28	3.18	0.61
CD at 5%	-	-	0.41	0.49	-	-	-	-	-

which ultimately promotes vegetative growth. Similar increase in vegetative growth with increased level of nitrogen was also found bySingh *et al*. (2008) in Asiatic hybrid lily and Devi and Singh (2010) in tuberose.

Among the different levels of potassium, significantly maximum plant height and shoots plant^{-1} were found with 225 kg potassium ha^{-1} which was followed by 150 kg potassium ha^{-1}, however, plantheight and shoots plant^{-1} were noted minimum with 0 kg potassium ha^{-1}. The increase in growth parameters with higher dose of potassium might be due to improvement in efficiency of nitrogenous fertilizers and active involvement of potassium in the development of chlorophyll. Similar results were also obtained by El-Naggar (1999) in tuberose and Singh *et al*. (2008) in Asiatic hybrid lily.

The interaction effect of nitrogen and potassium was found non significant in respect of growth parameters studied in this experiment.

Corm yield parameters *viz*. corms plant^{-1}, corms ha^{-1}, cormels plant^{-1}, and cormels ha^{-1} (Table 1) were significantly influenced by nitrogen and potassium levels. Significantly maximum corms plant^{-1}, corms ha^{-1}, cormels plant^{-1} and cormels ha^{-1} were found with 450 kg nitrogen ha^{-1} which was statistically at par with 300 kg nitrogen ha^{-1}, however, minimum corms plant^{-1}, corms ha^{-1}, cormels plant^{-1} and cormels ha^{-1} were noted with 0 kg nitrogen ha^{-1}. The favorable effect of higher levels of nitrogen in promoting corms and cormels yield might be due to the fact that the higher level of nitrogen provides better growth and development of plant and helps in translocation of photosynthates from source to sink (corms) which might have been resulted in to higher yield of corms. Devi and Singh (2010) and Khan *et al.* (2012)[b] also reported that, increasing nitrogen levels resulted in superior yield of bulbs in tuberose and cormels in freesia respectively.

Significantly maximum corms plant^{-1}, corms ha^{-1}, cormels plant^{-1}, andcormels ha^{-1} were found with 225 kg potassium ha^{-1} which was followed by150 kg potassium ha^{-1} however, all these parameters were recorded minimum with the application of 0 kg potassium ha^{-1}. Yield of corms and cormelsin gladiolus was increased with every increment of potassium application up to the level of 225 kg potassium ha^{-1} asbetter vegetative growth might have increased photosynthesis resulting in assimilation of more carbohydrates and their translocation in to the corms and this might be the probable cause for increase in corms and cormels yield. Similar increase in corm yield due to higher dose of potassium was also reported by Barman *et al*. (2005) and Zubair (2011) in gladiolus.

An interaction effect of nitrogen and potassium on number of corms plant^{-1} and ha^{-1} was found to be significant (Table 2). The treatment combination of 300 kg of nitrogen with 225 kg of potassium had recorded significantly maximum number of corms plant^{-1} and ha^{-1} which was significantly superior than other treatment combinations except 300 kg N ha^{-1} with 150 kg K_2O ha^{-1}, 450 kg N ha^{-1} with 225 kg K_2O ha^{-1} and 300 kg N ha^{-1} with

Table 2: Corm yield in gladiolus as influenced by interaction effect of nitrogen and potassium

Treatment combinations	Corms plant^{-1}	Corms hectare^{-1} (lakh)
N_0K_0	1.87	2.13
N_0K_1	1.87	2.13
N_0K_2	1.93	2.21
N_0K_3	2.40	2.74
N_1K_0	1.93	2.21
N_1K_1	2.13	2.44
N_1K_2	2.40	2.74
N_1K_3	2.73	3.12
N_2K_0	2.13	2.44
N_2K_1	2.60	2.97
N_2K_2	3.40	3.89
N_2K_3	3.47	3.96
N_3K_0	2.63	3.01
N_3K_1	3.00	3.43
N_3K_2	3.27	3.73
N_3K_3	3.33	3.81
F test	**Sig.**	**Sig.**
SE (m) ±	0.14	0.16
CD at 5%	0.41	0.49

150 kg K_2O ha^{-1}whereas, the treatment combinations of 0 kg N ha^{-1} with 0 kg K_2O ha^{-1} and0 kg N ha^{-1} with 75 kg K_2O ha^{-1} had counted minimum number of corms plant^{-1} and ha^{-1}. The highest yield of corms were noted with the application of 300 kg N and 225 kg K_2O ha^{-1} which might have been due to the combine effect of the optimum levels of both the nutrients. These results are in harmony with those obtained by Khan *et al*. (2012)[a] in gladiolus.

An effect of nitrogen and potassium on various quality parameters *viz*. diameter of corm, weight of corm and cormels etc. (Table 1) was found to be significant. Significantly maximum diameter of corm and weight of corms and cormels plant^{-1} were found with 450 kg nitrogen ha^{-1} which was statistically at par with 300 kg nitrogen ha^{-1}, however, minimum diameter of corm and weight of corms and cormels plant^{-1} were noted with 0 kg nitrogen ha^{-1}. The increase in quality parameters with higher rates of nitrogen may be due to positive effect of nitrogen in stimulation of vegetative growth and increase in translocation and accumulation of organic matter in the new corms and finally reflexes on corm and cormels quality. Similar trend was also found byKumar *et al*. (2006) and Sewedan *et al*. (2012) in gladiolusand Khalaj and Edrisi (2012) in tuberose.

Various quality parameters *viz*.diameter of corm, weight of corm and cormels plant^{-1} were found significantly maximum with 225 kg potassium ha^{-1} which was followed by150 kg potassium ha^{-1}, however, minimum diameter of corm, weight of corms and cormelswere noted with 0 kg potassium ha^{-1}. The increase in diameter of corm, weight of corms and cormels plant^{-1} with increase in level of potassium might be due to the fact that, potassium promotes larger size of corms and cormels by increasing water accumulation in the underground plant parts resulting in higher weight of corms and cormels. These results are in conformity with those of Barman *et al*. (2005) in gladiolus.

The interaction effect of nitrogen and potassium was found non significant in respect of corms quality parameters studied in this experiment.

REFERENCES

Barman, D., Rajni, K., Pal, R. and Upadhyaya, R.C. 2005. Corm multiplication of gladiolus as influenced by application of potassium and spike removal. *Journal of Ornamental Horticulture*. **8(2)**: 104-107.

Devi, K.L. and Singh, U.C. 2010. Effect of nitrogen on growth, flowering and yield of tuberose *cv*. Single. *Journal of Ornamental Horticulture*.**13(3)**: 228-232.

El-Naggar, A.I. 1999. Effect of potassium fertilization rates and application frequencies on vegetative growth, flowering and bulb production of tuberose plants (*Polianthestuberosa* L.) *cv*. Double under field conditions. *Annals Agricultural Science*. **37(2)**: 1299-1321.

Khalaj, M. A. and Edrisi, B. 2012. Effect of plant spacing and nitrogen levels on quantity and quality characteristics of tuberose (*Polianthes tuberosa*L.) under field experiment.*International Journal of AgriScience*.**2(3)**: 244-255.

Khan, F.N., Rahman, M.M., Karim, A. J. M. S. 2012[a]. Effect of nitrogen and potassium on growth and yield of gladiolus corms.*Bangladesh Journal of Agricultural Research*. **37(4)**: 607-616.

Khan, M.K., Sajid, M., Rab, A., Jan, I., Zada, H., Zamin, M., Haq, I., Zaman, A., Shah, S.T. and Rehman, A. 2012[b]. Influence of nitrogen and phosphorus on flower and corm production of freesia. *African Journal of. Biotechnology*. **11(56)**: 11936-11942.

Kumar, R., Yadav, D.S. and Roy, A.R. 2006. Effect of nitrogen, phosphorus and potassium on growth, flowering and corm production of gladiolus *cv*. Pusa Shabnum under Meghalaya conditions. *Environment and Ecology*. **24(3A)**: 939-942.

Sewedan, E., El-Naggar, H. and Osman, A. 2012. Effect of nitrogen and diphenylamine on *gladiolus hybrida* cv. Sancerre production. *Journal of Horticultural Science & Ornamental Plants*, **4(3)**: 267-274.

Singh, M.K., Kumar, S. and Ram, R. 2008. Effect of nitrogen and potassium on growth, flowering and bulb production in Asiatic hybrid lily cv. Novecento. *Journal of Ornamental Horticulture*. **11(1)**: 45-48.

Zubair, M. 2011. Effect of potassium fertility levels on gladiolus yield quality of cut flowers and corm production. *Egyptian AcademicJournal of Biological Sciences*. **2(1)**: 17-27.

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Effect of different packaging materials on biochemical parameters of guava (*Psidium guajava* L.)

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ABSTRACT

The main achievement of present finding is that black polythene was found good for improving significantly TSS, ascorbic acid and acidity of guava fruits in cultivar Allahabad Safeda and Lalit. The tissue paper is useful for improving T.S.S. of guava fruits. These treatments were found to be the good for 16 days of storage in both cultivar Allahabad Safeda and Lalit. Cultivar Allahabad Safeda has given better results as compared to Lalit.

KEY WORDS: Guava, TSS, acidity, ascorbic acid and packaging material.

Guava, scientifically known as *Psidium guajava* L. belongs to the genus *Psidium* of the family *Myrtaceae* is the most important, highly prolific, delicious and nutritious fruit of tropical and sub-tropical regions of Indo-pak sub-continent. Guava is available to cheap rate and popularly known as '*apple of plain's and 'poor man's apple'*. It is now cultivated in more than 60 countries of the world. It is commercially cultivated in India, Brazil, Mexico, Florida, Hawaii, California, Peru, Egypt, South Africa, Algeria, Columbia, West Indies, China and Malaysia. The common guava is a diploid (2n=22), but natural and artificial triploid (2n=33) and aneuploids exist . Guava is fourth most important fruit crop in area and production after mango, banana and citrus in India. Guava share 3.3 per cent of area and 3.3 per cent of production of total fruit crops grown throughout India. Guava is 5th in productivity among different fruit crops grown in India. Guava is being cultivated in India on 2.35lakh ha area with an annual production of 31.98 lakh ton (Anon., 2014). Uttar Pradesh leads in area and production while Karnataka leads in productivity (13.6mt per ha).

In north Indian agro-climate conditions guava flower twice in a year- first in April-May for rainy season crop and then, August-September for winter season crop. Generally, fruit yield is more in rainy season crop as compared to winter season crop but rainy season crop is insipid in taste and poor in quality (Singh, 1978). It is one of the most common fruits liked by the rich man and the poor equally and is popularly known as the "*Apple of the tropics*". Excellent salad and pudding are prepared from the shell of the ripe fruit. It can also be canned in sugar syrup or made into fruit butter. Guava juice is used for preparation of '*sherbets*' and *ice-cream*. With a view to nutritive value, guava is a rich source of vitamin C and pectin. It contains vitamin C two to five times more than oranges and ten times more than tomatoes. The guava is a moderately good source of calcium and iron as well as a fair source of phosphorus compared with other fruits (Singh and Singh, 2000). Therefore, it is an ideal fruit for the nutritional security. Besides this, fruits are very good for preparing jam and jelly due to its high pectin content (Kumar, 2008). Pink pulped guava varieties supply carotenoid called as Lycopene. The leaves and bark have high tannin content.

Allahabad Safeda is the most famous variety of Allahabad as well as all over India. Tree is vigorous, 5.8 to 6.5 meter in height with heavy branching. Fruits are medium roundish having yellowish in colour at maturity stage. Lalit is also recommended cultivar for most of the guava growing states in India. Plants are 3.8 to 4.5 meter in height, vigorous and flat crown. Tree is heavy yielder with 24% higher yield than Allahabad Safeda. Fruit is attractive saffron yellow with red blush and medium in size fruit (185g.) It is suitable for both table use and processing for making beverage and jelly . Guava is a highly perishable fruit. The post harvest loss in guava fruits is estimated to be at 3.4-15.1 per cent. Various means of extending the shelf-life of fresh fruits have been

experimented and recommended for different kinds of fruits viz. cold storage, skin coating with wax, growth regulator and chemicals treatments, packaging materials, ethylene absorbent. Since, the response of fruits to these treatments vary with different kinds of fruits and the varieties and the local ambient conditions, it may be necessary to find out a suitable technology for extending the shelf-life of guava fruits.

MATERIALS AND METHODS

The experiment was carried out during the month March 2014 to April 2014 in laboratory situated at the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya -Vihar Campus on Lucknow. The observations viz., T.S.S, Acidity and Ascorbic Acid. Fully mature guava fruits cultivar Lalit and Allahabad Safeda at greenish yellow stage were harvested by hand in the month of February and obtained from Central Institute of Tropical & Subtropical Horticulture, Raheman khera, Lucknow. Healthy fruits were selected and washed thoroughly with tap water to remove adhering dirt and dust and were dried in air and subsequently kept in plastic crates for packaging and storage. The selection of packaging materials was done according to quantity of fruit to be packed for certain storage period at a particular storage temperature and RH as per procedure given for the selection of packaging material by Ranganna (1986). Fruits were packed in different packaging materials selected and each was designed as treatment viz.

Table 1: Details of treatments and their symbols

S.No.	Treatments details	Symbols
1.	Control	T_0
2.	Black Polythene	T_1
3.	White polyethylene	T_2
4.	Tissue Paper	T_3

The weight of the ten fruits in each treatment was recorded with the help of electronic balance. The Total Soluble Solids were determined by using a Hand Refractometer (Erma Japan). The ascorbic acid in fresh fruit pulp was estimated by using 2, 6 dichlorophenol indophenols dye visual titration method and cidity in fresh fruit pulp was estimated as reported by Ranganna (1986). The data recorded during the experimentation was subjected to suitable statistical analysis to test level of significant as per method given by Chandel (1984).

RESULTS AND DISCUSSION

Under the present study it was observed that fruits retained acceptable visual appearances and accepted edible quality for 16 days when stored at room temperature. Acceptable fruit quality with increase time was evaluated by analysis of bio-chemical parameters of stored fruits is discussed below.

Biochemical parameters:

The data regarding effects of different packaging materials on TSS of guava fruits are presented in Table 1. The effect of storage period, packaging material and storage temperature on TSS of guava fruits was statistically significant. The TSS was increase gradually till 10 day of storage and there after it decreased in all treatments and both cultivars but the reduction was much faster in Allahabad Safeda and then Lalit(Table-1). Maximum TSS recorded in T_3 (tissue paper) both cultivars (V_1) Allahabad Safeda(13.07 °B) as well as (V_2) Lalit (12.85 °B) at 16 days of storage. Minimum TSS was recorded in treatment T_0 (control) both cultivars. Similar trend has been reported by Kumar *et al.* (2003) who recorded that maximum TSS was in news paper packaging guava fruits during storage periods. Attri and Singh (2003) conducted a similar study in guava fruits and found that TSS was reduced in all treatments during 48 days of storage under both temperature. Singh *et al.* (2005) found that TSS of guava fruits increased with increasing period of storage up to 8 days and decreased until 16 days of storage in all packaging materials. It may possibly be owing to enhanced rate of ripening brought about by high temperature development inside the polythene bags. These findings are in general agreement with the Kirad *et al.* 2008

The data regarding effects of different packaging materials on acidity of fruits are presented in Table 2. Statistically non significant differences were recorded in acidity in various packaging material and both cultivars during storage condition. Treatment T_1(black polythene) proved to be the best having highest retention values for acidity both in Allahabad Safeda (0.46%) and Lalit(0.41%) after 16 days of storage. Maximum acidity was decreased in T_3 (tissue paper) in both cultivars Allahabad Safeda(0.40%) as well as Lalit (0.37%) at 16 days of storage. The results are accordance with a similar study in guava fruits by Attri and Singh (2003) who analyzed that acidity of guava fruits decreased with increasing storage period. The decrease was corporately more in Lalit and then Allahabad Safeda during storage condition. Similar results have been obtained when in guava. Singh *et al.* (1993). The decrease in acidity during storage may be due to absorption of water vapor and its conversion in to sugar. It decreased with advancement of storage period and was

Table: 1. Effect of different packaging on the TSS of guava fruit in cultivars Allahabad Safeda and Lalit

Days	0 – Days					4 - Days					8 - Days					12 - Days					16 – Days				
Treatments / Cultivar	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN
Allahabad Safeda (V_1)	9.400	10.10	9.500	9.000	9.500	10.30	10.90	10.33	11.20	10.67	11.20	11.90	11.00	12.80	11.72	11.50	12.70	11.60	13.70	12.375	11.90	13.30	12.20	14.90	13.075
Lalit (V_2)	9.000	9.100	9.900	8.500	9.125	10.10	10.80	10.90	10.50	10.75	10.90	11.80	11.60	12.00	11.57	11.30	12.50	12.10	12.80	12.175	11.80	13.10	12.60	13.90	12.850
Mean (T_1)	9.20	9.600	9.750	8.750		10.20	10.85	10.60	10.85		11.05	11.85	11.30			11.40	12.60	11.85	13.25		11.85	13.20	12.40	14.40	
CD at 5%		S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.		
	A	0.072	0.153			A	0.087	N.S.			A	0.101	N.S.			A	0.115	N.S.			A	0.130	N.S.		
	B	0.102	0.216			B	0.122	0.260			B	0.143	0.303			B	0.163	0.346			B	0.184	0.390		
	AxB	0.144	0.306			AxB	0.173	0.367			AxB	0.202	0.428			AxB	0.231	0.490			AxB	0.260	0.551		

A- Allahabad Safeda, B- Lalit, N.S.- Non significant

Table: 2. Effect of different packaging on the acidity of guava fruit in cultivars Allahabad Safeda and Lalit

Days	0 – Days					4 - Days					8 - Days					12 - Days					16 – Days				
Treatments / Cultivar	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN
Allahabad Safeda (V_1)	0.590	0.570	0.600	0.550	0.578	0.570	0.560	0.580	0.520	0.558	0.550	0.550	0.550	0.480	0.533	0.520	0.530	0.5510	0.450	0.502	0.490	0.510	0.470	0.400	0.467
Lalit (V_2)	0.560	0.530	0.570	0.540	0.550	0.530	0.510	0.540	0.510	0.522	0.500	0.510	0.500	0.460	0.492	0.470	0.490	0.460	0.430	0.463	0.430	0.460	0.410	0.370	0.418
Mean (T_1)	0.575	0.550	0.585	0.545		0.550	0.535	0.560	0.515		0.525	0.530	0.525	0.470		0.495	0.510	0.485	0.440		0.460	0.485	0.444	0.385	
CD at 5%		S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.		
	A	0.014	N.S.			A	0.022	N.S.			A	0.026	N.S.			A	0.026	N.S.			A	0.027	N.S.		
	B	0.020	N.S.			B	0.031	N.S			B	0.037	N.S.			B	0.037	N.S.			B	0.039	N.S.		
	AxB	0.029	N.S.			AxB	0.043	N.S.			AxB	0.052	N.S.			AxB	0.052	N.S.			AxB	0.055	N.S.		

A- Allahabad Safeda, B- Lalit, N.S.- Non significant

Table 3: Effect of different packaging on the ascorbic acid of guava fruit in cultivars Allahabad Safeda and Lalit

Days	0 – Days					4 - Days					8 - Days					12 - Days					16 – Days				
Treatments / Cultivar	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN	T_0	T_1	T_2	T_3	MEAN
Allahabad Safeda (V_1)	187.0	186.0	181.0	183.0	184.25	183.0	184.0	177.0	179.0	180.0	181.0	183.0	174.0	176.0	178.500	178.0	180.0	173.0	173.0	175.750	176.0	178.0	172.0	168.0	173.0
Lalit (V_2)	205.0	210.0	198.0	190.0	200.75	203.0	209.0	196.0	186.0	198.0	202.0	208.0	194.0	183.0	196.750	200.0	206.0	193.0	193.0	194.500	197.0	204.0	193.0	176.0	192.0
Mean (T_1)	196.0	198.0	189.5	186.5		193.0	196.5	186.5	182.5		191.0	195.0	184.0	179.5		189.0	193.0	18 3.0	18 3.0		186.5	191.00	182.0	172.0	
CD at 5%		S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.				S.E. (d)	C.D.		
	A	1.443	3.060			A	1.155	2.448			A	0.866	1.836			A	0.722	1.530			A	0.722	1.530		
	B	2.041	4.328			B	1.633	3.462			B	1.225	2.597			B	0.021	2.164			B	1.021	2.164		
	AxB	2.887	6.120			AxB	2.309	4.896			AxB	1.732	3.672			AxB	1.443	3.060			AxB	1.443	3.060		

A-Allahabad Safeda, B- Lalit, N.S.- Non significant

comparatively more in cultivar Lalit and then Allahabad Safeda Singh and Mandal (1996).

The data regarding effects of different packaging materials on ascorbic acid of fruits are presented in Table 3. Statistically significant difference was recorded for ascorbic acid content in various treatment and both cultivars during cold storage condition. Treatment T_1 (black polythene) proved to be the having highest retention values for ascorbic acid in cultivar Lalit (204.0 mg/100gm) as well as Allahabad Safeda (178.8 mg/100gm) at 16 days of storage. Ascorbic acid was decreased maximum in treatment T_0 (control) in both cultivars (186.5 mg/100gm pulp) during 16 days of storage. Similar trend by Kumar *et al.* (2003), Raghava and Tiwari (2006) and Singh *et al.* (2005) was reported that minimum ascorbic acid observed in news paper packaging fruits (127.5mg/100gm) followed by fruits packaging in commercial rough polythene bags (130mg/100gm) during 16 days of storage. Similar results have been obtained even by Hussein *et al.* (1996) who studied significant increase and decrease in ascorbic acid at low temperature reduced level of ascorbic acid in control fruits may be due to their direct exposure to the air. Ascorbic acid increased at 5 days and decreased at 15 days of storage period that was comparatively more cv. Allahabad Safeda and than Lalit during storage condition.

