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Vol **4**, No. 2 July–December 2016

CONTENTS

Research Review Article

Current Horticulture **4**(2): 3–6, July–December 2016

Essential oils beyond aroma — a review

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ABSTRACT

Essential oils are odorous, volatile and secondary metabolites produced by diverse group of plants. Aromatic plants are referred as 'natural biochemical factories' or 'chemical goldmines'. They are present in different parts of plant like roots, stems, bark, flowers, fruits, seeds and leaves. The regular use of essential oils for different purposes like cosmetics, perfumery, paint industry, paper and printing industry etc. is a known factor. But beyond this, aromatic plants can be utilized for different purposes like aromatherapy, food preservation, preservation of fruits and vegetables, plant protection, weed management and veterinary pest management which are lesser-known to the mankind. Therefore an attempt is made to highlight the significance of essential oils beyond aroma.

KEY WORDS: Essential oils, Chemical gold mines, Aromatherapy, Protection, Volatile, Natural biochemical factories

About 4,000 years ago mesapotamians discovered the first form of perfume as incense. Ayurveda mentions about the rasayanatantra and vajikaranatantra which are the therapies to be young and live longer.Vedas mention about offering of essence to the gods through yagnas, flowers and herbs. Essential oils are the odorous, volatile, secondary metabolites produced by diverse group of plants. Aromatic plants are referred as 'natural biochemical factories' or 'chemical goldmines'. They are present in different parts of plant like roots, stem, bark, flowers, fruits, seeds and leaves. The basic fact is that plants do not produce essential oils either for aroma or essence but for the function of oils is that they act as the immune system of the plant by protecting the plants from bacterial, fungal and viral infections, recovers the breaks in plant tissues and provide self-defense against insects (Peter *et al.* 2006).

The essential oil molecules are primarily made up of carbon, hydrogen and oxygen. They normally form a ring like chemical structure held by the carbon atoms. Oxygen, hydrogen, nitrogen, sulfur and other carbon atoms attach at various points of the chain, to make different oils. Properties of essential oils remain in liquid form at room temperature, volatile in nature, less denser than water, high refractive index, insoluble in water, but soluble in alcohol and organic solvents. In general, essential oils are mainly utilized for their aroma and essence in various sectors cosmetic industry, dental products, food and beverage industry, tobacco industry, paper and printing industries, adhesive pastes and glue tapes, textile industries, toiletries, paint industry and perfumery industry. With all above benefits now-a-days essential oils can also be utilized in different ways. The present compilation deals with uses of essential oils in context to aromatherapy, pharmaceutical uses, food preservation, preservation of fruits and vegetables, plant protection, weed management and animal pest management.

Aromatherapy

It is one of the alternative medicines using essential oils. Aromatherapy is the use of fragrant volatile from plant sources oils and herbs for psychological and physiological well being. Rene Maurice Gattefosse is rightly called as Father of aromatherapy who coined the term aromatherapy. Suppression of carrageenan and collagen II-induced inflammation in mice by using *Geranium* oil was studied (Maruyama *et al.* 2006), *Geranium* oil has suppression effect on both acute and

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chronic inflammation in mice and foot thickness recorded was 0.96 mm and 0.91 mm, respectively, when treated with *geranium* oil against which injected footpad with carrageenan was 1.68 mm and 1.55 mm, respectively for 6 and 24 hours of injection. This shows that *geranium* oil has a positive interaction to overcome carrageenan induced edema in mice.

Balchin and Hart (1999) reported that lavender *(Lavendula officinalis)* oil has a spasmolytic activity on guineapig ileum and rat uterus in vitro and it also decreases the tone in skeletal muscle preparation of phrenic nerve diaphragm of rats. This activity shows that lavender oil can be utilized in aromatherapy. Hence, with all above findings essential oils of different aromatic plants can be utilized for aromatherapy instead of regular use in perfumery industry and there is a need for research and also standardization of concentrations in aromatherapy, implementation of different types of oils in aromatherapy has to be studied, with all this aromatherapy can be utilized as a natural source for curing the diseases.