REFERENCES

Attri, B.L. and Singh, D.B. 2003. Post harvest changes in guava during storage period prospects. *Indian Horticulture.* 24-25.

Chandel, S. R. S. 1984. Principals of experimental design. *A Hand book of Agriculture Statistics*. Pp. 14-53.

Hussain, A.M.; Sabrout, M.B. and Zaghloul, A.E 1998. Post harvest physical and biochemical changes of common and late type of seedy guava fruits during storage.*Alexandria Journal of Agriculture Research, **43** (3): 187-204.*

Kumar, J.; Sharma, R.K.; Singh, R. and Goyan , R.K. 2003. Different types of polythene on shelf life of summer guava. *Haryana J. Horti. Sci.,* **32** (3/4): 201-202.

Kirad, K.S., Barche, S., Singh, D.B., and Mahapatra, S., 2008. Studies on maturity standards of guava (*Psidium guajava L.)* cultivars. *The Orissa J. Hort.,* **36** (2): 136-141.

Singh, A. and Singh, S.P. 2000. Evaluation of varieties for quality characters of under eastern Uttar Pradesh Conditions. *Prog. Hort.,* **32**(2): 190-196**.**

Singh, R.V.; Tewari, J.D. and Chauhan, B.B.S. 1993**.** Effect of wax coating and pre-packaging in polythene bags on the storage behaviour of guava cv Allahaba Safeda. *Haryana J. Hort. Sci.* **22** (2): 126-130.

Singh, S.; Godara, A.K.; Sehrawat., S.K. and Dahiya, D.S. 2005. Effect of modified atmosphere packaging on post harvest physiology of guava fruits. *First International Guava Symposium,* December 5-8, 2005 CISH, Lucknow (9. P.9), Page-111.

Singh, V.P. and S.B. Mandal 1996. The effect of season on physiological and chemical composition of two varieties of guava (Lucknow - 49 and Allahabad Safeda). *Anals of Agri. Bio. Research,***1**(1/2): 159-161.

Ranganna, S.1986. A hand book of analysis and quality control for fruits and vegetable products second edition. *Tata McGraw Hill Pub. Co. Ltd.* New Delhi. India.

Raghava, M. and Tiwari, J.P. 2006. Seasonal variation in physico-chemical characteristics of guava fruits. *Prog.Hort.,* **38**(1):42-48.

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Effect of foliar sprays of plant growth regulators on corm production and vase life in gladiolus

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ABSTRACT

Influence of plant growth regulator sprays on corm production and post harvest life of two gladiolus cultivars Darshan and Dhiraj was investigated for two consecutive years, 2008-09 and 2009-10. Growth regulators viz., GA_3, TIBA, CPPU and BR were sprayed at different concentrations at 3 rd and 6th leaf stage. The cultivar Darshan recorded maximum number of big cormels per plant and cormel weight. Cv. Dhiraj recorded maximum number of small cormels per plant. Foliar sprays of BR 10 ppm and GA_3 150 ppm significantly increased number of corms produced per plant, corm size, corm weight and propagation coefficient. Number of big cormels and total number of cormels per plant were recorded significantly higher with BR 10 ppm followed by TIBA 100 ppm. BR 10 ppm and TIBA 100 ppm produced maximum number of small cormels per plant. Weight of cormels per plant was recorded maximum with BR 10 ppm and GA_3 150 ppm. Post harvest studies revealed that the cultivar Darshan recorded maximum diameter of the second fully opened floret and higher vase life than cv. Dhiraj due to pre-harvest foliar sprays of plant growth regulators. Pre harvest foliar sprays of GA_3 150 ppm, BR 10 ppm and CPPU 5 ppm induced earliest first floret opening and recorded maximum values for number of florets opened at a time per spike, diameter of second fully opened floret and vase life.

KEY WORDS : Gladiolus, corm, vase life, GA_3, brassinosteroids, CPPU.

Floricultural experts at various occasions stated that there is utter dearth of planting material of elite ornamental cultivars in the country for commercial cultivation and felt that there is an acute need to develop a comprehensive protocol for clonal multiplication of all such crops. The use of quality planting material or seed is the foundation for successful cultivation of all flowers. Shortage of quality planting material is the major constraint hindering the development of floriculture industry in India (Choudhury and Prasad, 2004). Gladiolus, one of the important bulbous cut flower crops is commercially propagated by corms. The profitability of gladiolus flower spike production and export is closely linked to the cost of corms. Poor multiplication rate of corms and cormels (each corm producing 1-2 corms) in gladiolus results in high cost of corms which is often higher than the sale price of flower spike produced by that corm. Since many years, high rate of multiplication and good corm enlargement under varied soil and climatic conditions is the chief objective of breeding gladioli for corm production. Micro propagation protocols although, standardized for gladiolus (Hussain *et al*., 1997) commercially this method is not followed as the plantlets take 2-3 seasons to produce flower grade corms. Various approaches were tried to increase the rate of corm multiplication in gladiolus. Leaf and spike removal, although increases corm and cormel production to some extent (Das, 1998), it results in decrease in spike yield and quality. Research work on the effect of traditional plant growth regulators like gibberellins and tri iodo benzoic acid (TIBA) for improving corm multiplication rate as well as corm enlargement in gladiolus was reported by different workers in different parts of the country (Tawar *et al*., 2007 and Devi *et al*., 2007). But there was no organized research on the effect of new class of plant growth regulators viz., brassinosteroids (BR) and 2-chloro 4-pyridyl phenyl urea (CPPU) on corm multiplication of gladiolus in India as well as in abroad.

Table 1: Effect of foliar sprays of plant growth regulators on number of corms per plant and corm size in gladiolus cultivars

Treatments	Number of corms per plant						Corm size (cm)					
	2008-09			2009-10			2008-09			2009-10		
	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean
GA_3 (100 ppm)	1.67	1.60	1.64	1.67	1.60	1.64	4.43	4.51	4.47	4.26	4.54	4.40
GA_3 (150 ppm)	1.87	1.67	1.77	1.93	1.67	1.80	5.00	4.86	4.93	4.81	4.85	4.83
TIBA (50 ppm)	1.53	1.37	1.45	1.53	1.40	1.47	4.15	4.68	4.42	4.28	4.72	4.50
TIBA (100 ppm)	1.47	1.27	1.37	1.43	1.30	1.37	3.84	3.86	3.85	3.91	3.80	3.86
CPPU (2.5 ppm)	1.53	1.47	1.50	1.60	1.43	1.52	4.30	4.71	4.51	4.37	4.58	4.48
CPPU (5 ppm)	1.60	1.60	1.60	1.63	1.67	1.65	4.59	4.83	4.71	4.55	4.74	4.65
BR (5 ppm)	1.63	1.53	1.58	1.53	1.60	1.57	4.39	4.94	4.67	4.52	4.73	4.63
BR (10 ppm)	1.93	1.72	1.83	1.80	1.85	1.83	4.98	5.17	5.08	4.73	5.30	5.02
Control (Water)	1.47	1.37	1.42	1.47	1.33	1.40	4.26	4.40	4.33	4.30	4.31	4.31
Mean	1.64	1.50		1.65	1.54		4.44	4.66		4.41	4.62	
CD at 5%												
Cultivars (C)	N.S.			N.S.			N.S			N.S		
Treatments (T)	0.16			0.19			0.44			0.47		
Interaction(CxT)	N.S.			N.S.			N.S.			N.S.		

Claims have been made that from 30-70 per cent of the potential lasting quality of many flower crops is predetermined at harvest. In gladiolus, pre harvest application of chemicals and plant growth regulators was found to extend the vase life of cut spikes (Raju *et al*., 2008). Similarly, for extending the vase life of gladiolus, use of sucrose in combination with aluminium sulphate ($Al_2(SO_4)_3$) as the holding solution has been reported by many workers (Namita *et al*., 2006 and Nelofar and Paul, 2008). Hence, an investigation aimed to ascertain the effect of foliar sprays of BR, CPPU along with GA_3 and TIBA on corm multiplication and post harvest life in two gladiolus cultivars Darshan and Dhiraj was carried out at Herbal garden, Hyderabad for two consecutive years, 2008-09 and 2009-10.

MATERIALS AND METHODS

In the study, corms of gladiolus cultivars Darshan and Dhiraj were used. There were 9 growth regulator treatments viz., GA_3 100 and 150 ppm, TIBA 50 and 100 ppm, CPPU 2.5 and 5.0 ppm, BR 5.0 and 10.0 ppm and control (water spray) each replicated thrice in factorial Randomized Block Design. Corms were planted at a spacing of 30 cm x 20 cm and at a depth of 5 cm in September. Treatments were imposed as foliar sprays at

Table 2: Effect of foliar sprays of plant growth regulators on corm weight and number of big cormels per plant in gladiolus cultivars Darshan and Dhiraj

Treatments	Corm weight (g)						Number of big cormels per plant					
	2008-09			2009-10			2008-09			2009-10		
	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean
GA_3 (100 ppm)	30.23	33.91	32.07	29.56	36.55	33.06	3.33	2.87	3.10	3.00	2.07	2.54
GA_3 (150 ppm)	33.80	35.81	34.81	32.89	36.95	34.92	3.67	2.87	3.27	3.67	3.33	3.50
TIBA (50 ppm)	30.99	32.87	31.93	29.15	33.54	31.34	3.07	2.07	2.57	2.47	2.00	2.23
TIBA (100 ppm)	27.45	31.05	29.25	27.80	29.72	28.76	4.87	3.53	4.20	5.00	3.00	4.00
CPPU (2.5 ppm)	31.62	34.55	33.09	30.67	33.60	32.14	3.00	2.40	2.70	3.33	2.00	2.67
CPPU (5 ppm)	32.75	35.18	33.97	31.99	35.01	33.50	3.67	3.20	3.44	4.33	3.40	3.87
BR (5 ppm)	33.15	33.49	33.32	32.79	32.37	32.58	3.00	2.00	2.50	3.00	3.33	3.17
BR (10 ppm)	34.11	36.66	35.39	35.04	36.76	35.90	6.07	4.80	5.44	5.00	4.33	4.67
Control (Water)	31.46	32.33	31.90	31.94	31.10	31.52	2.67	1.87	2.27	3.27	1.53	2.40
Mean	31.73	33.98		31.31	33.96		3.70	2.84		3.66	2.78	
CD at 5%												
Cultivars (C)	N.S			N.S			0.34			0.32		
Treatments (T)	1.28			1.08			0.72			0.66		
Interaction(CxT)	N.S.			N.S.			N.S.			N.S.		

Table 3: Effect of foliar sprays of plant growth regulators on number of small cormels per plant and total number of cormels per plant in gladiolus cultivars Darshan and Dhiraj

Treatments	Number of small cormels per plant						Total number of cormels per plant					
	2008-09			2009-10			2008-09			2009-10		
	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean
GA_3 (100 ppm)	4.67	3.33	4.00	4.87	3.00	3.94	8.00	6.20	7.10	7.87	5.07	6.48
GA_3 (150 ppm)	3.67	4.67	4.17	3.80	5.33	4.57	7.34	7.54	7.44	7.47	8.66	8.07
TIBA (50 ppm)	3.00	3.67	3.33	3.07	4.33	3.70	6.07	5.74	5.90	5.54	6.33	5.93
TIBA (100 ppm)	5.67	6.33	6.00	5.53	6.07	5.80	10.54	9.86	10.20	10.53	9.07	9.80
CPPU (2.5 ppm)	2.00	3.33	2.67	1.93	3.93	2.93	5.00	5.73	5.37	5.26	5.93	5.60
CPPU (5 ppm)	4.33	4.00	4.17	4.33	4.20	4.27	8.00	7.20	7.60	8.66	7.60	8.14
BR (5 ppm)	5.00	6.67	5.84	4.80	6.33	5.57	8.00	8.67	8.33	7.80	9.66	8.74
BR (10 ppm)	6.00	8.20	7.10	5.93	8.00	6.97	12.07	13.00	12.54	10.93	12.33	11.64
Control (Water)	3.67	4.33	4.00	4.33	5.07	4.70	6.34	6.20	6.27	7.60	6.60	7.10
Mean	4.22	4.95		4.29	5.14		7.92	7.79		7.95	7.92	
CD at 5%												
Cultivars (C)	0.59			0.76			N.S.			N.S.		
Treatments (T)	1.23			1.28			1.28			1.33		
Interaction(CxT)	N.S.			N.S.			N.S.			N.S.		

3rd and 6th leaf stage. Well decomposed farmyard manure at 10 t ha^{-1} was incorporated into all the experimental plots uniformly as basal application. N, P, and K @ 200:200:300 kg/ha were applied in the form of urea, single super phosphate and muriate of potash respectively. Urea was applied in 3 splits, the first dose as basal application and other two split doses at 30 and 60 days after planting. The entire dose of single super phosphate and muriate of potash were applied at the time of planting as basal dose. Standard cultural practices were followed during the entire crop period for all the experimental plots. Observations on corm attributes were recorded. Data were subjected to analysis of variance as applicable to factorial Randomized Block Design.

For conducting post harvest studies, uniform sized spikes were harvested from all the experimental plots early in the morning when the basal 1-2 florets showed color break and immediately brought to the laboratory by putting them in a bucket containing water. Lower most leaves of the spikes were removed and the basal 2 cm portion was recut under water before placing them in holding solution. A solution containing sucrose (4 %) in combination with $Al_2(SO_4)_3$ (300 ppm) was used as the holding solution. The experiment was laid out in Completely Randomized Block Design (CRD) with factorial concept. There were three replications and three spikes per replication. Observations on days to first floret opening, number of florets opened at a time per spike, diameter of the second fully opened floret and vase life were recorded. Data were subjected to analysis of variance as applicable to factorial Completely Randomized Block Design.

RESULTS AND DISCUSSION

Results from the present study (Tables 1, 2, 3 and 4) indicate that the two cultivars did not differ significantly in respect of number, size and weight of corms during both the years of study. However, they differed significantly in respect of number of big and small cormels per plant, weight of cormels per plant and propagation coefficient. Cv. Darshan produced higher number of big cormels and weight of cormels per plant whereas cv. Dhiraj was efficient in producing higher number of small cormels and propagation coefficient. Variation in cultivars on individual gladiolus corm characteristics was earlier reported by several workers.

BR 10 ppm followed by GA_3 150 ppm significantly increased the number of corms per plant, size and weight of corms per plant and weight of cormels and there by propagation coefficient during both the years of investigation. BR 10 ppm also recorded maximum number of big and small cormels per plant. Except with number of big and small cormels per plant, TIBA 100 ppm treatment recorded significantly minimum values with all the corm and cormel characters under study. CPPU at 5 ppm increased the number of corms per plant and corm size significantly and was on a par with BR 10 ppm and GA_3 150 ppm.

The variation in number of corms per plant may be attributed to variation in number of buds sprouted per corm, which have been governed by the presence of number of active buds in the corms. Gladiolus has two sources, corm or cormel used for planting which serve as reserve

Table 4: Effect of foliar sprays of plant growth regulators on weight of cormels per plant and propagation coefficient in gladiolus cultivars Darshan and Dhiraj

Treatments	Weight of cormels per plant (g)						Propagation coefficient (%)					
	2008-09			2009-10			2008-09			2009-10		
	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean
GA_3 (100 ppm)	4.57	4.45	4.51	5.83	4.36	5.10	131.34	144.78	138.06	133.58	154.37	143.97
GA_3 (150 ppm)	7.06	4.91	5.99	6.80	4.94	5.87	154.21	153.64	153.93	149.77	158.08	153.92
TIBA (50 ppm)	5.17	4.82	5.00	5.03	4.78	4.91	136.50	142.22	139.36	128.98	144.58	136.78
TIBA (100 ppm)	5.94	4.40	5.17	5.86	4.93	5.40	126.08	133.77	129.92	127.02	130.78	128.90
CPPU (2.5 ppm)	4.00	3.85	3.93	3.77	3.78	3.78	134.44	144.92	139.68	129.95	141.06	135.50
CPPU (5 ppm)	4.63	4.61	4.62	5.52	4.94	5.23	141.07	150.16	145.61	141.56	150.78	146.17
BR (5 ppm)	4.89	3.78	4.34	4.86	3.99	4.43	143.53	140.63	142.08	142.08	137.21	139.64
BR (10 ppm)	6.86	5.19	6.03	7.02	5.55	6.29	154.63	157.93	156.28	158.74	159.64	159.19
Control (Water)	4.23	4.03	4.13	4.40	3.80	4.10	134.68	137.20	135.94	137.14	131.69	134.41
Mean	5.37	4.45		5.44	4.57		139.61	145.03		138.76	145.35	
CD at 5%												
Cultivars (C)	0.23			0.32			3.85			4.71		
Treatments (T)	0.48			0.66			8.08			9.88		
Interaction(CxT)	N.S.			N.S.			N.S.			N.S.		

food material in the initial stages and photosynthesizing leaves in later stages. Likewise it has two competing sinks, flower spike or inflorescence and developing corm and cormels. TIBA 100 ppm treatment promoted the sink activity of developing cormels and this might be the reason for increase in number of big cormels and small cormels. The results are in support with Devi *et al.* (2007). The increase in corm size and weight of corms and cormels with the application of GA_3 150 ppm can be attributed to its ability to increase the growth criteria which in turn increased the photosynthetic assimilates. These assimilates would have transported to the developing daughter corms and cormels thereby increasing their size and weight. Similar results have been reported by Vijai Kumar and Umrao (2007).

Treatment with BR 10 ppm increased the corm production and also size and weight of corm over remaining treatments. This treatment also produced highest mean number and weight of cormels per plant and propagation coefficient. These results represent the first demonstration of a clear favorable effect of BR at 10 ppm on corm and cormel inducing activity in gladiolus cvs. Darshan and Dhiraj. This also indicates the potential of BR in increasing the number of corms significantly without impairing the quality of corms. The results

Table 5: Effect of foliar sprays of plant growth regulators on days to first floret opening and number of florets opened at a time per spike in gladiolus cultivars Darshan and Dhiraj

Treatments	Days to first floret opening						Number of florets opened at a time per spike					
	2008-09			2009-10			2008-09			2009-10		
	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean
GA_3 (100 ppm)	1.67	2.22	1.95	1.67	2.11	1.89	2.56	2.11	2.33	2.45	2.22	2.34
GA_3 (150 ppm)	1.45	1.56	1.51	1.44	1.56	1.50	3.22	2.67	2.95	3.11	2.89	3.00
TIBA (50 ppm)	2.44	2.22	2.33	2.33	2.45	2.39	2.22	1.89	2.06	2.11	2.00	2.06
TIBA (100 ppm)	2.45	2.44	2.45	2.45	2.44	2.45	2.00	1.78	1.89	2.11	1.78	1.95
CPPU (2.5 ppm)	2.11	2.33	2.22	2.22	2.44	2.33	2.11	2.22	2.17	2.33	2.00	2.17
CPPU (5 ppm)	1.56	1.89	1.73	1.56	2.11	1.84	2.89	2.33	2.61	2.78	2.33	2.56
BR (5 ppm)	2.00	2.33	2.17	2.00	2.33	2.17	2.33	2.22	2.28	2.44	2.00	2.22
BR (10 ppm)	1.44	1.78	1.61	1.44	1.78	1.61	2.67	2.56	2.62	2.78	2.67	2.73
Control (Water)	2.22	2.33	2.28	2.33	2.33	2.33	2.11	2.33	2.22	2.34	2.22	2.28
Mean	1.93	2.12		1.95	2.17		2.48	2.24		2.49	2.24	
CD at 5%												
Cultivars (C)	N.S.			N.S.			N.S.			N.S.		
Treatments (T)	0.43			0.51			0.50			0.50		
Interaction(CxT)	N.S.			N.S.			N.S.			N.S.		

Table 6: Effect of foliar sprays of plant growth regulators on diameter of second fully opened floret (cm) and vase life (days) in gladiolus cultivars Darshan and Dhiraj

Treatments	Diameter of second fully opened floret (cm)						Vase life (days)					
	2008-09			2009-10			2008-09			2009-10		
	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean	Darshan	Dhiraj	Mean
GA_3 (100 ppm)	8.74	8.31	8.53	8.71	8.35	8.53	9.00	8.44	8.72	8.89	8.55	8.72
GA_3 (150 ppm)	9.24	8.83	9.04	9.32	8.87	9.10	9.44	9.33	9.39	9.56	9.33	9.45
TIBA (50 ppm)	8.43	7.38	7.91	8.38	7.63	8.00	8.50	7.83	8.17	8.39	8.06	8.23
TIBA (100 ppm)	7.60	7.20	7.40	7.61	7.17	7.39	8.00	7.61	7.81	7.78	7.50	7.64
CPPU (2.5 ppm)	8.65	8.30	8.48	8.70	8.30	8.50	9.11	8.28	8.70	9.00	8.17	8.59
CPPU (5 ppm)	8.86	8.55	8.71	8.93	8.54	8.74	9.00	9.11	9.06	9.22	9.11	9.17
BR (5 ppm)	8.72	8.31	8.52	8.70	8.33	8.52	8.78	8.56	8.67	8.67	8.56	8.62
BR (10 ppm)	8.94	8.67	8.81	9.04	8.69	8.87	9.22	9.11	9.17	9.44	9.00	9.22
Control (Water)	8.67	8.00	8.33	8.71	8.03	8.37	8.72	8.11	8.42	8.67	7.78	8.23
Mean	8.65	8.17		8.68	8.21		8.86	8.49		8.85	8.45	
CD at 5%												
Cultivars (C)	0.28			0.30			0.28			0.32		
Treatments (T)	0.61			0.65			0.60			0.68		
Interaction(CxT)	N.S.			N.S.			N.S.			N.S.		

obtained with BR treatment in respect of corm and cormel production are similar to the reports of Ramraj *et al*. (1997) who reported significant increase in potato yields with foliar application of BR and Nunez *et al*. (1998) in onion. Thus it can be concluded that two foliar sprays of BR 10 ppm, at 3rd and 6th leaf stage increases number of corms and cormels in gladiolus.

With respect to post harvest attributes as indicated in tables 5 and 6, Cv. Darshan recorded maximum diameter of second full opened floret and vase life than cv. Dhiraj. Variation in vase life and other quality parameters among the cultivars may be attributed to the differential accumulation of carbohydrates due to varied leaf production and sensitivity of cultivars to ethylene. In turn, variations in these aspects might be due to genetical make up of the plants (Kamble *et al*., 2004). GA_3 150 ppm followed by BR 10 ppm and CPPU 5 ppm induced significantly earliest first floret opening with more number of florets opened at a time per spike. This might be due to the reason that the spikes from these treatments would have sufficient food material required for opening of the florets as evident from greater spike length and weight. Diameter of second fully opened floret and vase life were also influenced significantly by pre harvest spray of plant growth regulators during both the years of investigation. GA_3 150 ppm, BR at 10 ppm and CPPU 5 ppm registered maximum diameter of second floret and longest vase life. All the post harvest parameters under study were found to be minimum with TIBA 100 ppm and TIBA 50 ppm. Increased vase life with foliar sprays of GA_3 was reported by Pal and Choudhury (1998) in gladiolus. The improvement in floret size by the foliar spray of GA_3 was reported by Nagarjuna *et al*. (1988) in chrysanthemum. Halevy and Shild (1970) opined that GA_3 increase the photosynthetic and metabolic activities causing more transport and utilization of photosynthetic products which are necessary for growth and development of the flower. The maximum diameter of second floret noticed with foliar application of GA_3 treatment could be attributed to drawing of more photosynthates to the flower as a consequence of intensification of sink (Zieslin *et al*., 1974).

Padmapriya and Chezhiyan (2002) reported that increased flower diameter in the chrysanthemum cv. Indira with foliar sprays of BR could be due to the synergism between BR and auxins. BR might have altered the bio-physical properties of cell wall and this led to high energy conversion in broadening the flower diameter. The increase in floret diameter with CPPU 5 ppm treatment might be due to its triggering activity on cell division and cell enlargement.

The reduction in floret size caused by the application of TIBA is probably due to its anti auxin activity by preventing the transport of naturally produced auxins and thereby, reducing cell elongation. The results were in line with the findings of Nanjan and Muthuswamy (1975) in rose. Minimum vase life due to TIBA was reported by Umadevi (2002) in gladiolus.

In addition to the foliar sprays of GA_3 150 ppm or BR 10 ppm or CPPU 5 ppm, exogenous supply of sucrose balanced the depletion of carbohydrates and improved the vase life and quality of the spikes. The sucrose in the vase solution also maintained the water balance and osmotic potential since sugar has been observed to decrease

moisture stress in cut flowers by affecting the stomatal closure and preventing water loss (Ranvir Singh and Sashikala, 2002). $Al_2(SO_4)_3$ helped in improving the keeping quality due to its antimicrobial action.

REFERENCES

Choudhury, M.L. and Prasad, K.V. 2004. Strategies for improving productivity, post harvest quality of floriculture crops. Souvenir, First Indian Horticulture Congress-2004 organized by Horticultural society of India, New Delhi.

Das, T.K. 1998. Corm and cormel production of gladiolus as affected by spike removal and K application. *Indian Journal of Horticulture,* **55(4)**: 327-331.

Devi, D.U., Sekhar, R.C. and Babu, J.D. 2007. Effect of growth regulators on flowering and corm production in gladiolus cv. Jacksonville Gold. *Journal of Research, ANGRAU*, **35(1)**: 6-14.

Halevy, A.H. and Shild, R. 1970. Promotion of growth and flowering of plants with endogenous GA_3 in gladiolus plants treated with CCC. *Physiologia Plantarum,* **23**: 820-827.

Hussain, S.C.T., Geetha, C.K., Rajeevan, P.K. and Valsala Kumari, C.K. 1997. Plant regeneration from root derived callus in gladiolus. *Journal of Ornamental Horticulture*, **2(1-2)** : 36-40.

Kamble, B.S., Reddy, B.S., Patil, R.T. and Kulkarni, B.S. 2004. Performance of gladiolus cultivars on flowering and flower quality. *Journal of Ornamental Horticulture,* **7(3)** : 51-56.

Nagarjuna, B., Reddy, V.P., Rao, M.R. and Reddy, E.N. 1988. Effect of growth regulators and potassium nitrate on growth, flowering and yield of chrysanthemum. *South Indian Horticulture,* **36(2)**: 136-140.

Namita, Kumar, R. and Singh, K. 2006. Response of vase solution on keeping quality of cut spikes of gladiolus. *Journal of Ornamental Horticulture,* **9(4)**: 296-297.

Nanjan and Muthuswamy. 1975. Growth and flowering of Edward rose (*Rosa Bouboriana* Desp.) to certain growth retardant sprays. *South Indian Horticulture,* **23**: 94-99.

Nelofar and Paul, T.M. 2008. Post harvest management of gladiolus. *Journal of Ornamental Horticulture,* **11(1)**: 69-71.

Nunez, M., Sosa, J.L., Alfonso, J.L. and Coll, F. 1998. Influence of two new Cuban bioregulators on plant yield of onion cv. Red Creole. *Cultivos Tropicales,* **19**(1): 21-24.

Padmapriya, S. and Chezhiyan, N. 2002. Influence of gibberellic acid and certain other chemicals on flowering characters of chrysanthemum (*Dendranthema grandiflora* Tzeled.) cultivars. *South Indian Horticulture,* **50(4-6)**: 437-443.

Pal, P. and Choudhury, T. 1998. Effect of growth regulators and duration of soaking on sprouting growth, flowering and corm yield of gladiolus cv. Tropic Sea. *Horticultural Journal*, **11(2)**: 69-77.

Raju, D.V.S., Misra, R.L. and Singh, V.P. 2008. Effect of pre harvest spray of thiol compounds on post harvest life of gladiolus spikes. *Journal of Ornamental Horticulture*, **11(1)**: 75-76.

Ramraj, V.M., Vyas, N.B., Godrej, K.B., Mistry, Swami, B.N. and Singh, N. 1997. Effects of 28-Homobrassinolide on yields of wheat, rice, groundnut, mustard, potato and cotton. *Journal of Agriculture science*, **128(4)**: 405-413.

Singh R. and Sashikala, B. 2002. Post harvest life of gladiolus as influenced by floral preservatives. *Journal of Ornamental Horticulture,* **8(2)**: 115-118.

Tawar, R. V, Sable, A. S., Kakad, G. J., Hage, N. D. and Ingle, M. B. 2007. Effect of growth regulators on corms and cormels production of gladiolus cv. Jester. *Annals of Plant Physiology*, **21(2)**: 257-258.

Umadevi, D. 2002. Effect of growth regulators application at three stages of crop growth on production of flowers, propagules and vase life of cut spikes in three cultivars of gladiolus (*Gladiolus grandiflorus* L.). M.Sc. (Hort) Thesis, Acharya N. G. Ranga Agricultural University, Hyderabad, A.P., India.

Kumar, V. and Umrao, V. 2007. Effect of gibberellic acid on gladiolus. *South Indian Horticulture,* **55 (1-6)**: 303-305.

Zieslin, N,I., Brian and Halevy, A. H. 1974. The effect of growth regulators on growth and pigmentation of 'Baccara' rose flowers. *Plant Cell Physiology*, **15**: 341-349.

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Studies on processing and storage of bael beverages

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ABSTRACT

Bael fruit is an underutilized indigenous fruit of India. Because of the hard shell, mucilaginous texture and numerous seeds, the bael fruit is difficult to eat out of hand. The excellent flavor, nutrition and therapeutic values of the bael lies an untapped potentiality for processing. In the present investigation, recipes for RTS (Ready to serve) and squash from bael was standardized. Recipe containing 12% juice extract, 12% TSS and 0.25% acidity was found suitable for making RTS. For squash making, recipe containing 30% juice, 50% TSS and 12% acidity was found ideal. The browning of RTS and squash did not change upto 2 and 1 month of storage, respectively. Further, increase in browning of RTS and squash upto 6 and 4 months of storage, respectively were statistically insignificant. The findings of present investigation indicated that bael fruit can be very promising for producing the quality beverages like RTS and squash. These products might have excellent market potential because of their therapeutic values and reasonably longer shelf life.

KEY WORDS: Bael, processing, squash, RTS, organoleptic

Bael fruit (*Aegle marmelos* Correa) is a indigenous fruit of India. Bael is also known as Shri phal, Baelpatra and Bengal quince. Bael is highly nutritious and rich in riboflavin, vit. A and carbohydrates. Marmelosin is most probably the therapeutically active principal of bael fruit. It contains 61.5 gm water, 1.8 g protein, 0.3 g fat, 1.7 g minerals, 31.8 g carbohydrates, 55 mg carotene, 0.13 mg thiamine, 7.19 mg riboflavin, 1.1 mg niacin and 8 mg per 100 g of edible portion of vitamin C. Fruit is hard shelled berry with numerous seeds in pulp, it is difficult to eat in raw state and hence it is not popular as table fruit. The fruit has rich aroma, which is not destroyed even during processing, thus it has a great untapped potential for processing into several products like ready to serve drinks, squashes, syrup, candy, jam, murabba, slab and powder etc. Processing of such underutilized fruits potentially could provide employment and income generating opportunities in rural communities. The value added diversified products will be a convenient way of obtaining the benefits of the fruit for the people with busy life style. Therefore the present study was undertaken to exploit its potential in the beverage industry.

MATERIALS AND METHODS

The present investigation was carried out at Krishi Vigyan Kendra, Patiala in the year 2011-12. Beal fruit was procured from local market of Patiala. The experiment was laid out in factorial CRD with 3 replications. The investigation comprised two sets of experiments – evaluation of recipes for the preparation of beverages and studies on storage stability of bael beverages. Observations were recorded for total soluble solids, acidity, non-enzymatic browning and organoleptic quality. Ripe bael fruits were thoroughly washed in running water and broken by striking against hard surface. The fruit pulp along with its seeds and fibers was scooped with the help of a stainless steel spoon. An equal amount of water to the weight of pulp was mixed with the pulp. The mixture of pulp and water was mixed, heated for one minute at 80°C and passed through fruit pulper to obtain homogenized pulp free from seeds and fibers. Pulp is further used for preparation of squash and ready to serve beverage.

Ready to serve beverage and squash were analyzed for per cent TSS, acidity and browning. TSS was estimated at ambient temperature 30-35°C by Erma hand

Table 1: Standardization of recipes for bael squash and RTS

Treat-ment	% juice extract		% TSS		% Acidity		O AA	
	Squash	RTS	Squash	RTS	Squash	RTS	Squash	RTS
T1	25	10	48	11	1.0	0.20	7.8	7.6
T2	30	12	50	12	1.18	0.25	8.5	8.7
T3	30	15	52	13	1.2	0.30	6.7	6.8

Table 2: Changes in chemical composition and organoleptic qualities of bael squash and RTS during storage

Storage days (months)	% TSS		% Acidity		% O AA		Browning O. D.	
	Squash	RTS	Squash	RTS	Squash	RTS	Squash	RTS
1	50	12.0	1.18	0.25	8.3	8.6	0.57	0.27
2	50	12.0	1.18	0.25	7.9	8.4	0.71	0.42
3	50.5	12.10	1.20	0.25	7.9	8.3	0.74	0.45
4	50.5	12.10	1.20	0.28	7.8	8.1	0.75	0.46
5	50.7	12.40	1.21	0.28	7.6	7.8	0.79	0.47
6	51.0	12.40	1.21	0.29	7.6	7.5	0.79	0.49
C.D. at 5% level	NS	NS	NS	NS	NS	0.02	.07	0.04

refractometer (0-32%) and the values were expressed as % TSS after correcting at 20°C. Acidity was analyzed by titration against 0.1 N NaOH (Ranganna 1986). Sensory evaluation was done on nine point hedonic scale.

RESULTS AND DISCUSSION

The data presented in Table 1 shows that three recipes were evaluated for squash. T_2 containing 30% juice, 50% TSS and 1.18% acidity was found suitable for making squash. It is obvious from Table 1 that the composition of bael RTS (T_2) with 12% juice, 12% TSS and 0.25% acidity was found ideal. Significant lower scores of T_1 and T_3 in case of squash and also T_1 and T_3 in case of RTS were probably due to imbalance of the juice acidity level. TSS content of squash and RTS increased slightly (50-51.0% and 12 to 12.4%, respectively) during six months of storage. However, the differences were statistically insignificant. Increase in TSS content of bael beverages may be possible due to conversion of polysaccharides into sugars. Similar results were reported by Prasad and Mali (2003). Similarly, acidity of squash and RTS did not alter upto 1 and 2 months of storage respectively, and thereafter a slight increase was noticed upto end of storage period. The findings are also in agreement with the observation of Ram et al (2010). Roy and Singh (1979) also reported a slight increase in acidity during storage in nector and squash of bael. Increase in acidity during storage might be due to the formation of organic acids by degradation of ascorbic acid.

Organoleptically, scores of bael squash and RTS for over all acceptability ranged from 8.3 to 7.6 and 8.6 to 7.5, respectively during six months of storage with good acceptability. Table 2 also indicated that the browning of RTS and squash increase continuously till the end of the experiment. It is mainly due to non-enzymatic reactions which occur between nitrogenous compound and sugar or organic acids.

It can be concluded that bael fruit can be used for preparation of RTS and squash and other value added products and have appreciably longer storage stability.

REFERENCES

Prasad, R.N. and Mali, P.C. 2003. Changes in physico- chemical characteristics of ber squash during storage. *Prog. Hort.* **35**: 170-172.

Ranganna, S. 1986. Handbook of analysis and quality control for fruit and vegetable products. Tata Mc Graw Hills Publications Ltd., New Delhi.

Ram, R.B., Meena, M.L. Lata, R. Maurya, D. and Awasthi, A.P. 2010. Processing and storage of ginger beverates. *Processed Food Industry*, **33(5)**: 42-45.

Roy, S.K. and Singh, R.N. 1979. Studies on utilization of bael fruit (Aegle marmelos correa.) for processing. III Preparation and preservation of bael fruit products. *Indian Food Packer*. **33(5)**: 9-14.

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(Short Comunication)

Characterization of salt-affected soils of main experiment station of the narendra deva university of agriculture and technology

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The investigation was carried out at Main Experimentation Station (MES) of ND University of Agriculture & Technology, Kumarganj, Faizabad (U.P.). The farm is worst affected by salt infestation and has an area of 126.0 hectares. These soils if reclaimed will contribute a major share to the research on different crops. It is possible only when one knows the nature and degree of deterioration of salt-affected soils of the farm. The present study was under taken to characterize salt-affected soils to provide necessary information for present and future activities of reclamation. An intensive soil survey was carried out of characterize the salt-affected soils Main Experiment Station. The morphological features, physiography, relief and drainage conditions were recorded. On the basis of land use, the soils were categorised into soil under cultivation, soil under reclamation, soil under plantation and barren soil. Random sampling was adopted for collect 20 soil samples from all the four categories identified. A total 80 soil samples were collected from 0-15 cm and 15-30 cm depth representing each categories (20 samples from each category). Four soil profiles (one from each category) were exposed and examined. The samples were collected from different depths for detailed study in laboratory. Soil samples were analysed by the procedures of Richards (1954), Piper (1966) and Jackson (1967).

Table 1: Physico-chemical characteristics at different depths of profile of salt-affected

Soil Category	Depth (cm)	pHs	ECe	ESP	SAR	Available Nutrients (Kg/ha)		
						N	P	K
Under cultivated land	0-15	**8.32**	0.33	**21.43**	**9.90**	223	10.5	230
	15-30	8.38	0.24	21.83	10.4	215	10.2	212
	30-45	8.65	0.17	24.55	10.5	180	10.0	190
	45-60	8.96	0.15	32.56	12.3	155	9.5	185
	60-100	9.02	0.12	34.85	13.7	150	9.0	175
Under reclamation land	0-15	9.5	2.35	43.30	43.2	180	10.0	220
	15-30	9.6	2.00	46.51	44.1	171	9.8	203
	30-45	9.72	2.42	46.96	46.3	150	9.4	177
	45-60	9.91	1.78	54.11	52.3	135	9.0	165
	60-100	9.90	1.58	53.30	48.7	95	8.5	145
Under plantation land	0-15	9.20	1.79	74.60	36.5	201	9.5	223
	15-30	9.48	1.05	74.44	37.4	193	9.2	207
	30-45	9.50	0.90	74.71	39.2	162	9.0	170
	45-60	9.80	0.81	60.59	41.8	110	8.8	155
	60-100	9.90	0.63	60.49	56.7	90	8.5	150
Barren land	0-15	**10.21**	5.41	**75.94**	**88.6**	170	8.6	220
	15-30	10.42	3.50	74.18	69.6	163	8.0	170
	30-45	10.04	2.31	72.51	61.7	140	7.8	155
	45-60	9.98	2.03	72.73	59.4	135	7.5	150
	60-100	9.90	1.37	73.73	48.3	115	7.2	135

The topography of the soils MES is mostly uneven. The barren soils have white to dark brown colour. The surface is well drained with extremely poor permeability. The water table fluctuated between 2.0 to 6.5 meters depth.

Table 1 show that pHs of the soils ranged from 8.32 to 10.42, ECe from 0.21 to 5.21 dSm-1, ESP from 21.43 to 75.84 and SAR from 9.90 to 88.60, available N from 90 to 223, P from 7.2 to 10.5 and K from 135 to 230 kg per ha. The values all these parameters decreased with increasing depth in barren soil which indicates that the process of alkalization had started at the surface and proceeded in downward direction. The pHs, ESP and SAR in other category of soils studied, increased with depth which indicates barren of upper surface soil due to reclamation, cultivation and plantation. ECe, available N, P and K decreased with depth in all the four category of soils studied.

This showed higher salinity/alkalinity in the surface layers. Similar trend was also recorded by Prakash *et al.* (1995) in profiles of salt-affected soils of Sultanpur (U.P).

On the basis of 80 samples analysis, the pHs was positively correlated with ESP, SAR and (CO_3^{2-}+ HCO_3^-) (r=0.474,0.422 and 0.697), respectively. Prakash *et al.* (1995) and Abrol*etal.* (1980) also reported positive correlation between pHs vs ESP and pHs vs SAR. The regression equation between then worked out as pHs= 0.0435+ (6.7782) ESP, pHs= 0.0368+(7.9268) SAR and pHs= 0.4585+(2.8129)(CO_3^{2-}+ HCO_3^-) (Table 2). On the other hand ECe was positively correlated with (Cl^-+ SO_4^{2-}), (r=0.425). The regression equation between them was worked out as ECe= 0.0663+(2.4669)(Cl^-+ SO_4^{2}). It is quite evident that the soils of the MES are salt-affected. Sodicity being more in surface soils of barren land which will pose difficulty in reclamation.

Table 2: Correlation coefficient and regression equation

Factor Y	Correlated	Correlation-coefficient	Regression equation
pHs	ESP	0.474	Y=0.0435+(6.7782)X
pHs	SAR	0.422	Y=0.0368+(7.9268)X
pHs	**CO_3^{2-}+HCO_3^-**	**0.697**	**Y=0.4585+(2.8129)X**
ECe	Cl^-+ SO_4^{2-}	0.425	Y=0.0663+(2.4669)X

REFERENCES

Abrol, I.P., Chhobra, R. and Gupta, R.K. 1980. Intern. Symp.Salt-affected Soils, CSSRI, Karnal, pp. 142.

Jackson, M.L. 1967. Soils chemical analysis, Prentice hall of India Pvt Ltd. New Delhi.

Piper, C.S. 1966. Soils and plant analysis. Hans Publications, Bombey.

Prakash, V., Sharma, N.L. and Singh, R. 1995. Characterization of salt-affected soils of Sultanpur district of Uttar Pradesh, J. Indian Soc. of Soil Sci., 43(1):143-44.

Richards, L.A. 1954. AgricHandb. U.S. Dep. Agric. 60.