Table 1. Essential oils used in aromatherapy

Essential oil	Therapeutic properties
Clary sage	Ease tension and muscle cramps
Eucalyptus	Activate nervous system, boosts immunity
Geranium	Controls emotions, anxiety, stress
Lavender	Sedative and narcotic actions
Lemon	Rejuvenates dull skin
Pepper mint	Anti-inflammatory, carminative
Roman chamomile	Ulcer, muscle spasms, wounds
Rosemary	Constipation, tonic to liver and gall bladder
Tea tree	Herpes, burns, dandruff.
Ylangylang	Depression, anxiety, hypertension

Pharmaceutical uses

In recent years, public has shown interest in plant based medicines hence essential oils which are extracted from aromatic plants has a wider scope in pharmaceutical industries as essential oils exhibits clinical properties like anti-cancerous, antioxidant, anti-inflammatory and antimicrobial *etc*. can be utilized to cure certain chronic diseases. Several aromatic plants like *Geranium*, origanum, lavender, mentha are utilized in pharmaceutical industries. Fayed (2009) studied antioxidant and anti-cancerous activities of *Geranium* and *Citrus* essential oils and revealed that essential oils of both the plants decreases the concentration of DPPH (2, 2-diphenyl-1-picrylhydrazyl) free radicals and also showed that the oils of *Geranium* and *Citrus* has an anti-cancer activity, where geranium oil has 79.27% of dead cells causing the leukemia and petitgra in mandarin (citrus) has 68.87% of dead cells.

Antimicrobial activity of essential oils and other plant extracts was studied by Hammer *et al.* (1999). They used several plants, out of which lemongrass, oregano and bay inhibited growth of all the microbes at concentrations of 2.0% (v/v). Burtis and Bucar (2000) reported the antioxidant property of *Nigella sativa*. The compounds like thymoquinone and the components carvacrol, t-anethole and 4-terpineol demonstrated respectable radical scavenging property, when tested in the diphenyl picryl hydracylassay, which showed that *Nigella* has an antioxidant property. Adam *et al.* (1998) revealed the antifungal activity of several aromatic plants, of which *O. vulgare* subsp. *hirtum* oil showed the highest fungicidal or antifungal activity in which organism and at a dilution of 1/50000 caused a 95% reduction in the number of metabolically active cells within 6 hr of exposure, by this it can be concluded that *Origanum* has an antifungal activity against the human pathogenic fungi.

Food preservation

The loss of food due to proper scientific means of storage and also due to attack of diseases during the preservation has created a new way to preserve food, i.e. use of chemical preservatives has a positive action to overcome the loss, but now a days as people are more concern with the organic and also eco-friendly products this method of preservation using the essential oils has a preservative which has dual nature activity like preserving and also which enhances and maintains the natural taste and essence is new to all of us. *Trachysper mumammi* L. essential oil as plant based preservative in food system was studied by Kedia *et al.* (2015) and reported that thymol showed the highest antifungal and anti-aflatoxigenic activity and stated thymol inhibited *Aspergillus flavus* at very low concentration compare with other essential oils.

Preservation of fruits and vegetables

The use of chemical fungicides has created the residual effect on the fruits, post-harvest loss of perishables due to fungi is about 10 - 50% (Tripathi *et al.*, 2008). Hence use of chemical fungicides has an ill effect on the quality, so use of botanicals has a significant importance. Tripathi *et al.* (2008) in his study used some essential oils to control post-harvest management of grey mould in grapes, essential oils like *O. sanctum* and *Prunus persica* enhanced the storage life and also did not had any phytotoxic effect on fruit peel, along with

that, oils are also reported to exhibit broad fungi toxic over the growth of fruit rot causing fungi. Similarly, Wilson *et al.* (1997) studied the rapid evaluation of plant extracts and essential oils for anti-fungal activity against *Botrytis cinerea* and revealed that palmarosa *(Cymbopogon martini)*, red thyme *(Thymus zygis)*, cinnamon leaf *(Cinnamomum zeylanicum)* and clove buds *(Eugenia caryophyllata)* demonstrated the most antifungal activity against *B. cinerea*, and also spore germination was completely inhibited at a 0.78% dilution after 40 hr by palmarosa *(Cymbopogon martini)* and red thyme *(Thymus zygis)*.

Plant Protection

Repeated use of chemical or synthetic pesticides or fungicides has led to resistance in insects and also pathogens against the conventional insecticides and fungicides, above all the ill effects of chemicals is well known to all of us, the residual effect of the sprayed chemicals not only deteriorate the quality but also harmful. Unfortunately, the indiscriminate use of synthetic herbicides has led to toxic effect on environment, hence with above all consequences this review helps all of us to know that there are some essential oils to overcome the ill effects caused by chemical fungicides, pesticides and herbicides which are eco-friendly and can be used in management.

Julienne *et al.* (2013) used essential oils of *Callistemon citrinus* and *Cymbopogan citratus* to control brown spot disease of rice, the oil of *C. citratus* at 450 microgram per ml totally inhibited the growth of *Alternaria padwickii*. The cold water extract of *C. citrinus* was effective against *B. oryzae* and reduced 77% of the radial mycelial growth. George *et al.* (2009) studied variation in chemical composition and acaricidal activity against *Dermanyssus gallinae* of four eucalyptus essential oils and stated that eucalyptus oils may be of use as alternative to synthetic acaricides. More than 65 % mite mortality was reported by using eucalyptus essential oils. Phytotoxicity of volatile oil from *Eucalyptus citriodora* against some weedy species was studied by Setia *et al.* (2007).

The oil was used against several weedy spp., oil concentration at 0.06% was found to be effective and none of the tested weed seeds got germinated and maximum inhibition of germination was found in *Amaranthus viridis*, where seed germination was inhibited at very low concentration (0.03%). Finally, reduction in germination was seen in the range from 21-28%. Baldin *et al.* (2015) studied the bioactivity of *Pelargonium graveolens* essential oil and related mono-terpenoids against sweet potato whitefly (*Bemisia tabaci* biotype B) and concluded that the oil killed 100% of the insects at all the tested concentrations and also reported repellent activities of mono-terpenoids on insects.

CONCLUSION

The use of essential oils in conventional methods like perfumery industry, cosmetic industry and lubricant industry is only for aroma, but the present review shows potential use of essential oils for different purposes like aromatherapy, pharmaceuticals, food preservation, plant protection and weed management. But, still there is a need for extensive research for further refinement with respect to their practical applicability and standardization of the concentration to be used.

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Research Article

Current Horticulture **4**(2): 7–10, July–December 2016

Yield and quality response of cabbage *(Brassica oleracea)* var. Pride of India to nitrogen and biofertilizers

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ABSTRACT

A field experiment was conducted to study the effect of nitrogen and biofertilizers on growth, yield and quality of cabbage (*Brassica oleracea* var. *capitata* L.) var. Pride of India in *rabi* season during 2010-11 at Department of Vegetable Science, College of Horticulture and Forestry, Jhalawar. The experiment consisted of 17 treatment *viz*. four levels of nitrogen (control, 100 kg, 125 kg and 150 kg) and three doses of biofertilizers (*Azotobacter, Azospirillium* and PSB) in combination with nitrogen levels, while the control was laid out in simple randomized block design with three replications. The treatment T_{16} (150 kg N + PSB) recorded maximum plant height (24.64 cm), head diameter (97.49 mm), average weight of head / plant (0.877 kg), volume of head (1.079 cc), yield of heads (432.92 q / ha), TSS (7.53%), ascorbic acid content (34.73 mg / 100 g) and total chlorophyll content (0.786 mg / g). However, it was statistically at par with 150 kg N + *Azospirillium* (T_{12}) and 150 kg N + *Azotobacter* (T_8) inoculation. The application of nitrogen and biofertilizers under the treatment combination 150 kg N + *Azospirillium* exhibited maximum available nitrogen content in soil after harvesting, which was significantly higher over the control. The application of nitrogen and biofertilizers under the treatment combination 150 kg N + PSB had significant effect on yield and yield attributes and quality parameters. The maximum net return of ₹ 3,00,022.2 / ha with benefit : cost ratio (6.48:1) was obtained with the treatment combination of 150 kgN +PSB and the minimum net profit of ₹ 1,29,704.3 / ha (absolute control) and 1,38,662.3 / ha (the control).