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Assessment of genetic variability and correlation in gladiolus germplasm

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ABSTRACT

Twenty genotypes of gladiolus were evaluated for seventeen characters to ascertain the genetic variability and association among the characters during 2013-14 at G. B. Pant University of Agriculture and Technology, Pantnagar. High GCV and PCV were observed for number of cormels per plant, fresh weight of corm, number of corms per plant, rachis length and fresh weight of spike. High heritability with high genetic advance was observed for number of cormels per plant, fresh weight of corm, rachis length and fresh weight of spike. Correlation and path coefficient analysis in gladiolus revealed that, total blooming life, rachis length and diameter of second floret had positive and significant correlations with maximum direct effect on number of florets per spike. While leaf width, spike length and fresh weight of spike though had positive significant correlations, they exhibited maximum indirect effects.

KEY WORDS: Gladiolus, genetic variability, coefficient of variation, heritability, genetic advance, correlation, path-coefficient, number of florets per spike.

Gladiolus (*Gladiolus grandiflorus* L.) popularly known as "Queen of bulbous flowers", member of family Iridaceae, is one of the most important bulbous ornamentals grown for its majestic spikes which contain attractive, elegant and delicate florets. These florets open in sequence over longer duration and hence have a good keeping quality of cut spikes. These spikes of gladiolus are mainly used for garden and interior decoration and for making bouquets.

However, commercial success of any crop depends upon the availability of suitable cultivars to suit the particular environment and need of the consumers. The extent of genetic variability is of paramount importance for the improvement of a crop as greater is the genetic variability in the existing germplasm better would be chance of selecting superior genotypes. Further heritability estimates help in determining the relative amount of heritable portion of variation. Although, the heritability in broad sense would be reliable if accompanied by a high genetic advance. Also, the association of component characters and their relative contribution to economic yield (number of florets per spike and rachis length) is most important and useful for planning the improvement in desirable directions. In addition, direct and indirect effects are useful for determining the significance of characters in selection programme.

The present study, therefore, was aimed to measure the genetic variability, nature and magnitude of character association and path analysis in the 20 gladiolus genotypes for 17 quantitative characters.

MATERIALS AND METHODS

The present investigation was conducted during 2013-14 in randomized block design (RBD) with three replications at Model Floriculture Centre, Department of Horticulture, G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The experimental materials for the present investigation were consisted of 20 genotypes. Ten corms of each genotype were planted with a spacing of 30 cm x 20 cm. All the recommended agronomic package and practices were followed to grow a successful crop. The observations were recorded on three randomly selected plants for 17 characters from each genotype per replication. The data were put to statistical analysis as per Panse and Sukhatme (1969). The various genetic parameters of variability were calculated as per formula given by Berton and Devane (1953), Johnson *et al.* (1955) and Allard (1960). Correlation analysis was carried out as per the formulae suggested by Fisher (1954), whereas path analysis was estimated by the method suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION Variability

For successful plant breeding programme, an insight into the magnitude of variability present in a crop species

is of utmost importance as it provides the basis for effective selection. The analysis of variance revealed significant differences among the genotypes for yield and component characters indicating considerable amount of genetic variation among the different genotypes. High magnitude of phenotypic and genotypic coefficients of variation (Table 1) was recorded for number of cormels per plant, fresh weight of corm, number of corm per plant, rachis length and fresh weight of spike. Hence, these characters can be relied upon simple selection for further improvement. These results are in consonance with those of Kumar *et al.* (2013), Nimbalkar *et al.* (2007) and Bhujbal *et al.* (2013). The moderate phenotypic and genotypic coefficients of variation were recorded for leaf width, spike length, diameter of second floret and vase life. These results are in conformity with the findings of Archana *et al.* (2008) and Lepcha *et al.* (2007). Minimum values of phenotypic and genotypic coefficients of variation were recorded for characters like number of leaves, days taken to spike emergence and days taken to first floret showing colour and total blooming life. Because of low coefficient of variation these characters have minimum scope of improvement through selection. Similar results have also been reported by Archana *et al.* (2008) and Bhujbal *et al.* (2013). High heritability coupled with high genetic advance was observed for number of cormels per plant, fresh weight of corm, rachis length and fresh weight of spike. This indicates the lesser influence of environment in expression of these characters and prevalence of additive gene action in their inheritance hence, selection for these traits will be effective. Similar results were also noticed by Kumar *et al.* (2013), Balaram and Janakiram (2009) and Archana *et al.* (2008). High heritability with moderate genetic advance was recorded for leaf width, days taken

Table 1: Estimates of variance component and related genetic parameters for different quantitative characters

Character	Range	Mean ± S.E.m.	Variance			Coefficient of variation			Heretability (%)	Genetic advance	Genetic advance (% of mean)
			Genotypic (GV)	Phenotypic (PV)	Environmental (EV)	Genotypic (GCV)	Phenotypic (PCV)	Environmental (ECV)			
Plant height (cm)	43.74 - 81.28	62.1 ±3.605	69.30	108.30	39.00	13.41	16.76	10.06	63.99	13.72	22.09
No. of leaves/ plant	6.22- 9.33	8.13 ± 0.486	0.47	1.17	0.71	8.39	13.32	10.35	39.66	0.88	10.88
Width of leaves (cm)	2.27 - 3.74	2.82 ± 0.100	0.18	0.21	0.03	15.19	16.38	6.13	86.00	81.80	29.01
Days taken to spike emergence	56.01 - 91.36	78.99 ±1.261	118.17	122.94	4.77	13.76	14.04	2.77	96.12	21.95	27.79
Days taken to first floret showing colour	68.77 - 105.08	91.54 ± 1.748	110.56	119.73	9.17	11.49	11.95	3.31	92.34	20.81	22.74
Total blooming life (day)	12.29 - 19.50	17.04 ± 0.477	3.28	3.96	0.68	10.63	11.69	4.85	82.77	3.40	19.92
Spike length (cm)	50.50 - 105.93	83.63 ± 3.768	220.31	262.89	42.58	17.75	19.39	7.80	83.80	27.99	33.47
Rachis length (cm)	21.95 - 50.81	35.61 ± 2.077	86.65	99.59	12.94	26.14	28.02	10.10	87.01	17.89	50.23
Dia. of 2nd floret (cm)	5.56 - 12.21	9.25 ± 0.235	2.59	2.76	0.17	17.41	17.96	4.41	93.98	3.22	34.77
No. of florets per spike	6.54 - 14.87	12.06 ± 0.638	4.88	6.10	1.22	18.32	20.48	9.16	80.02	4.07	33.76
Fresh wt. of spike (g)	37.12 - 86.79	62.12 ± 3.335	206.94	240.31	33.37	23.16	24.95	9.30	86.11	27.50	44.27
Vase life (day)	6.12 - 11.33	8.34 ± 0.260	1.87	2.27	0.41	16.38	18.08	7.66	82.07	2.55	30.57
Dia. of corm(cm)	4.31 - 6.97	5.31 ± 3.376	0.49	0.70	0.20	13.21	15.71	8.49	70.77	1.22	22.90
Fresh wt. of corm	14.06 - 68.65	29.4 ± 0.251	217.98	252.18	34.20	50.22	54.01	19.89	86.44	28.28	96.18
No. of corms /plant	1.00 - 4.67	2.25 ± 1.451	0.75	0.94	0.19	38.49	43.07	19.34	79.84	1.59	70.84
no. of cormels per plant	1.32 - 33.00	6.69 ± 0.579	53.48	59.79	6.31	109.31	115.59	37.56	89.44	14.25	212.97
Dia. of cormels (mm)	6.72 - 15.18	10.35 ± 3.605	4.93	5.93	1.01	21.45	23.53	9.69	83.06	4.17	40.27

to spike emergence, spike length, diameter of second floret, number of florets per spike and vase life indicating that these characters were also governed by both additive gene action and non additive gene action. These results are in accordance with Bhujbal *et al.* (2013) and Kumar *et al.* (2012). High heritability coupled with low genetic advance was recorded for days taken to first floret showing colour, total bloomimg life and diameter of corm indicating non additive gene action. These results are in conformity with the findings of Archana *et al.* (2008).

Correlation

To determine the nature and magnitude of association, phenotypic and genotypic correlation coefficients between pairs of traits were estimated and presented in Table 2 and Table 3.

The study showed a positive and significant association of plant height with spike length, corm diameter and fresh weight of spike at both phenotypic and genotypic level. This result is supported by the findings of Kumar et al. (2013) and Balaram and Janakiram (2009) in gladiolus. Leaf width (cm) exhibited significant and positive correlation with fresh weight of corm, total blooming life and number of florets per spike at both genotypic and phenotypic level. Similar result was also noticed by Neeraj *et al.* (2001). Days taken to spike

Table 2: Estimate of genotypic correlation of various quantitative characters in different gladiolus genotypes

Character	Plant height (cm)	No. of leaves/ plant	Leaf width (cm)	Days taken to spike emergence	Days taken to first floret showing colour	Total blooming life (day)	Spike length (cm)	Rachis length (cm)	Dia. of 2nd floret (cm)	No. of florets per spike	Fresh wt. of spike (g)	Vase life (day)	Corm dia.(cm)	Fresh wt. of corm	No. of corms /plant	No. of cormels per plant	Cormel dia.(mm)
Plant height (cm)		.5364 *	.5036 *	.0060	.0674	.5474 *	.7556**	.4942 *	-.0027	.2622	.6846**	.5155 *	.6383**	.4049	-.0713	-.0832	-.1707
No. of leaves/ plant			.2098	.0482	.0665	.4105	.6084**	.3754	-.2700	.1913	.5085 *	.5966**	.7526**	.5506 *	.0556	.3327	-.1749
Leaf width (cm)				.0332	.0219	.5769**	.3613	.4262	.2603	.5598 *	.4382	.1275	.5599 *	.6173**	-.3492	.0060	.4230
Days taken to spike emergence					.9734**	.0317	.0771	.1744	.2311	.0859	.1473	.3788	-.2080	-.1990	.2893	.3622	-.1068
Days taken to first floret showing colour						.0224	.1476	.2628	.2381	.1129	.1886	.3235	-.1963	-.2557	.4199	.3575	-.1655
Total blooming life (day)							.8024**	.8770**	.5534 *	.8190**	.8533**	.5099 *	.3264	.3368	-.2960	.1682	.3021
Spike length (cm)								.8831**	.8831**	.8831**	.8831**	.8831**	.8831**	.8831**	.8831**	.8831**	.8831**
Rachis length (cm)									.7161**	.8299**	.9479**	.3244	.2428	.1330	.0378	.2680	.2110
Dia. of 2nd floret (cm)										.7419**	.6439**	.0270	-.1245	-.0830	.0191	.2516	.0403
No. of florets per spike											.7563**	.1060	.2803	.3493	-.3017	.1829	.3220
Fresh wt. of spike (g)												.4561 *	.4427	.3227	-.0299	.3572	.1358
Vase life (day)													.2855	.2261	-.1027	.1960	-.0741
Corm dia.(cm)														.8864**	-.2521	.0845	.1352
Fresh wt. of corm															-.5439 *	.1705	.3609
No. of corms /plant																.0543	-.3879
No. of cormels per plant																	.2104
Cormel dia.(mm)																	

Table 3: Estimate of phenotypic correlation of various quantitative characters in different gladiolus genotypes

Character	Plant height (cm)	No. of leaves/ plant	Leaf width (cm)	Days taken to spike emergence	Days taken to first floret showing colour	Total blooming life (day)	Spike length (cm)	Rachis length (cm)	Dia. of 2nd floret (cm)	No. of florets per spike	Fresh wt. of spike (g)	Vase life (day)	Corm dia.(cm)	Fresh wt. of corm	No. of corms /plant	No. of cormels per plant	Cormel dia.(mm)
Plant height (cm)		.2392	.3661	.0160	.0615	.3874	.5833**	.3852	.0333	.1939	.5043 *	.3517	.5352 *	.3870	-.0799	-.0247	-.1080
No. of leaves/ plant			.1757	.0328	.0509	.3160	.3582	.1979	-.2013	.1762	.3147	.3297	.4125	.3503	.0076	.2073	-.1362
Leaf width (cm)				.0363	.0251	.5070 *	.3387	.3966	.2130	.5015 *	.3888	.0544	.4333	.5437 *	-.3018	.0239	.2996
Days taken to spike emergence					.9357**	.0128	.0575	.1728	.2220	.0751	.1336	.3390	-.1568	-.1752	.2974	.3435	-.0943
Days taken to first floret showing colour						-.0105	.1341	.2435	.2171	.0819	.1792	.2802	-.1285	-.2122	.3677	.3298	-.1435
Total blooming life (day)							.7080**	.7581**	.4691 *	.8027**	.7483**	.4600 *	.2993	.3234	-.2383	.1684	.1810
Spike length (cm)								.7959**	.4207	.5160 *	.9421**	.4425	.4193	.2836	.0529	.2809	-.0119
Rachis length (cm)									.6582**	.7449**	.8659**	.3064	.2244	.1309	.0628	.2289	.1168
Dia. of 2nd floret (cm)										.6172**	.5813**	.0119	-.1166	-.0866	.0416	.2254	.0634
No. of florets per spike											.6644**	.1166	.2470	.3092	-.2366	.1698	.1512
Fresh wt. of spike (g)												.4109	.4112	.3197	-.0062	.3157	.0813
Vase life (day)													.3056	.2393	-.0843	.1985	-.0430
Corm dia.(cm)														.8741**	-.1480	.1045	.1021
Fresh wt. of corm															-.4670 *	.1798	.3019
No. of corms /plant																.0351	-.3198
No. of cormels per plant																	.1902
Cormel dia.(mm)																	

emergence showed significant and positive correlation with days taken to first floret showing colour at both genotypic and phenotypic level. Total blooming life (day) had significant and positive correlation with rachis length, fresh weight of spike, number of florets per spike, spike length, diameter of second floret and vase life at both genotypic and phenotypic level. Similar findings were reported by Anuradha *et al.* (2002) in gladiolus. Spike length (cm) exhibited significant and positive correlation with rachis length, number of florets per spike and fresh weight of spike at both genotypic and phenotypic level. These results are also corroborated by Verma (2004) and Balaram and Janakiram (2009) in gladiolus. Positive and significant association was recorded for rachis length with fresh weight of spike, number of florets per spike and diameter of second floret at both genotypic and phenotypic level. Hussain *et al.* (2001) and Anuradha *et al.* (2002) also reported similar observations in gladiolus. There exists a positive and significant relationship of diameter of second floret (cm) with number of florets per spike and fresh weight of spike at both genotypic and phenotypic level. Similar results were reported by Anuradha *et al.* (2002) and Balaram and Janakiram (2009) in gladiolus. Number of florets per spike exhibited significant and positive correlation with fresh weight of spike at both genotypic and phenotypic level. Corm diameter was recorded to be

Table 4: Path coefficient analysis showing the direct (diagonal) and indirect (above and below diagonal) effect of different characters on number of florets per spike at genotypic level in gladiolus

Character	Plant height (cm)	No. of leaves/ plant	Leaf width (cm)	Days taken to spike emergence	Days taken to first floret showing colour	Total blooming life (day)	Spike length (cm)	Rachis length (cm)	Dia. of 2nd floret (cm)	Fresh wt. of spike (g)	Vase life (day)	Corm dia.(cm)	Fresh wt. of corm	No. of corms /plant	No. of cormels per plant	Cormel dia.(mm)	Correlation with no.of florets per spike
Plant height (cm)	**0.1644**	-0.2071	-0.3133	-0.0005	0.0342	0.9108	-0.3363	0.2762	-0.0006	-0.5807	-0.2804	0.4766	0.1055	0.0001	-0.0135	0.0267	0.2622
No. of leaves/ plant	0.0882	**-0.3860**	-0.1305	-0.0037	0.0337	0.6830	-0.2708	0.2098	-0.0633	-0.4313	-0.3245	0.5620	0.1434	-0.0001	0.0540	0.0273	0.1913
Leaf width (cm)	0.0828	-0.0810	**-0.6221**	-0.0025	0.0111	0.9598	-0.1608	0.2382	0.0610	-0.3717	-0.0693	0.4181	0.1608	0.0005	0.0010	-0.0661	0.5598 *
Days taken to spike emergence	0.0010	-0.0186	-0.0207	**-0.0763**	0.4936	0.0527	-0.0343	0.0975	0.0541	-0.1249	-0.2060	-0.1553	-0.0518	-0.0004	0.0588	0.0167	0.0859
Days taken to first floret showing colour	0.0111	-0.0257	-0.0136	-0.0743	**0.5070**	0.0373	-0.0657	0.1469	0.0558	-0.1600	-0.1759	-0.1466	-0.0666	-0.0006	0.0580	0.0259	0.1129
Total blooming life (day)	0.0900	-0.1585	-0.3589	-0.0024	0.0114	**1.6638**	-0.3571	0.4902	0.1296	-0.7238	-0.2773	0.2437	0.0877	0.0005	0.0273	-0.0472	0.8190**
Spike length (cm)	0.1242	-0.2349	-0.2248	-0.0059	0.0748	1.3350	**-0.4451**	0.4936	0.1144	-0.8143	-0.2751	0.3214	0.0698	-0.0001	0.0513	-0.0025	0.5820**
Rachis length (cm)	0.0813	-0.1449	-0.2651	-0.0133	0.1333	1.4591	-0.3930	**0.5589**	0.1678	-0.8040	-0.1764	0.1813	0.0346	-0.0001	0.0435	-0.0330	0.8299**
Dia. of 2nd floret (cm)	-0.0004	0.1042	-0.1619	-0.0176	0.1207	0.9207	-0.2174	0.4002	**0.2343**	-0.5462	-0.0147	-0.0930	-0.0216	0.0000	0.0408	-0.0063	0.7419**
Fresh wt. of spike (g)	0.1126	-0.1963	-0.2726	-0.0112	0.0956	1.4197	-0.4273	0.5298	0.1508	**-0.8482**	-0.2481	0.3306	0.0840	0.0000	0.0579	-0.0212	0.7563**
Vase life (day)	0.0848	-0.2303	-0.0793	-0.0289	0.1640	0.8484	-0.2252	0.1813	0.0063	-0.3869	**-0.5438**	0.2132	0.0589	0.0002	0.0318	0.0116	0.1060
Corm dia.(cm)	0.1049	-0.2905	-0.3483	0.0159	-0.0995	0.5431	-0.1916	0.1357	-0.0292	-0.3755	-0.1553	**0.7467**	0.2309	0.0004	0.0137	-0.0211	0.2803
Fresh wt. of corm	0.0666	-0.2126	-0.3840	0.0152	-0.1297	0.5604	-0.1193	0.0743	-0.0194	-0.2737	-0.1230	0.6619	**0.2604**	0.0008	0.0277	-0.0564	0.3493
No. of corms /plant	-0.0117	-0.0215	0.2172	-0.0221	0.2129	-0.4925	-0.0289	0.0211	0.0045	0.0254	0.0559	-0.1883	-0.1417	**-0.0015**	0.0088	0.0606	-0.3017
No. of cormels per plant	-0.0137	-0.1284	-0.0037	-0.0277	0.1813	0.2799	-0.1406	0.1498	0.0589	-0.3030	-0.1066	0.0631	0.0444	-0.0001	**0.1622**	-0.0329	0.1829
Cormel dia.(mm)	-0.0281	0.0675	-0.2631	0.0082	-0.0839	0.5026	-0.0071	0.1179	0.0094	-0.1152	0.0403	0.1010	0.0940	0.0006	0.0341	**-0.1563**	0.3220

Residual factor = 0.006

positively and significantly associated with fresh weight of corm at both genotypic and phenotypic level. Similar findings were reported by Balaram and Janakiram (2009). Fresh weight of corm had significant but negative correlation with number of corms per plant at both genotypic and phenotypic level.

Path coefficient analysis

Path coefficient analysis partitioned the correlation coefficient into direct and indirect effects (Table 4 and Table 5). Path coefficient analysis for number of florets per spike as a dependent variable showed that total blooming life, rachis length and diameter of second floret had positive and significant correlations as well as maximum direct effect on number of florets per spike. While leaf width, spike length and fresh weight of spike though had positive significant correlations but they exhibited maximum indirect effects. Highest positive indirect effect was recorded for leaf width via fresh weight of corm, total blooming life and number of florets per spike. Highest positive indirect effect was recorded for leaf width via fresh weight of corm, total blooming life and number of florets per spike; for spike length and fresh weight of spike via total blooming life, rachis length, corm diameter, plant height and diameter of second floret. Residual effect of 0.60 per cent indicates that, the characters studied contributed to 99.4 per cent of variation on number of florets per spike.

Based on the variability studies, it can be concluded that characters like number of cormels per plant, fresh weight of corm, rachis length and fresh weight of spike are suitable for selection because of lesser influence of environment in the expression of these characters. Whereas, association studies revealed that improvement in gladiolus thus may be enhanced through the direct selection of genotypes (to be used in breeding programme) for the above mentioned characters exhibiting high positive direct and indirect effects with positive correlation.