Key Words: Nitrogen, Biofertilizers, Cabbage, Plant height, Head diameter, Volume of head

Cabbage (*Brassica oleracea* var. *capitata* L.) is most important member of genus Brassica grown in the world. It is well documented that growth, yield and quality of plants are greatly influenced by a wide range of nutrients which has great significance in plant growth, development and metabolism. Nitrogen is a constituent of several macro and micro molecules including amino acid and is found to be associated with carbohydrates utilization and protein biosynthesis. The deficiency of nitrogen leads to chlorosis, poor vegetative growth, reduced yield and quality of leafy vegetables (Singh, 1989). Biofertilizers include a range of nitrogen fixer's, *viz. Rhizobium, Azotobacter, Azospirill*ium, Blue Green Algae and *Azolla*. Out of these the importance of *Azotobacter* and *Azospirillium* have been well recognized for their beneficial effects on vegetable crops (Kachari and Karla, 2009). In inoculated plants the fixing of atmospheric nitrogen and its effectiveness increases with the addition of nitrogen at the lower level (Subbiah, 1991; Wange *et al.,* 1995).

Azospirillium, an ubiquitous rhizosphere bacterium, represents the main group of microaerophilic free living / associative nitrogen fixing bacteria (Dobereiner and Day, 1976). They are isolated from the rhizosphere of many grasses and cereals all over world and their role on plant growth and yield have been well established (James, 2000). *Azospirillium* are also known as plant growth promoting bacteria (Bashan and Holguin, 1998). The stimulatory effect exerted by *Azospirillium* has been attributed to several mechanisms including secretion of phytohormons, biological

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nitrogen fixation, and enhancement of mineral uptake by plants (James, 2000).

Besides, Phosphate Solubilizing Bacteria (PSB) increases phosphate level in soil (Singh, 2008). Consistent and indiscriminate use of chemical fertilizers has caused serious damage to the soil and ecology. The high yield of vegetable cannot be realized only with use of organic and biological origin products. Therefore, a judicious combination strategy of using chemical fertilizers and biofertilizers may be helpful in increasing vegetable productivity. These days biofertilizers have emerged as an important component to improve an overall crop performance, yield, nutrient supply, reducing the quantity of chemical fertilizers used in agricultural production. Further, use of biofertilizers with nitrogen, can serve as alternative practice in place of sole fertilizers for improving soil structure, microbial biomass, minimizing global warming and producing quality yield.

MATERIALS AND METHODS

The experiment was conducted at Department of Vegetable Science, College of Horticulture and Forestry, Jhalawar. It is situated between 23°45' 20" and 24°52' 17" North latitudes and 75°27' 35" and 76°56'46" East longitudes covering an area of 6322.35 Km^2. Jhalawar district falls under sub-humid South Eastern Plains under agroclimatic zone V. The climate of Jhalawar is typically sub-humid and characterized by extremes of temperature both in summer and winter with high rainfall and moderate relative humidity. The soil of the experimental field was black cotton, pH 6.8, clay, and loam in texture, normal in reaction with medium in respect to nitrogen, phosphorus and potassium availability in the soil.

The experiment consisted of 17 treatment, *viz.* four levels of nitrogen (control, 100 kg, 125 kg and 150 kg/ha) and three biofertilizers (*Azotobacter*, *Azospirillium* and PSB) in combination with nitrogen levels and one is absolute control was laid out in simple RBD with three replications. The treatments were: T_0, absolute control; T_1, control (applied RDF of P and K); T_2, 100 kg N + No Biofertilizer' T_3, 125 kg N + No Biofertilizer: T_4, 150 kg N + No Biofertilizer; T_5, 0 kg N + *Azotobacter*: T_6, 100 kg N + *Azotobacter*; T_7, 125 kg N + *Azotobacter*: T_8, 150 kg N + *Azotobacter*; T_9, 0 kg N + *Azospirillium*; T_{10}, 100 kg N + *Azospirillium*; T_{11}, 125 kg N + *Azospirillium*; T_{12}, 150 kg N + *Azospirillium*; T_{13}, 0 kg N + PSB; T_{14}, 0 kg N + PSB; T_{15}, 0 kg N + PSB, and T_{16}, 0 kg N + PSB. Plots of 2.7 m × 1.8 m size were prepared. The distance between plant to plant as well as row to row was kept at 45 cm × 45 cm. Thus, 24 plants were accommodated in each plot. Five plants were randomly selected from each plot and tagged for recording various observations. The observations were recorded on diameter of head, weight of head/plant, volume of head, yield of head/ha, TSS, ascorbic acid content in head, and chlorophyll content in leaves, and N after harvesting in soil.