Table 5: Path coefficient analysis showing the direct (diagonal) and indirect (above and below diagonal) effect of different characters on number of florets per spike at phenotypic level in gladiolus

Character	Plant height (cm)	No. of leaves/ plant	Leaf width (cm)	Days taken to spike emergence	Days taken to first floret showing colour	Total blooming life (day)	Spike length (cm)	Rachis length (cm)	Dia. of 2nd floret (cm)	Fresh wt. of spike (g)	Vase life (day)	Corm dia.(cm)	Fresh wt. of corm	No. of corms /plant	No. of cormels per plant	Cormel dia.(mm)	Correlation with no.of florets per spike
Plant height (cm)	**-0.1187**	-0.0079	-0.0233	-0.0009	0.0142	0.3080	-0.3863	0.1170	0.0008	0.2767	-0.1207	0.0455	0.0626	0.0093	0.0003	0.0173	0.1939
No. of leaves/ plant	-0.0284	**-0.0332**	-0.0112	-0.0019	0.0118	0.2512	-0.2372	0.0601	-0.0046	0.1727	-0.1131	0.0351	0.0567	-0.0009	-0.0026	0.0218	0.1762
Leaf width (cm)	-0.0435	-0.0058	**-0.0636**	-0.0021	0.0058	0.4031	-0.2243	0.1205	0.0049	0.2133	-0.0187	0.0368	0.0879	0.0352	-0.0003	-0.0479	.5015 *
Days taken to spike emergence	-0.0019	-0.0011	-0.0023	**-0.0570**	0.2163	0.0102	-0.0381	0.0525	0.0051	0.0733	-0.1163	-0.0133	-0.0283	-0.0347	-0.0043	0.0151	0.0751
Days taken to first floret showing colour	-0.0073	-0.0017	-0.0016	-0.0533	**0.2312**	-0.0084	-0.0888	0.0740	0.0050	0.0983	-0.0961	-0.0109	-0.0343	-0.0429	-0.0042	0.0229	0.0819
Total blooming life (day)	-0.0460	-0.0105	-0.0322	-0.0007	-0.0024	**0.7950**	-0.4689	0.2303	0.0108	0.4106	-0.1578	0.0254	0.0523	0.0278	-0.0021	-0.0289	.8027**
Spike length (cm)	-0.0692	-0.0119	-0.0215	-0.0033	0.0310	0.5629	**-0.6623**	0.2418	0.0097	0.5169	-0.1518	0.0356	0.0459	-0.0062	-0.0035	0.0019	.5160 *
Rachis length (cm)	-0.0457	-0.0066	-0.0252	-0.0099	0.0563	0.6027	-0.5271	**0.3038**	0.0152	0.4751	-0.1051	0.0191	0.0212	-0.0073	-0.0029	-0.0187	.7449**
Dia. of 2nd floret (cm)	-0.0040	0.0067	-0.0136	-0.0127	0.0502	0.3730	-0.2786	0.2000	**0.0230**	0.3190	-0.0041	-0.0099	-0.0140	-0.0049	-0.0028	-0.0101	.6172**
Fresh wt. of spike (g)	-0.0599	-0.0104	-0.0247	-0.0076	0.0414	0.5949	-0.6239	0.2631	0.0134	**0.5487**	-0.1410	0.0349	0.0517	0.0007	-0.0040	-0.0130	.6644**
Vase life (day)	-0.0418	-0.0109	-0.0035	-0.0193	0.0648	0.3657	-0.2931	0.0931	0.0003	0.2255	**-0.3431**	0.0260	0.0387	0.0098	-0.0025	0.0069	0.1166
Corm dia.(cm)	-0.0635	-0.0137	-0.0276	0.0089	-0.0297	0.2380	-0.2777	0.0682	-0.0027	0.2256	-0.1049	**0.0850**	0.1414	0.0173	-0.0013	-0.0163	0.2470
Fresh wt. of corm	-0.0459	-0.0116	-0.0346	0.0100	-0.0491	0.2571	-0.1878	0.0398	-0.0020	0.1754	-0.0821	0.0743	**0.1617**	0.0545	-0.0023	-0.0483	0.3092
No. of corms /plant	0.0095	-0.0003	0.0192	-0.0170	0.0850	-0.1895	-0.0350	0.0191	0.0010	-0.0034	0.0289	-0.0126	-0.0755	**-0.1167**	-0.0004	0.0511	-0.2366
No. of cormels per plant	0.0029	-0.0069	-0.0015	-0.0196	0.0762	0.1339	-0.1860	0.0695	0.0052	0.1732	-0.0681	0.0089	0.0291	-0.0041	**-0.0126**	-0.0304	0.1698
Cormel dia.(mm)	0.0128	0.0045	-0.0191	0.0054	-0.0332	0.1439	0.0079	0.0355	0.0015	0.0446	0.0148	0.0087	0.0488	0.0373	-0.0024	**-0.1598**	0.1512

Residual factor = 0.1123

REFERENCES

Allard, R.W. 1960. Principles of plant breeding. 1st ed. New York, John Wiley and Sons. 485 p.

Anuradha, S.; Gowda, J.V.N. and Jayaprasad, K.V. 2002. Path coefficient analysis in gladiolus. *J. Orn. Hort.*, **5**(1): 32-34.

Archana, B.; Patil, A.A.; Hunje, R. and Patil, V.S. 2008. Studies on genetic variability analysis in gladiolus hybrids. *J. Orn. Hort.*, **11**(2): 121.

Balaram, M.V. and Janakiram, T. 2009. Correlation and path coefficient analysis in gladiolus. *J. Orn. Hort.*, **12**(1): 22-29.

Balaram, M.V. and Janakiram, T. 2009. Genetic variability in gladiolus genotypes for corm characters. *J. Orn. Hort.*, **12**(2): 123-126.

Bhujbal, G.B.; Chavan, N.G. and Mehetre, S.S. 2013. Evaluation of genetic variability, heritability and genetic advance in gladiolus (*Gladiolus grandiflorus* L.) genotypes. *The Bioscan*, **8**(4): 1515-1520.

Burton, G.W. and Devane, E.W. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agron. J.*, **4**: 78-81.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.*, **51**: 515-518.

Fisher, R.A. and Yates, F. 1963. Statistical tables. 6th ed. Oliver and Boyed, Edinburgh, London. 57p.

Hussain, C.T.S.; Misra, R.L.; Bhattacharjee, S.K. and Saini, H.C. 2001. Correlation and path coefficient analysis in gladiolus. *J. Orn. Hort. New Series*, **4**(1): 13-16.

Johnson, H.W.; Robinson, H.F. and Comsstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.*, **47**: 314-318.

Kumar, P.; Maurya, R.K.; Chakraborty, B.; Mer, R. and Mishra, D.S. 2013. Genetic variability and correlation studies in *Gladiolus hybrida* L. under *tarai* condition of Uttarakhand. *Prog. Agri.*, **13**(1): 68-74.

Kumar, R.; Kumar, S. and Yadav, Y.C. 2012. Genetic variability, heritability, genetic advance, correlation coefficient and path analysis in gladiolus. *Indian J. Hort.*, **69**(3): 369-373.

Lepcha, B.; Nautiyal, M.C. and Rao, V.K. 2007. Variability studies in gladiolus under mid hill conditions of Uttarakhand. *J. Orn. Hort.*, **10**(3): 169-172.

Neeraj; Mishra, H.P. and Jha, P.B. 2001. Correlation and path coefficient analysis in gladiolus. *J. Orn. Hort. New Series*, **4**(2): 74-78.

Nimbalkar, C.A.; Katewate, S.M.; Singh, B.R.; Kakade, D.S. and Gurav, S.B. 2007. Selection strategy for improvement in economic traits of gladiolus. *J. Orn. Hort.*, **10**(1): 9-14.

Panse, V.G. and Sukhatme, P.V. 1969. Statistical methods for agriculture workers. 2nd ed. ICAR Publications, New Delhi. 37p.

Verma, S. 2004. Genetic variability and character association in gladiolus (*G. grandiflorus* L.). Thesis, Master of Science in Ag. Horticulture (Floriculture and Landscaping). G.B. Pant University of Agriculture and Technology, Pantnagar. 84p.

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Drying and dehydration of ornamentals: A tool for rural empowerment

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ABSTRACT

Drying and dehydration is one of the easy and effective way to add value to the flowers and foliages creating ample scope of employment generation specially for rural youths including women by setting up small scale industry. In this context an attempt has been made to standardize package of techniques to dry and dehydrate flowers and foliages of selected ornamental crops. It was observed that maximum 79.22% moisture loss was achieved under press drying method for leaves of *Polyalthia longifolia* in 13 days. While, press drying followed by oven drying was the best for quick drying which required only 3-6 days as compared to 9-15 days in only press drying for drying, but the dried materials were more brittle in nature and care should be taken for retention of colour. Use of silica gel (60-120 mesh) solely and in combination with 100-200 mesh at 1:1 ratio was found as slow but steady method for dehydration maintaining good texture, structure and natural colour. Thus, it can be suggested that press drying followed by oven drying was good for quick drying of foliages and use of silica gel was better for dehydration of flowers with good quality.

KEY WORDS: Drying, Dehydration, Flowers, Ornamentals, Rural employment

Flowers are generally utilized for their beauty and fragrance. From child to old all love flowers and use different flowers for different purposes. Thus, it became an integral part of human life from birth to death. The fresh flowers are more attractive but are very perishable in nature as well as a particular type of flower is available during a particular season. On the other hand dried flowers and foliages are long lasting and keep their originality irrespective of season (Malcolm, 1994). Floriculture is now becoming profitable business word wide. Among this, flower is the basic component but kipping quality or self-life of fresh flowers is very short. Several investigations have been carried out to improve the self-life or base life of cut flowers but success is limited. A large amount of fresh flowers and foliages waste regularly and cause pollution at nearer and surrounding the flower market. India has a rich source of diversity of ornamentals having it diverse agro-climatic condition. Some ornamental crops are grown naturally at road side, field and hilly areas of our country as commercial crop, garden crop or even wild. These neglected ornamentals grow naturally and died or waste naturally without any use. So, there is a huge scope for floral trading by value addition of this neglected or underutilized crop. Among the various process of value addition drying and dehydration of flowers and foliages is getting popularity very fast. Dry flowers constitute more than two third of total floriculture export and demand for dry flowers is increasing very fast (8-10% annually). Therefore, there is an opportunity for development of dry flower industry in India (Maji, 2014; Maji and Kumar, 2014). Although, flower drying has been cited as very old process and mentioned in the book 'The florist' in the year 1860 (Dilta *et al*., 2011) but, complete technical packages for drying and dehydration of various flowers and foliages is limited to the common people. Some efforts have been made by Datta and Roy (2013) to formulate standard package of drying and dehydration. It is very easy and low cost technology to convert fresh flowers in to dehydrated products to establish small scale industry. Moreover, it's very promising because of eco-consciousness of consumers as the dry flower techniques is near natural and eco-friendly. The present work emphasized on standardization of low cost eco- friendly drying and dehydration technique for value addition of neglected and underutilized flowers and foliages.

MATERIALS AND METHODS

The experiment was conducted during 2013-2014 at Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India. The climate of Lucknow is drier subtropical

Table 1: Moisture loss and days required for drying of different materials under press drying

Materials	Fresh weight (g)	Dry weight (g)	Weight loss (g)	Moisture loss (%)	Days required
Marigold petals	1.1	0.41	0.69 ± 0.55	62.73±0.08	9±0.46
Marigold leaves/twig	10.12	4.14	5.98 ± 0.39	59.09±0.76	12± 0.07
Parthenium leaves	9.75	3.12	6.63 ± 0.50	68.00± 0.80	9 ± 0.46
Kochia leaves	7.62	2.1	5.52 ± 030	72.44± 1.59	9 ± 0.46
Polyalthia longifolia leaves	10.2	2.12	8.08 ± 0.76	79.22± 2.79	13± 0.24
Neem leaves	0.91	0.21	0.7 ± 0.55	76.92± 2.39	14± 0.42
Bougainvillea leaves	0.65	0.39	0.26 ± 0.63	40.00± 4.14	15± 0.60
Thuja leaves	5.72	3.15	2.57 ± 0.22	44.93± 3.27	12± 0.07

having maximum temperature of 45°C during summer and minimum 3°C during winter with average relative humidity of 60-80% during various seasons. The techniques which were followed are very easy and with indigenous materials. Very few literatures are available and thus the methods have been followed with the modification of available methods as described by Datta and Roy (2011) and as per Horticultural MU Guide published by University of Missouri Extensions.

COLLECTION OF MATERIALS

Materials were collected from local fields as well from road side adjoining areas of university. The plant materials like marigold (*Tagetes* sp.) flowers and leaves were collected from Horticultural Research Farm of Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University (BBAU), Lucknow. Leaves of neem (*Azadirachta indica*), Sita ashok (*Polyalthia longifolia)*, Kochia (*Bassia scoparia*), *Baugainvillea* and Thuja (*Thuja standishii*), and inflorescence of *Baugainvillea*, *Clerodendrum infortunatum*, *Calotropis gigantea*, *Lantana camara* flowers etc. were collected from plants grown at the side of various roads of BBAU and from adjoining areas. Proper stage of harvesting was followed to retain their colour, texture intact after drying and dehydration. The materials were covered under tissue papers immediately after collection to soak the outer moisture initially and then kept under different treatments for drying and dehydration i.e. Press drying, Press drying followed by Hot air oven drying and embedding.

PRESS DRYING

The materials were collected and kept under tissue paper for soaking of moisture present at adhering to outside of the materials initially. Then the materials were kept between blotting papers. 3-4 blotting paper sheets were kept below and above the materials. The sheets were cut according to the size of the press drier. The press-drier was made by placing two ply boards with nut and bolts. The materials were kept on the blotting sheets with sufficient space from each other. Different types of materials were kept on different sheets. The blotting paper sheets containing materials (leaves/petals) were kept between two ply boards and tightened with nut and bolt. Then the press-drier was kept under room temperature. The weight of the materials was recorded before and after drying. The blotting sheets were replaced every two days interval to avoid fungal contamination and for proper drying.

PRESS DRYING FOLLOWED BY OVEN DRYING

In this method, the materials were made ready similar to the press drier. After became ready, the materials were kept in hot air oven – cum - drier for quick drying. For this, the temperature was maintained at 55 °C. The materials were dried for 40-72 hours in first phage and subsequent phages depending on the condition of sample materials and blotting paper sheets were also changed regularly at 3 days intervals.

Table 2: Weight loss and days required for different materials under press drying followed by oven drying.

Materials	Fresh weight (g)	Dry weight (g)	Weight loss (g)	Moisture loss (%)	Days required
Marigold petals	1.1	0.49	0.61± 0.52	55.45± 0.41	4± 0.09
Marigold leaves/twig	10.12	4.98	5.14± 0.28	50.79± 1.23	4± 0.09
Parthenium leaves	9.75	3.45	6.30 ± 0.49	64.62± 1.21	4± 0.09
Kochia leaves	7.62	2.15	5.47± 0.34	71.78± 2.48	3± 0.27
Polyalthia longifolia leaves	10.2	2.50	7.7± 0.74	75.49±3.13	5± 0.09
Neem leaves	0.91	0.22	0.69± 0.50	75.82± 3.19	4± 0.09
Bougainvillea leaves	0.65	0.45	0.20 ± 0.59	30.77± 4.77	6± 0.27
Thuja leaves	5.72	3.58	2.14± 0.25	37.41± 3.60	6± 0.27

Table 3: Dehydration of different materials under embedding with silica gel (60-120 mesh)

Materials	Fresh weight (g)	Dry weight (g)	Weight loss (g)	Moisture loss (%)	Days required
Marigold flowers	7.49	2.45	5.04± 0.17	67.29± 0.70	8 ± 0.02
Marigold leaves	10.92	3.05	7.87± 0.62	72.07± 1.45	9 ± 0.14
Parthenium leaves	10.02	2.99	7.03± 0.48	70.16± 1.15	8 ± 0.02
Clerodendrum infortunatum inflorescence	4.12	0.71	3.41± 0.09	82.77± 3.15	9 ± 0.14
Calotropis gigantea inflorescence	5.21	0.89	4.32± 0.05	82.92± 3.17	9 ± 0.14
Kochia leaves	7.62	1.21	6.41± 0.38	84.12± 3.36	7 ± 0.17
Polyalthia longifolia leaves	7.98	2.99	4.99± 0.16	62.53± 0.05	8 ± 0.02
Bougainvillea leaves	0.72	0.56	0.16 ±0.60	22.22± 6.43	8 ± 0.02
Lantana camara flower	0.74	0.41	0.33± 0.58	44.59± 2.89	8 ± 0.02
Baugainvillea flower	0.65	0.39	0.26± 0.59	40.00± 3.62	7 ± 0.17

EMBEDDING

The silica gel (60-120 mesh) individual grade and their mixture were used for dehydration. Silica gel (60-120 mesh) and combination of silica gel (60-120 and 100-200 mesh) at 1:1 ratio were also used to cover the materials for dehydration.

STATISTICAL ANALYSIS

Data were recorded with four replications for each treatments and statistical design was made following CRD. The recorded data were calculated statistically using programming made by the author in Microsoft Excel data sheet following the standard method of Sahu and Das (2014) compared the variance at 5% level of significance and standard error was also calculated and expressed in tables.

RESULTS AND DISCUSSION

Table 1 showed the days requirement and moisture loss under press drying method for drying of various ornamentals. It indicated that the maximum moisture loss (79.22%) was observed for drying of *Polyalthia longifolia* leaves followed by neem leaves (76.92%). 79.22% of moisture loss was sufficient for proper drying of *Polyalthia longifolia* leaves under press drying whereas, neem leaves required 76.92% weight loss for its proper drying. Interestingly, it was noted that only 40.00% weight loss was sufficient for drying of *Bougainvillea* leaves and 44.93% weight loss for Thuja leaves. It was also recorded that leaves of *Bougainvillea* required maximum of 15 days for drying though, it exhibited minimum weight loss (40.00%) for proper drying. Similarly, 12 days were required for drying of Thuja leaves which exhibited only 44.93% weight loss under press drying. Although, *Bougainvillea* leaves required 13 days for its drying but showed the maximum 79.22% weight loss among the ornamentals under study. Other ornamental materials required averagely 9-12 days for their drying under press drying method.

Results for drying of ornamentals under press drying followed by oven drying were presented in Table 2. It clearly showed that the materials under study lost weight almost similar to press drying, but comparatively less effective as it showed lower weight loss as compared to normal press drying. 75.49 % weight loss was achieved under this method of press drier followed by oven drying but 79.22 % weight loss was achieved under only press drying. In this method maximum 75.82% weight loss was recorded for neem leaves and 75.49% for *Polyalthia longifolia* leaves. While, only 30.77% weight loss was achieved for

Table 4: Dehydration of different materials under embedding with mixture of silica gel of 60-120 mesh and 100-200 mesh at 1:1 ratio.

Materials	Fresh weight (g)	Dry weight (g)	Weight loss (g)	Moisture loss (%)	Days required
Marigold flowers	7.44	2.3	5.14 ±0.18	69.09 ± 0.62	8 ± 0.02
Marigold leaves	11.1	2.87	8.23 ± 0.67	74.14 ± 1.42	9 ± 0.14
Parthenium leaves	10.15	2.78	7.37 ± 0.54	72.61 ± 1.18	8 ± 0.02
Clerodendrum infortunatum inflorescence	4.0	0.65	3.35 ± 0.10	83.75 ± 2.94	9 ± 0.14
Calotropis gigantea inflorescence	5.25	0.87	4.38 ± 0.06	83.43 ± 2.89	9 ± 0.14
Kochia leaves	7.5	1.15	6.35 ± 0.37	84.67 ±3.08	7 ±0.17
Polyalthia longifolia leaves	7.85	2.97	4.88 ± 0.14	62.17 ± 0.48	8 ± 0.02
Bougainvillea leaves	0.8	0.56	0.24 ± 0.59	30.00 ± 5.56	8 ± 0.02
Lantana camara flower	0.77	0.42	0.35 ± 0.57	45.45 ± 3.12	8 ± 0.02
Bougainvillea flower	0.69	0.37	0.32 ± 0.58	46.38 ± 2.97	7 ± 0.17

Bougainvillea leaves and 37.41% for Thuja leaves. But, this method considerably reduced the time of drying compared to normal press drying. *Polyalthia* leaves required only 5 days for 75.49% moisture loss whereas, it required 13 days for 79.22% moisture loss under only press drying. So, this method reduced 8 days for drying of *Polyalthia* leaves. It was also seen that only 3 days was required for 71.78% weight loss in case of drying of Kochia leaves. Thus, on an average 4-6 days were required for drying under press drying followed by oven drying, thus, it can be called as quick method of drying as compared to only press drying.

Table 3 and 4 presented the data for dehydration of flowers and foliages under embedding method (embedding with silica gel 60-120 mesh and embedding with mixture of silica gel 60-120 mesh and 100-200 mesh at 1:1 ratio). The results showed that there was no significant difference among these two methods of embedding in respect of time (days) required for dehydration. Similar days were required for same materials under those two methods and 7-9 days were required for dehydration. Only difference noticed was that some more amount of moisture loss could be achieved by the embedding with mixture of silica gel (60-120 and 100-200 mesh mixed at 1:1 ratio).

From the experiment, it could be suggested that embedding was more effective for more and effective drying but press drying followed by oven drying was effective for quick drying as it reduced the days requirement for drying and dehydration.

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REFERENCES

Datta, S. K. and Roy, S. 2011. Employment generation using dehydration technology for drying flowers and foliage and floral craft. *Sci. Cult.* **77** (1-2): 58-61.

Datta, S. K. and Roy, S. 2013. Quick drying of flower petals and leaves in microwave oven. *Sci. Cult.* **79** (5-6): 243-244.

Dilta, B. S., Sharma, B. P., Baweja, H. S., Kashyap, B. 2011. Flower drying techniques- a review. *Int. J. Farm Sci.* **1** (2): 1-16.

Maji, S. 2014. Flower drying – a potential industry for women empowerment. Handbook on post harvest management techniques in horticultural crops. Workshop on post harvest management techniques in horticultural crops. pp 18-20.