RESULTS AND DISCUSSION

The results showed that application of nitrogen and biofertilizers significantly increased the diameter of head, weight of head/plant, volume of head, and yield of head/ha (Table 1). The maximum values of yield and yield attributes, *i.e.* head diameter (97.49 mm), average weight of head (0.877 kg/plant), volume of head (1.079 cc), and yield of head (432.92 q/ha) were recorded with the application of 150 kg N + PSB (T_{16}) over absolute control (213.99 q/ha) and the control (228.80 q/ha). However, it was found statistically at par with T_{12} and T_8. These results are in conformity with the findings of Singh and Singh 2005; Singh 2008; Kachari and Korla, 2009 in cauliflower; Wange *et al.*, 1995 and Chatterjee, 2010 in cabbage.

The increase in yield and yield attributes by the application of nitrogen and biofertilizers might be due to enhanced availability of nitrogen through direct addition and solubility of natural status of nutrient present in soil. Different increasing nitrogen levels favoured the large uptake of nutrients and effective utilization of utilized nutrients for increased metabolism and synthesis of carbohydrates, greater vegetative growth and subsequent partitioning and translocation from leaf (source) to the head (sink) and also release of energy rich organic compounds by biofertilizers which might have been increased auxin activities, growth and activity of microbial saprophytes and phosphates activity which ultimately influenced the yield and yield attributes. These findings were also substantiated by Din *et al.*, 2007; Sood and Vidyasagar, 2007 in cabbage; Kachari and Korla, 2009 in cauliflower and Yadav *et al.* 2012 in cabbage.

The TSS, ascorbic acid content in head and chlorophyll content in leaves also significantly increased with application of nitrogen and biofertilizers. The treatment T_{16} recorded maximum TSS, ascorbic acid content, and chlorophyll content, *i.e.* 7.53 per cent, 34.73 mg/100g and 0.786 mg/g, respectively as compared to absolute control and control (Table 1), which might be due to adequate nutrient availability in the root zone and soil plant system developed with the direct application of 150 kg nitrogen and solubilization of native phosphate status of the soil by PSB. It is well established fact that content of any nutrient in plant is directly related to its availability in feeding zone and growth of plants. Biofertilizers enhance the availability of nitrogen and phosphorus to plants and give rise to better utilization of nutrient by the crop which might

Table 1. Response of nitrogen and biofertilizers on different yield and quality parameters in cabbage var. Pride of India

Treatment	Diameter of head (mm)	Average weight of head (kg/plant)	Volume of head (cc)	Yield of head (q/ha)	TSS (%)	Ascorbic acid (mg/100g)	Chlorophyll (mg/g)	N after harvesting in soil (kg/ha)
T_0	69.18	0.433	0.562	213.99	5.93	22.31	0.510	319.84
*T_1	69.66	0.463	0.567	228.80	6.03	22.58	0.516	319.79
T_2	84.29	0.613	0.617	302.88	6.20	26.21	0.565	326.38
T_3	88.71	0.650	0.660	320.98	6.40	29.96	0.589	332.05
T_4	94.81	0.770	0.690	376.95	6.50	32.06	0.756	337.97
T_5	71.03	0.470	0.578	232.10	6.07	23.33	0.529	322.17
T_6	86.87	0.673	0.709	332.51	6.33	27.93	0.672	331.22
T_7	90.24	0.793	0.916	391.54	6.50	31.35	0.714	335.45
T_8	95.47	0.843	1.003	416.46	6.63	32.40	0.765	341.89
T_9	71.92	0.487	0.582	240.32	6.07	23.73	0.534	325.37
T_{10}	86.89	0.677	0.715	334.15	6.33	28.83	0.622	335.85
T_{11}	90.08	0.797	0.936	393.41	6.50	30.75	0.675	339.45
T_{12}	95.77	0.847	1.010	418.10	6.67	32.98	0.766	343.88
T_{13}	72.67	0.493	0.585	243.62	6.17	24.63	0.543	322.90
T_{14}	87.96	0.683	0.732	337.45	6.53	29.56	0.645	330.30
T_{15}	93.37	0.807	0.943	398.36	6.93	31.77	0.732	334.24
T_{16}	97.49	0.877	1.080	432.92	7.53	34.73	0.786	339.40
SEm±	2.368	0.020	0.030	9.683	0.180	0.938	0.047	0.560
CD (5%)	6.820	0.056	0.087	27.892	0.519	2.703	0.135	1.614

*Applied recommended dose of P and K @ of 120 kg/ha and 100 kg/ha, respectively.