Malcolm, H. 1994. Guide to arranging dried flowers. Step by step handbook of growing drying and displaying. Dorling Kindersley Ltd., London.

Sahu, P. K. and Das, A. K. 2014. In: *Agriculture and Applied Statistics-II*, Kalyani Pub. 163-170.

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Effect of planting distance and pinching on flowering and yield in China aster (*Callistephus chinensis* L. Nees) cv. Kamini

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ABSTRACT

An investigation was carried out at College of Horticulture, Rajendranagar, Hyderabad during rabi, 2013-14 to assess the effect of planting distance and pinching on flowering and yield in China aster cv. Kamini. The experiment was laid out in Randomized Block Design with factorial concept and replicated thrice. The study consisted of 12 treatment combinations with three spacings (30 cm x 15 cm, 30 cm x 30 cm and 45 cm x 30 cm) and four levels of pinching (pinching at 20 DAT, 30 DAT and 40 DAT and no pinching). The results revealed that closer spacing of 30 x 15 cm (S_1) recorded significantly minimum days to first flowering (82.30) and 50% flowering (100.42), maximum flower stalk length (37.18 cm), number of flowers per plot (3684.37), flower yield per plot (4.66 kg), flower yield per hectare (14.38 t), seed yield per plot (649.12 g) and seed yield per hectare (2003.46 kg). While wider spacing of 45 x 30 cm (S_3) recorded maximum flower diameter (6.20 cm), number of flowers per plant (65.88), flower yield per plant (70.56 g), seed yield per plant (12.40 g) and thousand seed weight (1.77 g). Plants pinched at 20 DAT recorded significantly maximum flower stalk length (36.83 cm), number of flowers per plant (70.47), number of flowers per plot (3760.86), flower yield per plant (73.46 g), flower yied per plot (4.01 kg), flower yield per hectare (12.38 t), seed yield per plant (13.07 g), seed yield per plot (684.02 g) and seed yield per ha (2161.58 kg) and thousand seed weight (1.78 g) when compared to other pinching treatments. It was concluded that for obtaining higher flower and seed yield per hectare in China aster cv. Kamini planting at a closer spcacing of 30 cm x 15 cm and pinching at 20 DAT could be recommended.

KEY WORDS : Flower stalk length, Flower yield, Pinching, Seed yield, Spacing,

China aster is a hardy and free blooming annual grown all over the world on account of its ease of cultivation and greater diversity in forms and colours. It is a popular bedding plant and also used as herbaceous boarder. Dwarf types are highly suitable for edging and window boxes. Large compact flowers with straight stalks are considered ideal for cut flower and flowers with more number of petals are suitable as loose flower for garland making. The growing popularity of China aster in most of the major cities in India has led to its cultivation as annual commercial crop for cut flower. In floriculture industry, improvement of agro-techniques facilitates viability of floricultural products, making the flower industry highly competent since only quality produce can *fetc*h a better price and consumer acceptability. Basic aspects of production like planting geometry, pinching *etc.* are of utmost importance for improving productivity and quality of a crop with respect to an agro-climatic zone. In most of the flower crops, flower and seed yield is mainly dependent on number of flower bearing branches which could be manipulated by arresting vertical growth of plants and encouraging side shoot by means of apical bud pinching. But, studies on influence of pinching in China aster on yield and quality are meagre. In marigold, the spacing also has great importance for manipulating plant growth, flowering behaviour and flower and seed yield. There is lack of scientific information with respect to optimum spacing for increased production in China aster. With this background, the present investigation on China aster cv. Kamini has been undertaken with the objective of studying the effect of spacing and pinching on flowering and flower and seed yield of China aster.

MATERIALS AND METHODS

The Experiment was laid out at College farm, College of Horticulture, Hyderabad during rabi seasson of 2013-14 in Randomized Block Design with factorial concept and replicated thrice. The study consisted of 12 treatment combinations with three spacings (30 cm x 15 cm, 30 cm x 30 cm and 45 cm x 30 cm) and four levels of pinching (no

Table 1: Effect of spacing and pinching on days to first flowering and days to 50% flowering in China aster cv. Kamini.

Spacing	Days to first flowering					Days to 50% flowering				
	Pinching									
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
S_1	71.49	98.57	83.76	75.38	82.30	77.92	120.65	107.30	94.13	100.42
S_2	72.62	101.63	84.60	76.34	83.79	83.19	121.86	114.72	106.56	106.58
S_3	73.46	105.46	85.45	78.56	85.73	92.43	122.22	115.68	108.41	109.68
Mean	72.52	101.88	84.60	76.76		80.40	119.07	115.06	103.03	
	SEm±			CD at 5%		SEm±			CD at 5%	
Spacing (S)	0.08			0.26		1.15			3.38	
Pinching (P)	0.10			0.30		1.33			3.90	
S x P	0.17			0.52		2.30			6.76	

S_1: 30 x 15 cm S_2: 30 x 30 cm S_3: 45 x 30 cm

P_0: no pinching P_1: Pinching at 20 DAT P_2: Pinching at 30 DAT P_3: Pinching at 40 DAT

pinching, pinching at 20 DAT, pinching at 30 DAT and pinching at 40 DAT). The net plot size was 1.8 m x 1.8 m. Well decomposed FYM @ 20 t ha $^{-1}$ was incorporated during the last ploughing in the main field. Phosphorous and potassium @ 80 and 120 kg ha^{-1} were applied in the form of single super phosphate and muriate of potash respectively as basal dose. Nitrogen @ 120 kg $^{-1}$ was applied in the form of urea in two split doses once at the time of planting and second one month after transplanting. Standard cultural practices were followed during the entire crop period. The observations on flower and seed parameters were recorded and analysed statistically as per the procedure described by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The data recorded on days to first flowering and days to 50% flowering as influenced by spacing, pinching and their interaction is presented in Table 1. Spacing had significant effect on days to first flowering. Among different spacing levels, S_3 (45 cm X 30 cm) recorded significantly highest number of days to first flowering (85.73) which was followed by S_2 (30 cm x 30 cm) spacing (84.60). The lowest number of days to first flowering was observed in S_1 level (30 cm x 15 cm) of spacig (82.30). Among different pinching levels, P_1 (pinching at 20 DAT) recorded significantly highest number of days to first flowering (101.88) which was followed by P_2 (pinching at 30 DAT) (84.60). The lowest number of days to first flowering was observed in P_0 (72.52). The interaction results showed that maximum number of days to first flowering was observed in S_3 P_1 treatment combination (105.46). The minimum number of days to first flowering was observed in S_1P_0 treatment combination (71.49). With regard to days to 50% flowering, spacing level S_3 (45 cm X 30 cm) recorded significantly highest number of days to 50% flowering (109.68) which was followed by the spacing of S_2 (30 cm x 30 cm) (106.58). The lowest number of days to first

Table 2: Effect of spacing and pinching on flower stalk length (cm) and flower diameter (cm) in China aster cv. Kamini.

Spacing	Flower stalk length (cm)					Flower diameter (cm)				
	Pinching									
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
S_1	32.49	40.13	39.53	36.60	37.18	6.31	5.95	5.83	5.68	5.94
S_2	31.44	37.01	36.40	34.75	34.90	6.32	6.13	6.00	5.90	6.08
S_3	27.68	33.34	32.43	32.13	31.39	6.38	6.28	6.21	5.94	6.20
Mean	30.53	36.83	36.12	34.49	34.49	6.33	6.12	6.01	5.84	6.07
	SEm±			CD at 5%		SEm±			CD at 5%	
Spacing (S)	0.10			0.31		0.06			0.21	
Pinching (P)	0.12			0.35		0.07			0.45	
S x P	0.21			0.62		0.12			0.66	

S_1: 30 x 15 cm S_2: 30 x 30 cm S_3: 45 x 30 cm

P_0: no pinching P_1: Pinching at 20 DAT P_2: Pinching at 30 DAT P_3: Pinching at 40 DAT

Table 3: Effect of spacing and pinching on number of flowers/plant and number of flowers per plot in China aster cv.

Spacing	Number of flowers per plant					Number of flowers perplot				
	Pinching									
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
S_1	24.40	51.66	45.03	42.66	40.93	2196.00	4649.40	4052.70	3839.40	3684.37
S_2	30.96	74.40	62.43	58.52	56.57	1517.04	3645.60	3059.07	2867.48	2772.29
S_3	35.33	85.36	77.30	65.53	65.88	1236.55	2987.60	2705.50	2293.55	2305.80
Mean	30.23	70.47	61.58	52.23		1649.86	3760.86	3272.42	3000.14	
	SEm±			CD at 5%		SEm±			CD at 5%	
Spacing (S)	0.06			0.20		9.00			26.42	
Pinching (P)	0.07			0.23		10.39			30.50	
S x P	0.13			0.40		18.01			52.84	

S_1: 30 x 15 cm S_2: 30 x 30 cm S_3: 45 x 30 cm

P_0: no pinching P_1: Pinching at 20 DAT P_2: Pinching at 30 DAT P_3: Pinching at 40 DAT

flowering (100.42) was observed in S_1 (30 cm x 15 cm). The maximum delay in 50% flowering was noticed in the treatment pinching at 20 DAT (119.07) which was significantly late compared to the remaining followed by pinching at 30 DAT (115.06). Among interactions, significantly maximum number of days to 50% flowering was observed in S_3P_1 (122.22). The minimum number of days to 50% flowering was observed in S_1P_0 treatment combination (77.92). These results revealed that flowering delayed significantly by increasing the spacing level from 30 cm x 15 cm to 45 cm x 30 cm. Plants spaced widely, remained in vegetative phase on account of lesser competition from the adjacent plants for space and light, thus delaying flowering. Similar results were obtained by Arora (1990) in marigold. Pinching at 20 DAT significantly delayed flowering. This indicated that the effort to suppress the apical dominance by means of pinching had a delaying effect on flower initiation. This might also be due to the fact that by removing the apical portion, the plants continued the vegetative phase and the new shoots which emerged on the pinched plants took longer time for physiologically mature and flower bud initiation. While non-pinched plants were able to initiate flower buds early. These results are in close conformity with earlier reports of Ravneet Kour *et al*. (2012) in marigold cv. Pusa Narangi Gainda.

The data recorded on flower stalk length (Table 2) showed that the spacing and pinching exhibited significant influence on cut flower stalk length. The maximum cut flower stalk length (37.18 cm) was recorded at S_1 (30 cm x 15 cm) which was followed by S_2 (30 cm x 30 cm) level of spacing. The minimum cut flower stalk length (31.39 cm) was recorded in S_3 (45 cm x 30 cm) level of spacing. Significantly maximum cut flower stalk length (36.83 cm) was recorded by pinching at 20 DAT (P_1), which was followed by pinching at 30 DAT (P_2) (36.12 cm). The

Table 4: Effect of spacing and pinching on flower yield per plant (g), flower yield per plot (kg) and flower yield per hectare (t) in

Spacing	Flower yield per plant (g)					Flower yield per plot (kg)					Flower yield per hectare (t)				
	Pinching														
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
S_1	40.48	60.46	55.69	50.64	51.81	3.64	5.44	5.01	4.55	4.66	11.23	16.79	15.46	14.04	14.38
S_2	44.77	72.14	64.72	59.74	60.34	2.19	3.53	3.17	2.92	2.95	6.75	10.89	9.78	9.01	9.10
S_3	49.50	87.79	78.51	66.46	70.56	1.73	3.07	2.74	2.32	2.46	5.33	9.47	8.45	7.16	7.60
Mean	44.91	73.46	66.30	58.94		2.52	4.01	3.64	3.26		7.77	12.38	11.23	11.07	
	SEm±			CD at 5%		SEm±			CD at 5%		SEm±			CD at 5%	
Spacing (S)	0.15			0.44		0.01			0.04		0.30			0.89	
Pinching (P)	0.17			0.51		0.01			0.04		0.35			1.02	
S x P	0.30			0.89		0.02			0.08		0.60			1.78	

S_1: 30 x 15 cm S_2: 30 x 30 cm S_3: 45 x 30 cm

P_0: no pinching P_1: Pinching at 20 DAT P_2: Pinching at 30 DAT P_3: Pinching at 40 DAT

Table 5: Effect of spacing and pinching on seed yield per plant (g), seed yield per plot (g) and seed yield per hectare (kg) in China aster

Spacing	Seed yield per plant (g)					Seed yield per plot (g)					Seed yield per hectare (kg)				
	Pinching														
	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean	P_0	P_1	P_2	P_3	Mean
S_1	4.58	9.08	8.50	6.69	7.21	412.20	817.20	765.00	602.10	649.12	1272.21	2522.21	2361.10	1858.32	2003.46
S_2	6.25	13.88	11.45	9.75	9.83	306.25	680.12	561.05	477.75	481.79	945.21	2099.12	1731.63	1474.53	1562.62
S_3	7.16	17.25	14.50	10.84	12.40	250.60	603.75	507.50	379.40	435.31	773.45	1863.42	1566.35	1170.98	1343.55
Mean	5.99	13.07	11.15	9.09		323.01	684.02	594.85	486.41		996.95	2161.58	1886.36	1501.27	
	SEm±			CD at 5%		SEm±			CD at 5%		SEm±			CD at 5%	
Spacing (S)	0.08			0.25		8.48			24.88		32.09			94.14	
Pinching (P)	0.10			0.29		9.79			28.73		37.05			108.70	
S x P	0.17			0.51		16.96			49.77		64.18			188.28	

S_1: 30 x 15 cm S_2: 30 x 30 cm S_3: 45 x 30 cm

P_0: no pinching P_1: Pinching at 20 DAT P_2: Pinching at 30 DAT P_3: Pinching at 40 DAT

minimum cut flower stalk length (30.53 cm) was recorded in unpinched plants (P_0). The combination of S_1P_1 recorded maximum stalk length (40.13 cm) and was on par with combination of S_1P_2 (39.53 cm). Minimum flower stalk length was recorded with the combination of S_3P_0 (27.68 cm). In present study the maximum cut flower stalk length recorded at S_1 (30 cm x 15 cm) might be due to heavy competition between plants for light resulting in elongation of main stem and primary branches and also might be due to the fact that the plants tend to grow vertically when they are crowded owing to shadowing effect of the plants on one another. The pinched plants showed significantly longer length of flower stalk than unpinched plants. Plants at early pinching stage (pinched at 20 DAT) could make lower branches productive and encourage the vertical growth of primary and secondary branches compared to non-pinched plants. Similar results were obtained by Rajesh Kumar *et al.* (2012) in China aster.

It was observed from Table 2 that the flower diameter recorded maximum (6.20 cm) in wider spacing (45 cm x 30 cm) which was statistically on par with the spacing S_1 (30 cm x 30 cm). In general, as the spacing decreased the diameter of the flower was also reduced. This might be attributed to favorable conditions like availability of light, water and nutrients to individual plants at wider spacing. Significantly maximum flower diameter (6.33 cm) was recorded in non pinched plants (P_0) and was on par with pinching at 20 DAT (P_1) (6.12 cm). Minimum flower diameter (5.84 cm) was recorded with pinching at 40 DAT (P_3). The combination of S_3P_0 recorded maximum flower diameter (6.38 cm). Minimum flower diameter was recorded with the combination of S_1P_3 (5.68 cm). This might be due to the fact that in pinched plants, more energy was utilized for the development of side branches whereas, in non pinched plants energy was utilized for the development of flowers.

The data recorded on number of flowers per plant and per plot (Table 3) indicated that significantly higher number of flowers per plant (65.88) was recorded with S_3 spacing (45 cm × 30 cm) which was followed by S_2 (30 cm x 30 cm) recording 56.57 number of flowers per plant. The minimum number of flowers per plant (40.93) was recorded in S_1 spacing (30 cm x 15 cm). Pinching at 20 DAT recorded significantly more number of flowers per plant (70.47) and was followed by pinching at 30 DAT (61.58). The less number of flowers per plant (30.23) was recorded in unpinched plants (P_0). Significantly more number of flowers per plant (85.36) was produced in S_3P_1 treatment combination which was followed by S_3P_2 treatment combination (77.30). Minimum number of flowers per plant (24.40) was recorded in S_1P_0 combination. Significantly higher numbers of flowers per plant were noticed in wider spacing than closer spacing's. The more number of flowers per plant at wider spacing may be attributed to the improvement in growth parameters and also less competition among the plants for nutrients and light. This might have contributed for more number of flowers per plant. More number of flowers per plant at wider spacing was also reported by Karuppaiah and Krishna (2005) in French marigold. Significantly higher number of flowers per plot (3684.37) was recorded in S_1 spacing (30 cm x 15 cm) which was followed by S_2 i.e., 30 cm x 30 cm spacing (2772.29). The minimum number of flowers (2305.80) was recorded in S_3 spacing (45 cm x 30 cm). Pinching at 20 DAT (P_1) resulted in the maximum number of flowers per plot (3760.86) and was significantly

Table 6 : Effect of spacing and pinching on thousand seed weight (g) in China aster cv. Kamini

Spacing	Thousand seed weight (g)				
	Pinching				
	P_0	P_1	P_2	P_3	Mean
S_1	1.49	1.68	1.62	1.58	1.59
S_2	1.70	1.80	1.76	1.72	1.74
S_3	1.71	1.86	1.78	1.74	1.77
Mean	1.63	1.78	1.72	1.68	
	SEm±			CD at 5%	
Spacing (S)	0.01			0.03	
Pinching (P)	0.02			0.06	
S x P	0.03			0.09	

S_1: 30 x 15 cm S_2: 30 x 30 cm S_3: 45 x 30 cm

P_0: no pinching P_1: Pinching at 20 DAT P_2: Pinching at 30 DAT P_3: Pinching at 40 DAT

superior to other pinching treatments followed by P_2 (pinching at 30 DAT) which recorded 3272.42 number of flowers per plot. Non-pinched plants (P_0) produced lowest number of flowers per plot (1,649.86). Significantly more number of flowers (4649.40) was produced in S_1P_1 treatment combination which was followed by S_1P_2 treatment combination (4052.70). The minimum number of flowers per plot (1236.55) was recorded in S_3P_0 treatment combination. Generally, widely spaced plants spread more towards horizontal plane. They had more auxiliary buds differentiated into branches each of which terminated with a group of flowers, thus leading to more number of branches and flowers per plant. However, because of decrease in plant population at wider spacing levels, yield of flowers per plot from widely spaced plants had not been able to compensate the loss in yield when compared to those spaced at closer spacing levels. These results are conformity with results of Kumar *et al.* (2012) in China aster.

The results of data on flower yield per plant, per plot and per hectare as influenced by spacing, pinching and their interaction effect (Table 4) revealed that spacing S_3 (45 cm x 30 cm) recorded significantly the highest flower yield of 70.56 g per plant followed by S_2 (30 cm x 30 cm) (60.34 g). The lowest flower yield per plant (51.81 g) was observed in closer spacing of 30 cm x 15 cm (S_1). Significantly more flower yield per plant (73.46 g) was recorded with pinching at 20 DAT (P_1) and it was followed by pinching at 30 DAT (66.30 g). The lowest flower yield per plant (44.91 g) was recorded in unpinched plants (P_0). The interaction of the various combinations gave significant results and the combination of S_3P_1 recorded maximum flower yield per plant (87.79 g). The interaction of S_1P_0 recorded lowest flower yield per plant (40.48 g). Given a set of soil and climatic conditions together with a defined nutrition and irrigation schedule plant productivity still varies significantly with its geometry over the growing media *i.e.* soil. Widely spaced plants are provided with a better explorable area in terms of rhizosphere as well as micro-climate thus, showing a better productivity per plant but not per unit area. Similarly, closely spaced ones are prone to stress on account of competition, thus showing lesser yield per plant, but relatively more yield per unit area.

The spacing of S_1 (30 cm x 15 cm) recorded significantly the highest flower yield of 4.66 kg per plot over S_2 (30 cm x 30 cm) (2.95 kg) and S_3 (45 cm x 30 cm) (2.46 kg). The lowest flower yield per plot (2.46 kg) was observed in wider spacing of 45 cm x 30 cm (S_3). Pinching at 20 DAT was the most productive with 4.01 kg flowers per plot followed by pinching at 30 DAT (3.64 kg) while minimum flower yield (2.52 kg) was recorded by non-pinched plants (P_0). The interaction of S_1P_1 plants gave the maximum yield (5.44 kg) of flowers per plot followed by S_1P_2 (5.01 kg) combination. The S_3P_0 treatment combination recorded minimum flower yield per plot (1.73 kg). Spacing showed significant difference in respect of flower yield per hectare. The spacing S_1 (30 cm x 15 cm) contributed significantly higher flower yield per hectare (14.38 t) which was followed by S_2 spacing (30 cm x 30 cm) with 9.10 t. The least flower yield per hectare (7.60 t) was recorded in S_3 spacing (45 cm x 30 cm). Pinching at 20 DAT was the most productive with 12.38 t flower yield followed by pinching at 30 DAT (11.23 t) whereas, a minimum floweyield of 7.77 t was recorded by non – pinched plants. Interaction also exhibited significant effects on flower yield per hectare. The maximum flower yield per hectare (16.79 t) was recorded in treatment combination of S_1P_1 followed by S_1P_2 treatment combination (15.46 t). The minimum flower yield (5.33 t) was recorded in S_3P_0 treatment combination. With wider spacing levels, yield parameters were found to decrease significantly. It must be due to the

fact that closer spacing having more number of plants per unit area gave more number of flowers per unit area, which in turn resulted in higher weight of flowers per unit area. Ravindran *et al.* (1986) had observed that number of flowers and their corresponding weight per plant and per unit were significantly affected due to different plant spacing's in African marigold and obviously closer spacing's had resulted more number of flowers per plot, per unit area and weight per unit area. These results were confirmed with the findings of Jankiram and Rao (2002) in China aster.

The results of data on seed yield per plant, per plot and per hectare are presented in Table 5. The spacing S_3 (45 cm x 30 cm) recorded significantly the highest seed yield of 12.40 g per plant over S_2 (30 cm x 30 cm) (9.83 g) and S_1 (7.21 g). The lowest seed yield per plant (7.21g) was observed in closer spacing of 30 cm x 15 cm (S_1). Maximum seed yield per plant (13.07 g) was recorded by pinching at 20 DAT. Pinching at 30 and 40 DAT were given 11.15 g and 9.09 g seed yield per plant respectively. The interaction of the various combinations gave a significant results and the combination of 45 cm x 30 cm spacing and pinched at 20 DAT was superior to the other combination levels for the seed yield per plant (S_3P_1) (17.25 g) followed by S_3P_2 combination (14.50 g). Interaction S_1P_0 recorded minimum seed yield (4.58 g) per plant. The highest seed yield per plant was recorded at wider spacing (45 cm x 30 cm) and with pinching at 20 DAT, which was indicating the dependence of seed yield on flower yield. The higher seed yield per plant at wider spacing may be attributed to the higher vegetative growth, flower size and weight of flowers produced per plant at wider spacing. The superiority of early pinching treatments can be attributed to the efficient photosynthetic area, better assimilation into reproductive parts and putting up optimum vegetative growth without interrupting floral bud initiation. Similar results were obtained by Bhat and Shepherd (2007) and Sunitha *et al.* (2007) in marigold.

The spacing had significant effect on seed yield per plot. The spacing of S_1 (30 cm x 15 cm) recorded significantly the highest seed yield of 649.12 g per plot over S_2 (30 cm x 30 cm) (481.79 g) and S_3 (45 cm x 30 cm) (435.31 g). The lowest seed yield per plot (435.31 g) was observed in wider spacing of 45 cm x 30 cm (S_3). Pinching at 20 DAT was the most productive with 684.02 g seed yield per plot followed by pinching at 30 DAT (594.85 g) while minimum seed yield per plot (323.01 g) was recorded in unpinched plants. The interaction of the various combinations gave significant results and the combination of S_1P_1 recorded maximum seed yield (817.20 g) per plot followed by S_1P_2 combination (765.20 g). Minimum seed yield per plot was recorded with combination of S_3P_0 (250.60). The spacing of S_1 (30 cm x 15 cm) recorded significantly the highest seed yield of 2003.46 kg per hectare. The lowest seed yield per hectare (1343.55 kg) was observed in wider spacing of 45 cm x 30 cm (S_3). Pinching at 20 DAT was the most productive with 2161.58 kg seed yield per hectare followed by pinching at 30 DAT (1886.36 kg) while minimum seed yield per hectare (996.95 kg) was recorded in unpinched plants. Among the interactions, the combination of S_1P_1 recorded maximum seed yield (2522.21 kg) per hectare and was on par with S_1P_2 (2361.10 kg). The minimum seed yield per hectare was recorded with combination of S_3P_0 (773.45 kg). It must be due to the fact that closer spacing having more number of plants per unit area gave more number of flowers per unit area which in turn resulted in higher weight of seeds per unit area. Similarly, Singh and Sangama (2001) reported increased yield of seeds in China aster due to increase in planting densities. In any crop, seed yield is a function of plant growth, number of flowers per plant, number of seeds per flower *etc*. Arresting of vertical growth of plants by pinching apical bud always results in production of more number of productive branches. The pinching is known to accumulate more photo synthates which are utilized for production of more number of flower bearing branches and more number of seeds per flower. Similar beneficial influence of pinching on seed yield and yield parameters were reported by Singh and Baboo (2003) in chrysanthemum.

The results of data on thousand seed weight (Table 6) revealed that the maximum numerical value was recorded by the treatment S_3 (45 cm x 30 cm) (1.77 g) followed by S_2 (30 cm X 30 cm) level of spacing (1.74 g). The differences recorded in thousand seed weight among the different levels of pinching were significant. Maximum thousand seed weight (1.78 g) was recorded by pinching at 20 DAT which was on par with 30 DAT pinching (1.72 g). Unpinched plants recorded the lowest value of thousand seed weight (1.63 g). Interaction of the various combinations of spacing and pinching gave significant results and the combination of 45 cm x 30 cm spacing (S_3) and pinching at 20 DAT (P_1) was superior to the other combination levels for the thousand seed weight (1.86 g).

On the basis of present research findings it was concluded that for obtaining higher flower and seed yield per hectare in China aster cv. Kamini planting at a closer spcacing of 30 cm x 15 cm and pinching at 20 DAT could be recommended.

REFERENCES

Arora, J.S.1990. Effect of spacing and pinching on growth and flower production of marigold (*Tagetes erecta*) cv. African Giant Double Orange. *National Seminar on Production Technology in Commercial Flower Crops*. 85-87.

Bhat, Z.A. and Shepherd, H. 2007. Effect of pinching on growth, flowering, seed yield and quality traits in African marigold (*Tagetes erecta* Linn.). *J. Orn. Hort.*, **10** (3): 197-198.

Jankiram, J. and Rao, T. M. 2002. China aster. Indian Institute Horticultural Research, Bangalore.

Karuppaiah, P. and Krishna, G. 2005. Response of spacings and nitrogen levels on growth flowering and yield characters of French marigold (*Tagetes patula* Linn.). *J. Orn. Hort.,* **8** (2): 96 – 99.

Panse, V. G. and Sukhatme, P. V. 1978. Statistical Methods for Agricultural Workers, ICAR, New Delhi.

Kumar, R, K., Sharad, B and Rajendra Singh, T. 2012. Effect of planting distance and pinching on growth, flowering and yield of China aster cv. Poornima. *Indian J. Agri. Sci.,* **82** (4): 334-339.

Kour, R., Khajura, S., Sharma, M. and Sharma, A. 2012. Effect of spacing and pinching on flower production in marigold cv. Pusa narangi gainda. *Asian J. Hort.,* **7** (2): 307-309.

Ravindran, D.L.V., Rao, R. and Reddy, N. 1986. Effect of spacing and nitrogen levels on growth, flowering and yield of African marigold. *South Indian Hort.,* **34**(5): 320-323.

Singh, M.K. and Baboo, R. 2003. Response of N, K and pinching levels on growth and flowering in chrysanthemum. *J. Orn. Hort.,* **6**(4): 390-393.

Singh, K.P. and Sangama. 2001. Response of China aster to spacing. *J. Orn. Hort.,* **4**(1): 61-62.

Sunitha, H.M., Hunje, R., Vyakaranahal, B.S. and Bablad, H.B. 2007. Effect of plant spacing and integrated nutrient management on yield and quality of seed and vegetative growth parameters in African marigold (*Tagetes erecta* Linn.). *J. Orn. Hort.,* **10**(4): 245-249.

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Performance of chrysanthemum varieties in Saurashtra region of Gujarat

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ABSTARCT

An experiment was conducted to evaluate 15 chrysanthemum varieties under Saurashtra region of Gujarat in relation to growth, yield, yield attributes and vase life. Out of all the 15 varieties, Shyamal registered maximum flower yield per plant and per hector (247.63g and 107.16 q/ha, respectively) and was also at par with IIHR-6. Plant height was found highest in Puja, whereas, plant spread (E-W) was recorded highest in Baggi and plant spread (N-S) was noted highest in Yellow Button. The variety Sharad Mala was earliest for flowering as well as longest flowering span. On the other hand, Shanti recorded biggest flower diameter. However, the smallest flower diameter, lowest weight of 10 flowers and highest number of flowers per plant were noted in Yellow Button. Significantly the flower weight was observed in IIHR-6 followed by Shyamal which was exhibited significantly the longest vase life (11.27 days). Highest monitory return was noted in IIHR-6 followed by Shyamal.

KEY WORDS: Evaluation, vase life, yield, diameter, flower span

Chrysanthemum (*C. morifolium* Ramat) commonly known as 'sevanti' is an important flower crop for cut flower industry. It has earned tremendous popularity as an ornamental flower. Two kinds of florets are present in a bloom. The small florets which are present at the centre of the bloom are called disc florets. The outer broad florets are called ray florets. In some cases the disc is visible and well-developed, whereas in others it is covered with florets. Ray florets may have different directions of growth and be arranged on the receptacle in distinctive patterns. Some of the florets may curve upwards and inwards. The chrysanthemum bloom type depends mainly upon the relative number of two kinds of florets, their shapes and directions of growth. They are mainly classified as large-flowered and small-flowered. Its flowers are used as cut flowers or as loose flowers for decoration purpose. Due to tremendous increase in use of flowers, farmers are getting good return from cultivating this crop commercially. There are large numbers of varieties available with huge variation in flower size, shape and colour. At present-day, colorful varieties have arisen through indiscriminate intervarietal hybridization, spontaneous and induced mutations and selection. Selection of varieties for commercial cultivation is depends on soils, prevailing climate, cultural practices, etc. Thus, it is true time to identify the good performing varieties for commercial cultivation in Saurashtra region of Gujarat state. Looking to this, the present investigation was planned with following objective and executed for three years.

MATERIALS AND METHODS

The present investigation was carried out during 2005-06 to 2007-08 at the Instructional Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) with 15 varieties. The trial was laid out in randomized block design (RBD) with 3 replications. The different varieties were planted during August. Necessary operations were followed as per the recommended agro techniques. The observations like plant height, plant spreads, number of branches per plant, days to first flower, flower span (days), flower diameter (mm), number of flower per plant, weight of 10 flower (g), flower yield per plant (kg) and per hectare (q/ha) as well as vase life of cut flower were recorded. The data were analyzed statistically.

RESULTS AND DISCUSSION

Variety Puja registered tallest height (60.28cm) at final growth stage and was at par with Alfred Wilson while Red anemone recorded shortest height followed by Chandani. The maximum plant spreads E-W & N-S (44.92 & 44.61 cm) were noted highest in variety Baggi and Yellow Button, respectively (Table 1). The variation in plant height and plant spreads might be due to its determinate and indeterminate growth habit. Similar results were also reported by Joshi *et al.* (2009) in chrysanthemum, Munikrishnappa *et al.* (2013) in China aster and Femina *et al.* (2007) in anthurium. Significantly maximum primary

Table 1: Comparative performance for plant height and plant spread E - W & N - S of chrysanthemum varieties.

Treatments	Plant height (cm)				Plant spread E-W (cm)				Plant spread N - S (cm)			
	2005-06	2006-07	2007-08	POOLED	2005-06	2006-07	2007-08	POOLED	2005-06	2006-07	2007-08	POOLED
V_1- Yellow Button	31.49	44.30	42.32	39.37	37.56	40.13	38.35	38.68	34.92	59.38	39.54	44.61
V_2- Red Anemone	20.45	22.54	23.13	22.04	38.08	41.26	40.27	39.87	32.88	40.34	41.54	38.25
V_3- Chandani	27.29	26.32	25.30	26.30	11.41	14.32	15.76	13.83	19.22	13.77	14.84	15.94
V_4- Sharad Mala	41.31	38.13	36.45	38.63	35.05	30.35	39.33	34.91	34.92	35.78	39.10	36.60
V_5- Bijali	28.98	30.82	28.32	29.37	37.93	38.39	40.10	38.81	35.39	36.42	37.23	36.35
V_6- Flirt	34.63	35.23	32.67	34.18	28.00	26.98	26.87	27.28	28.22	27.14	26.54	27.30
V_7- IIHR-6	51.76	52.36	55.60	53.24	28.83	30.33	38.05	32.40	26.36	29.38	30.32	28.69
V_8- Shyamal	39.84	42.26	45.15	42.42	24.10	25.26	25.36	24.91	22.89	23.48	24.10	23.49
V_9- Puja	57.89	60.72	62.22	60.28	29.16	30.08	31.26	30.17	27.39	29.76	30.76	29.30
V_{10}- Alfred Wilson	55.33	58.26	62.28	58.62	43.82	44.42	43.54	43.93	41.75	42.72	42.68	42.38
V_{11}- Lal Pari	39.58	40.31	42.46	40.78	32.88	30.78	30.14	31.27	31.24	31.26	30.54	31.01
V_{12}- Baggi	33.08	35.82	36.40	35.10	43.78	46.26	44.72	44.92	42.83	45.76	44.68	44.42
V_{13}- Shanti	49.17	50.11	49.64	49.64	31.24	33.24	32.75	32.41	26.55	32.88	32.54	30.66
V_{14}- Sel.-A	39.65	39.32	41.27	40.08	45.00	34.94	32.89	37.61	44.60	35.26	43.56	41.14
V_{15}- Sel.-B	44.65	46.40	43.54	44.86	34.29	33.87	32.88	33.68	28.60	33.76	33.68	32.01
S.Em.(±)	2.593	2.458	2.767	1.357	0.82	1.72	1.40	1.56	0.687	1.657	0.599	2.357
C.D. at 5%	7.87	7.46	8.39	3.93	2.49	5.20	4.24	4.51	2.08	5.03	1.82	6.83
C.V. %	9.24	8.37	9.37	9.00	6.47	7.27	5.79	6.73	7.05	6.80	8.48	7.61

Table 2: Performance for number of primary branches, days to open first flower and flowering span of chrysanthemum varieties.

Treatments	Number of primary branches/plant				Days to open first flower (days)				Flowering span (days)			
	2005-06	2006-07	2007-08	POOLED	2005-06	2006-07	2007-08	POOLED	2005-06	2006-07	2007-08	POOLED
V_1- Yellow Button	8.50	7.23	7.10	7.61	51.00	35.60	32.00	39.53	73.00	82.70	79.70	78.47
V_2- Red Anemone	8.39	7.84	7.89	8.04	43.50	50.40	52.70	48.87	73.00	78.50	76.30	75.93
V_3- Chandani	5.83	6.02	6.13	5.99	44.00	45.30	42.80	44.03	80.50	90.30	92.50	87.77
V_4- Sharad Mala	8.63	8.09	8.22	8.31	36.00	38.80	40.20	38.33	104.50	112.60	108.30	108.47
V_5- Bijali	13.83	15.36	14.23	14.47	55.50	57.80	60.50	57.93	92.00	100.40	98.30	96.90
V_6- Flirt	5.16	6.82	7.00	6.33	54.00	55.90	54.70	54.87	82.00	98.70	96.50	92.40
V_7- IIHR-6	6.99	7.42	7.25	7.22	44.50	42.60	43.50	43.53	97.50	95.30	92.40	95.07
V_8- Shyamal	4.16	4.28	4.30	4.25	51.00	52.80	53.60	52.47	93.00	94.40	93.40	93.60
V_9- Puja	4.66	4.86	4.92	4.81	64.00	66.80	68.50	66.43	83.50	81.70	82.70	82.63
V_{10}- Alfred Wilson	9.85	10.12	10.23	10.07	64.00	65.40	62.70	64.03	91.50	85.60	83.90	87.00
V_{11}- Lal Pari	4.49	5.26	5.36	5.04	44.00	46.00	48.20	46.07	80.50	78.40	72.80	77.23
V_{12}- Baggi	4.99	5.83	5.50	5.44	57.50	58.70	49.70	55.30	72.00	69.30	70.70	70.67
V_{13}- Shanti	4.83	5.02	4.93	4.93	43.50	44.80	42.80	43.70	87.50	88.50	84.30	86.77
V_{14}- Sel.-A	4.33	4.86	4.25	4.48	63.50	58.30	54.30	58.70	66.50	70.60	69.70	68.93
V_{15}- Sel.-B	3.00	4.56	4.35	3.97	61.00	60.50	60.20	60.57	69.00	68.40	76.70	71.37
S.Em.(±)	0.553	0.549	0.730	0.276	1.679	1.360	2.552	2.156	2.795	2.323	1.480	2.296
C.D. at 5%	1.68	1.67	2.22	0.80	5.09	4.13	7.67	6.24	8.48	7.05	4.49	6.65
C.V. %	12.02	11.25	15.24	12.96	4.58	3.70	4.53	4.53	4.76	3.80	7.46	7.77

branches (14.47) were registered in Bijali followed by Alfred Wilson, whereas minimum in Selection-B.

A wide of variation was noted among the varieties for days to flower and flower span and Sharad Mala was performed for earliest flowering (38.33 days) as well as longest flowering spans (108.47 days, Table 2). Such variation might be due to inherent genetically characteristics of the variety to produce early flowering with longer span. This finding is in conformity with Joshi *et al.* (2009) in chrysanthemum and Kumar (2013) in gerbera.

With respect to flower diameter, Shanti recorded highest flower diameter (6.66cm), which was significantly higher than that of other varieties. Likewise, smallest flowers were noted in Yellow Button which was also

Table 3: Performance for flower diameter, number of flowers and weight of 10 flowers of chrysanthemum varieties.

Treatments	Flower diameter (cm)				Number of flowers/ plant				Weight of 10 flowers (g)			
	2005-06	2006-07	2007-08	POOLED	2005-06	2006-07	2007-08	POOLED	2005-06	2006-07	2007-08	POOLED
V_1- Yellow Button	1.90	1.76	1.52	1.73	137.62	142.16	138.12	139.30	2.98	3.11	3.07	3.05
V_2- Red Anemone	3.24	3.82	3.93	3.66	111.16	109.32	93.24	104.57	6.11	6.24	6.22	6.19
V_3- Chandani	3.00	3.12	3.10	3.07	37.47	40.27	50.30	42.68	7.25	7.32	7.27	7.28
V_4- Sharad Mala	4.76	4.62	4.54	4.64	62.65	71.08	69.30	67.68	15.05	15.36	14.42	14.94
V_5- Bijali	6.11	6.35	6.36	6.27	40.26	44.09	46.54	43.63	17.71	18.38	17.36	17.82
V_6- Flirt	5.99	6.22	6.48	6.23	72.65	73.88	67.07	71.20	19.48	20.41	19.42	19.77
V_7- IIHR-6	6.37	6.50	6.42	6.43	72.92	76.42	75.36	74.90	27.85	28.84	29.54	28.74
V_8- Shyamal	5.81	5.92	5.80	5.84	77.99	80.82	78.28	79.03	26.80	27.32	26.32	26.81
V_9- Puja	5.50	5.62	5.64	5.59	90.46	96.24	95.24	93.98	13.65	14.70	15.13	14.49
V_{10}- Alfred Wilson	3.28	3.38	3.36	3.34	71.65	70.68	71.00	71.11	11.93	12.12	11.86	11.97
V_{11}- Lal Pari	4.06	3.94	4.00	4.00	94.10	98.12	88.12	93.45	10.39	9.84	9.50	9.91
V_{12}- Baggi	3.50	3.32	3.50	3.44	65.19	66.38	65.30	65.62	19.31	20.07	19.22	19.53
V_{13}- Shanti	6.44	6.78	6.76	6.66	37.71	40.14	36.15	38.00	27.75	29.38	24.54	27.22
V_{14}- Sel.-A	3.30	3.76	3.87	3.64	52.10	55.27	50.24	52.54	18.50	20.32	19.20	19.34
V_{15}- Sel.-B	4.90	3.98	3.88	4.25	50.16	52.32	52.37	51.62	16.65	17.84	18.33	17.61
S.Em.(±)	0.399	0.449	0.360	0.531	2.524	1.999	0.609	2.215	1.199	1.259	0.407	0.445
C.D. at 5%	1.21	1.36	1.09	1.20	7.66	6.06	1.86	6.42	3.64	3.82	1.23	1.29
C.V. %	12.41	13.77	11.04	12.46	4.98	3.80	4.18	3.68	10.54	10.63	8.58	8.94

Table 4: Performance for weight of flowers, flower yield and flowers vase life of chrysanthemum varieties.

Treatments	Flower yield/plant(g)				Flower yield(q/ha)				Cut flower vase life (days)			
	2005-06	2006-07	2005-06	POOLED	2005-06	2005-06	2007-08	POOLED	2005-06	2006-07	2007-08	POOLED
V_1-Yellow Button	37.07	48.32	46.36	43.92	18.25	23.79	22.66	21.56	7.00	8.20	7.90	7.70
V_2-Red Anemone	66.64	70.24	68.52	68.47	26.85	37.20	33.52	32.52	8.00	8.60	8.50	8.37
V_3-Chandani	19.83	25.36	26.54	23.91	9.58	12.67	13.63	11.96	7.50	7.40	7.20	7.37
V_4- Sharad Mala	46.48	50.52	51.54	49.51	22.77	24.87	22.94	23.53	8.50	8.80	8.30	8.53
V_5-Bijali	57.53	55.47	56.42	56.47	29.19	27.31	25.54	27.35	9.50	10.20	10.30	10.00
V_6-Flirt	147.05	162.03	159.10	156.06	72.05	79.77	80.25	77.36	8.00	9.20	9.00	8.73
V_7-IIHR-6	238.07	253.14	236.32	243.18	92.75	108.38	112.41	104.51	9.50	10.80	8.90	10.40
V_8-Shyamal	235.15	265.38	242.36	247.63	95.22	130.65	125.62	107.16	11.50	12.20	10.10	11.27
V_9-Puja	125.65	138.56	125.20	129.80	61.57	68.22	65.32	65.04	10.50	9.80	9.20	9.83
V_{10}-Alfred Wilson	98.26	100.32	92.36	96.98	48.13	49.39	51.32	49.61	9.50	9.80	9.30	9.53
V_{11}-Lal Pari	132.73	120.87	118.24	123.95	65.04	59.57	58.26	60.96	8.50	8.20	8.50	8.40
V_{12}-Baggi	80.52	75.38	70.30	75.40	39.45	37.11	40.12	38.89	7.50	7.60	7.30	7.47
V_{13}-Shanti	77.57	71.34	69.54	72.82	38.00	35.12	32.14	35.09	7.00	7.40	7.10	7.17
V_{14}- Sel.-A	47.26	50.32	48.32	48.63	33.15	24.77	23.31	27.08	6.50	6.60	6.50	6.53
V_{15}- Sel.-B	71.16	76.29	53.76	67.07	34.83	37.56	28.76	33.72	7.50	6.90	6.60	7.00
S.Em.(±)	5.252	2.595	2.726	3.829	2.060	3.380	1.526	2.778	0.908	0.513	0.501	0.328
C.D. at 5%	12.80	7.87	8.27	9.09	6.25	8.18	4.63	6.73	2.75	1.56	1.52	0.95
C.V. %	11.81	13.60	14.01	13.28	11.81	13.60	14.01	13.28	15.59	8.52	8.52	11.30

registered for highest number of flowers per plant (139.30) followed by Red Anemone (104.57). On the other hand the variety Shanti recorded the minimum number of flowers per plant. Similarly, the Yellow Button had registered lowest weight of 10 flowers (3.05g) whereas, the highest weight of 10 flowers was observed in IIHR-6 followed by Shyamal and Shanti (Table 3). The variation in flower diameter, flower weight and number of flower per plant are might be due to genetic diversity of the different varieties which reflects in correlations as lower diameter positively

Table 5: Comparison for monitory return from yield of one hector of two outstanding varieties of chrysanthemum.

Sr. No.	Name of variety	Av.market price * Rs./kg	Yield of flowers q/ha	Monetary return Rs/ha	Return Increased over (%)
1	IIHR-6 (T_7)	20	104.51	2,09,020	30%
2	Shyamal (T_8)	15	107.16	1,60,680	-

* Average market price calculated on basis of personal inquires made from local flower sellers in Junagadh.

correlates with higher number of flower with lower flower weight. The findings are conformity with those of Joshi *et al.* (2009) in chrysanthemum and Munikrishnappa *et al.* (2013) in China aster

Shyamal recorded the highest flower yield per plant and per hectare (247.63g & 107.16 q/ha, respectively) followed by IIHR-6. On the other hand the lowest flower yield was noted in Chandani (Table 4). The highest yield in these varieties might be due to cumulative effect of higher flower weight. The results were conformity with Joshi *et al.* (2009) in chrysanthemum, Kumar (2013) in gerbera and Susila (2013) in tuberose also obtained similar observation.

The similar trend of flower yield was noted and Shyamal exhibited the longest vase life (11.27 days) which was at par with IIHR-6 (10.40 days).

In case of economics, the variety IIHR-6 performed for highest market price (Rs.20/kg) and higher monetary return due to its white color which is more preferable as compared to Shyamal.

REFERENCES

Femina, Valsalakumari, P.K., Rajeevan, P.K. and Geetha, C.K. 2007. Performance of Anthurium (*Anthurium andreanum* Lind.) cultivars with respect to planting time in humid tropical plains. *J. of Ornam. Hort.*, **10**(1): 49-51.

Joshi, M., Verma, L.R. and Masu, M.M. 2009. Performance of different varieties of chrysanthemum in respect of growth, flowering and flower yield under north Gujarat condition. *Asian J. Hort.,* **4**(2): 292-294.

Kumar, R. 2013. Evaluation of gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.) genotypes for flower quality traits under naturally ventilated polyhouse. *Asian J. Hort.,* **8**(2): 680-682.

Munikrishnappa, P.M., Patil, A.A., Patil, V.S., Patil, B.N., Channappagoudar, B.B. and Alloli, T.B. 2013. Studies on the growth and yield parameters of different genotype of China aster (*Callistephus chinensis* Nees.). *Karnataka J. Agric. Sci.*, **26**(1): 107-110.

Susila, T. 2013. Performance of tuberose cultivars under north coastal Andhra Pradesh, India. *Agricultural Science Digest - A Research Journal.*, **33**(2): 161-162.

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Response of inorganic, organic and bio-fertilizers on the production and quality of onion

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ABSTRACT

Onions which are known for diffusing flavour in our diet grown in India for both domestic market as well as international market. Conventional methods of fertilization have undoubtedly helped in improving both bulb yield and quality. But lately, routine management practices in India appear to be incapable of maintaining yields over the long-term. A gradual shift from using purely organic sources to introducing some proportion of inorganic fertilization is gaining acceptance. Therefore, integrated nutrients management has become necessary for increasing productivity of onion by sustaining the soil productivity at low cost of input. In view of the following facts, an experiment was conducted to assess the effect of integrated nutrient management, as compared to solely application of inorganic fertiliser, on onion production and quality in 2013-14. It was revealed from the data that application of 50% recommended dose of NPK along with 50% recommended dose of the vermicompost results in maximum vegetative growth (Plant height, Number of leaves, Neck thickness) and bulb growth (Bulb weight, Bulb length, Bulb diameter and bulb size) which is at par with (50% recommended NPK + 50 % FYM), recommended dose of NPK. Similarly, maximum yield per hectare were found in (50% recommended NPK + 50% vermicompost) while minimum yield was observed in control. Maximum quality bulbs (TSS, vitamin C, Reducing Sugars, Non reducing Sugars and Total Sugars) were also found in 100% vermicompost followed by 100% FYM. Therefore, it is concluded that judicial application of organic fertilizer (vermicompost) along with chemical fertilizer will produce higher yield while quality bulbs produced from purely organic fertilisers.

KEY WORDS: Inorganic, Organic, Bio-fertilizers, Vermicompost, Pressmud, FYM

Onion belong to family *Alliacea*, having Chromosome number 2n=16, is one of the most important bulb crop grown in India and its cultivation area continuously increasing in northern part of the India. Total productivity of onion in India is about 13.20 t/ha which is very low as compared to world average productivity, 19.10 t/ha in 2012-13 (Bharti and Ram, 2014). For a long time, it has been a major part of total horticultural crops exported to Gulf countries and earns foreign exchange. But, still its production is less in respect to our domestic demand and potential productivity of soil. Conventional methods of fertilization (inorganic fertiliser) have undoubtedly helped in improving bulb yield. But it degrades the quality and shelf life and in India appears to be incapable of maintaining yields over the long-term. Shifting from using purely inorganic sources to introducing some proportion of organic fertilization is gaining acceptancetoday.The area under onion cultivation is continuously increasing to match the internal as well as external demand. So, it is obvious that increasing demand requires more production and in turn it requires more inorganic fertilizer application. Excess use of chemical fertilizers resulted in harmful and long term impact on the soil health and sustainability in yield of crops. Therefore, integrated nutrients management has become essential for increasing productivity of onion by sustaining the soil productivity. So, for the last few years organic cultivation is gaining importance because it replaces the inorganic fertilisers to reduce the high cost of cultivation and to maintainand sustain the fertility, productivity and biotic life of soil. Keeping in view the above facts, an experiment was conducted to assess the effect of inorganic, organic and bio-fertilizers as compared to purely application of inorganic fertilizer on onion growth, yield and quality.

Table 1: Effect of inorganic, organic and bio-fertilizers on growth and yield of onion

Parameters / Treatments	Plant height (cm)	No. of Leaves	Neck thickness (cm)	Bulb weight (g)	Bulb length (cm)	Bulb diameter (cm)	Bulb size (cm^2)	Yield per plot (kg)	Yield per hectare (tonnes)
Control	42.47	8.53	2.17	64.90	4.59	5.51	26.15	4.59	31.11
RDF	54.73	10.13	2.41	107.66	6.20	6.95	42.75	5.86	39.92
FYM	51.68	9.70	2.27	76.55	5.49	6.25	34.12	5.17	34.82
PoM	50.11	9.43	2.21	72.58	5.21	6.13	32.15	4.97	33.88
VC	52.29	9.93	2.31	83.78	6.04	6.82	41.06	5.27	35.06
PM	50.43	9.56	2.27	80.78	5.05	6.11	30.17	5.11	34.42
50 % RDF +50% FYM	55.92	10.76	2.48	110.77	6.57	7.22	46.85	5.82	38.89
50 % RDF +50% PoM	52.43	10.08	2.38	95.23	6.12	6.96	42.59	5.65	37.96
50 % RDF +50% VC	57.98	11.23	2.53	116.78	6.78	7.30	49.58	5.89	39.61
50 % RDF +50% PM	53.41	10.50	2.44	106.96	6.31	7.01	43.46	5.75	38.51
50 % RDF +Azo	51.97	9.46	2.26	84.93	5.41	6.22	33.35	5.47	36.87
50 % RDF +Azr	51.08	9.23	2.28	81.55	5.33	6.07	32.91	5.41	36.15
50 % RDF +PSB	50.07	9.13	2.23	79.38	5.15	5.97	30.93	5.32	35.52
75 % RDF +Azo	53.83	9.96	2.39	96.84	5.92	6.99	41.15	5.72	38.06
75 % RDF +Azr	52.69	9.66	2.36	92.37	5.67	6.71	37.60	5.57	37.80
75 % RDF +PSB	52.07	9.40	2.29	90.66	5.81	6.52	39.35	5.51	37.48
C.D (P=0.05)	2.38	0.45	0.10	5.36	0.26	0.26	2.19	0.12	0.90
SE (d)	1.16	0.21	0.05	2.61	0.12	0.12	1.06	0.06	0.43

FYM= Farm Yard Manure, PoM= Poultry manure, VC= Vermicompost, PM= Pressmud, Azo= Azotobactor, Azr= Azospirillum, PSB=Phosphate Solubilising Bacteria

MATERIALS AND METHODS

A field experiment was conducted to study the effect of chemical fertilizers, organic fertilizers and bio-fertiliser on yield and quality of onion cv. NHRDF Red 2 at the Horticulture Research Farm of Babasaheb Bhimrao Ambedkar University, Lucknow, India, during 2013-14. The experiment was laid out in RBD design with three replications having treatments consists of four levels of NPK (control, 100% of recommended dose of NPK, 75% of recommended NPK and 50% of recommended NPK), four organic fertilizers; Farm Yard Manure (FYM 25t/ha), Poultry Manure (PoM7.5t/ha), Vermicompost (VC 7.5t/ha) and Pressmud (PM 15t/ha) each at two levels (100% FYM, 50% FYM, 100% PoM, 50% PoM, 100% VC, 50% VC, 100% PM and 50% PM) and three bio-fertilizers; Azotobactor (Azo), Azospirillum (Azr) and Phosphate Solubilising Bacteria (PSB). There are fifteen treatment combinations and control (T_0- Control, T_1- 100% RDF, T_2- 100% FYM, T_3- 100% PoM, T_4- 100% VC, T_5-100% PM, T_6- 50 % RDF +50% FYM, T_7- 50 % RDF +50% PoM, T_8- 50 % RDF +50% VC, T_9- 50 % RDF +50% PM, T_{10}- 50 % RDF +Azo, T_{11}- 50 % RDF +Azr, T_{12}- 50 % RDF +PSB, T_{13}- 75 % RDF +Azo, T_{14}- 75 % RDF +Azr and T_{15}- 75 % RDF +PSB) Seedlings of same age (8 weeks old) were transplanted after seedling dip treatment with bio-fertilizers at the spacing of 15x10 cm. Recommended dose of fertilizer NPK (150:60:60) in the form of Urea, Single Super Phosphate and Muriate of Potash were applied to grow the crop. Data were recorded after harvesting on Plant height (cm), Number of leaves, Neck thickness (cm), Bulb weight (g), Bulb length (cm), Bulb diameter (cm), Bulb size (cm^2), Yield per plot (kg), Yield per hectare (t/ha), Total Soluble Solids (^{0}Brix), Ascorbic Acid (mg/100g), Pyruvic acid (µm/g), Total Sugars (%), Reducing Sugar (%) and Non- reducing sugar (%). TSS was analyzed by Hand Refractrometer, Indolphenol method was used for the determination of ascorbic acid while pyruvic acid analysis was performedasper standard method.

RESULTS AND DISCUSSION

Data presented in Table 1 showed that different combinations of inorganic, organic and bio-fertilizer have significant and beneficial effect on vegetative yield and biochemical traits of onion. Data indicated that maximum plant height (57.98 cm), number of leaves (11.23), neck thickness (2.53 cm), bulb weight (116.78 g), bulb length (6.78 cm), bulb diameter (7.30 cm), bulb size (49.58 cm^2), yield per plot (5.89 kg) and yield per hectare (39.61 t/ha) were found in T_8- 50% recommended dose of NPK + 50% VC followed by T_6- 50% recommended dose of NPK + 50% FYM havingplant height (55.92 cm), number of leaves (10.76), neck thickness (2.48 cm), bulb weight (110.77 g),

Table 2: Effect of inorganic, organic and bio-fertilizers on biochemical traits of onion.

Treatments	TSS (^{0}Brix)	Ascorbic acid (mg/100 g)	Pyruvic acid (µm/g)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)
Control	14.03	11.84	3.71	3.35	6.08	10.14
RDF	13.92	11.27	4.89	3.11	5.91	10.08
FYM	15.70	13.09	3.57	5.32	7.07	12.34
PoM	15.51	12.68	3.72	5.07	6.83	12.16
VC	15.82	13.12	3.48	5.59	7.24	12.58
PM	15.66	12.82	3.67	5.19	6.86	12.21
50 % RDF +50% FYM	15.41	13.24	3.70	5.22	6.91	12.28
50 % RDF +50% PoM	15.15	12.90	3.79	4.81	6.71	11.87
50 % RDF +50% VC	15.58	13.35	3.68	5.37	7.16	12.48
50 % RDF +50% PM	15.28	13.11	3.77	4.92	6.76	12.04
50 % RDF +Azo	14.92	12.60	4.11	4.42	6.67	11.37
50 % RDF +Azr	14.96	12.66	4.16	4.49	6.63	11.24
50 % RDF +PSB	14.80	12.52	4.27	4.29	6.58	11.13
75 % RDF +Azo	14.51	12.30	4.47	3.94	6.30	10.59
75 % RDF +Azr	14.48	12.31	4.49	3.71	6.24	10.52
75 % RDF +PSB	14.36	12.23	4.53	3.69	6.23	10.37
C.D (P=0.05)	0.14	0.13	0.18	0.20	0.13	0.08
SE (d)	0.07	0.06	0.08	0.09	0.06	0.03

FYM= Farm Yard Manure, PoM= Poultry manure, VC= Vermicompost, PM= Pressmud, Azo= Azotobactor, Azr= Azospirillum, PSB=Phosphate Solubilising Bacteria

bulb length (6.57 cm), bulb diameter (7.22 cm), bulb size (46.85 cm^2), and T_1 recommended dose of NPK for yield per plot (5.86 kg) and yield per hectare (39.92 t). T_6 was at par with T_1- recommended dose of NPK forplant height (54.73 cm), number of leaves (10.13) and bulb weight (107.66 g) were observed and T_9- 50% recommended dose of NPK + 50% PM for neck thickness (2.44 cm), bulb length (6.31 cm), bulb diameter (7.01cm), bulb size (43.46 cm^2). Application of 50% of recommended NPK and 50% of other organic manure was found more effective and productive as compared to full dose of organic fertilizers and full dose of recommended one. Minimum values for these parameters were observed in control. Similarly, data present in Table 2 exhibit a beneficial response to biochemical parameters that were significantly influenced by all the treatments. Maximum value for ascorbic acid (13.35 mg/100g) was found in T_8- 50% recommended dose of NPK + 50% VC which is at par with T_6- 50% recommended dose of NPK + 50% FYM while highest content of reducing sugar (5.59 %), non-reducing sugar (7.24 %), total sugar (12.58 %) and TSS (15.82 ^{0}Brix) were found in T_4- 100% VC which was followed by T_8- 50% recommended dose of NPK + 50% VC for reducing sugar (5.37 %), non-reducing sugar (7.16 %), total sugar (12.48 %) and T_2- 100% FYM for TSS (15.70 ^{0}Brix). Minimum value for pyruvic acid (3.48 µm/g) was found in T_4- 100% VC followed by T_2- 100% FYM.

The result revealed that vermicompost is an efficient source able to produce, in combination with inorganic fertilizers, by itself, plant growth and bulb yield that were equivalent to those under RDF. The highest growth and yield response were achieved with 50% RDF+50% VC. This positive performance of the reduced rate of inorganic fertilization with vermicompost might be due to vermicompost worked as supplements to inorganic fertilizers. Mineralizations of vermicompost build up the soil nutrient status due to which availability of nutrients increases for the crop (Singh *et al.*, 2001). Vermicompost also gives better performance in quality of okra as compared to solely inorganic fertiliser (Kumar *et al*, 2014). Beneficial effect of organic manure along with inorganic fertilizer results in greater and long-time availability of nutrients to the crop under irrigated condition. Highest plant height with the application of vermicompost was also reported by (Reddy and Reddy, 2005). The average bulb weight related to bulb length and bulb diameter which in turn affect yield. These findings are in confirmation with the findings of (Chaddha*et al*., 2006; Chattoo *et al*., 2011) who found significant effect of organic and inorganic fertiliser on bulb length and diameter. But the result obtained by (Bagali, *et al*., 2012) that the interaction effects between inorganics and organics were found non-significant for bulb yield while higher level of organics and inorganics recorded higher bulb yield individually. This result is

different might be due poor soil condition and high pH 7.2 level because at high pH level most of the nutrient becomes unavailable form. The poor performance of bio-fertilizers with inorganic fertilizers combination as comparison to inorganic and organic fertiliser and its combination might be due to 50% of inorganic fertilizers cannot be supplemented only through application of bio-fertiliser. This might be due to lack of organic matter in the soil and high pH because low organic matter and high pH bacterial population grow at very slow rate or sometimes no growth occur.

Data clearly indicated that biochemical attributes are much higher in 100% organically fertilised soil rather than combined application of organic and inorganic fertilizers. 100% application of vermicompost results in higher content of TSS, reducing, non-reducing and total sugars and minimum content of pyruvic acid. This might be due to balanced carbon: nitrogen ratio because excess nitrogen degrades the quality due to more accumulation of nitrate. Highest level of vitamin C by application of 50% RDF with 50% VC might be due to organically produced soils generally produce plants with lower content of nitrogen as compared to chemically fertilised soil as a result crop has more vitamin C less nitrate (Kumar *et al*., 2014). These findings are also in close agreement with the (Sharath Pal *et al*., 2014).

From this study, it can be concluded that, treatment combination50% RDF + 50% Vermicompost were found better as a substitute to 100 per cent inorganic fertilization for highest yield whereas 100 per cent fertilisation with Vermicompost produce good quality bulb but with less yield. Supplying adequate nutrients to produce onion can be done in an organic system. More important thing is that organic fertilizers are economically more viable than chemical one and in turn it reduces the cost of chemical fertilizers. So, if a farmer want to produce to produce good quality bulb along with high yield or somewhat less according to the demand of market without degrading the soil property and health, can be advised to apply half of organic fertiliser along with inorganic fertiliser.

REFERENCES

Bagali, A.N.;Patil, H.B.;Chimmad, V.P.;Patil, P.L. and Patil, R.V. 2012.Effect of inorganics and organics on growth and yield of onion (*Allium cepa*L.).*Karnataka J. Agric. Sci.* **25(1):** 112-115.

Bharti, N and Ram, R.B. 2014.Estimating variation in the production, quality and economics of onion in response to transplanting dates and sulphur fertilisation.*Euo. Acad. Res.* **2(4):** 4831- 4843.

Chadha, S.;Rana, S. S. and Chaudhary, D. R. 2006. Nutrient management in summer onion (*Allium cepa*L.) under cold desert conditions of North Western Himalayas. *Indian Journal of Agricultural Sciences*.**76(10):** 629-631.

Chattoo, M. A.; Ahmed, N.;Wani, M.H.; Mir, S. A.; Khan, S.H. and Jabeen, N. 2011.Effect of organic manures and inorganic fertilizers on growth, yield and quality of Okra [*Abelmochusesculentus*(L.)Moench]. *Vegetable Science*.**32(2):** 135-139.

Kumar, P.;Meghwal, P.R. and Painuli, D.K. 2014.Effect of organic and inorganic nutrient sources on soil health and quality of carrot.*Indian Journal of Horticulture*.**71(2):** 222-226.

Reddy, K.C. and Reddy, K.M. 2005.Differential levels of vermicompost and nitrogen on growth and yield in onion (*Allium cepa*L.)- raddish (*Raphanussativus*L.) cropping system. *J. Res.* ANGRAU.,**33(1):** 11-17.

Sharath Pal, M. V.;Hegde, N. K.;Hanamashetti and Kulkarni, M. S. 2014. Effect of organic manures on the performance of ginger under Northern Dry Zone of Karnataka.*Journal of Spices and Aromatic Crops*.**23 (1):** 121-124.

Singh, R.P.; Jain, N.K. and Poonia, B.L. 2001. *Indian Journal of Agricultural Sciences*.**71(5):** 310-312.

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