Table 2. Economics of different treatments of cabbage cultivation with the application of different fertility levels and biofertilizers

Treatment	Yield of head (q/ha)	Cost of cultivation (₹)	Gross return/ha @ ₹ 800 (q)	Net return (₹/ha)	Benefit : cost ratio
T_0	213.99	41487.7	171192	129704.3	3.13
T_1	228.80	44377.7	183040	138662.3	3.13
T_2	302.88	45595.1	242304	196708.9	4.31
T_3	320.98	45899.4	256784	210884.6	4.59
T_4	376.95	46213.8	301560	255346.0	5.72
T_5	232.10	44477.7	185680	141202.3	3.18
T_6	332.51	45695.1	266088	220392.9	4.82
T_7	391.54	45999.4	313232	267232.6	5.81
T_8	416.46	46313.8	333168	286854.2	6.19
T_9	240.32	44477.7	192256	147778.3	3.32
T_{10}	334.15	45695.1	267320	221624.9	4.85
T_{11}	393.41	45999.4	314728	124877.0	5.84
T_{12}	418.10	46313.8	334480	288166.2	6.22
T_{13}	243.62	44477.7	194896	150418.3	3.38
T_{14}	337.45	45695.1	269960	224264.9	4.91
T_{15}	398.36	45999.4	318688	272688.6	5.82
T_{16}	432.92	46313.8	346336	300022.2	6.48

have in turned greater root development, higher nitrogen fixation in the soil (Chatterjee, 2010) in cabbage. The increased nitrogen with biofertilizers helped in increasing chlorophyll content which coupled with increased net photosynthetic rates and in turn increased the supply of carbohydrates to plants. The present findings are in agreement to the earlier work done by Sable and Bhamare, 2007 in cauliflower; Kumar and Rawat, 2002; Kalabandi *et al.*, 2007.

Data pertaining to available nitrogen in soil after harvesting of the crop due to effect of nitrogen and biofertilizers significantly increased over control. The maximum nitrogen content (343.88 kg N / ha) was recorded with application of 150 kg nitrogen + *Azospirillium* (Table 1) and minimum in control (319.79 kg N / ha). Improvement in N status in soil at harvesting of the crop was due to addition of the nutrients through application of different nitrogen levels and biofertilizers (*Azotobacter, Azospirillium* and PSB).

The significant build up of the soil available nitrogen due to nitrogen and biofertilizers application could be attributed to increased activity of nitrogen fixing bacteria thereby, resulting in higher accumulation of nitrogen in soil besides additional supply of nitrogen to soil.

Such increase in available content of nitrogen of the soil at harvesting might be due to direct addition of nitrogen as well as seedling treatment with *Azospirillium* which absorb atmospheric nitrogen to the soil may be due to enhanced microbial activity and consequent release to organic complexing substances (chelating agents) which turned into more stable available nutrients (Sood and Vidyasagar, 2007). The data showed that treatment T_{16} (150 kg N + PSB) resulted in maximum net profit of ₹ 3,00,022.20 followed by ₹ 2,88,166.20, under treatment T_{12} (150 kg N + *Azospirillium*) and ₹ 2,86,854.20 under T_8 (150 + *Azotobacter*) with a benefit: cost ratio of 6.48:1, 6.22: 1 and 6.19: 1 respectively (Table 2).

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Evaluation of diversity in jackfruit *(Artocarpus heterophyllus)* in Tikrikilla block of West Garo Hills (Meghalaya)

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ABSTRACT

The study was undertaken to evaluate leaf characters, fruit-bearing and yield characters of jackfruit (*Artocarpus heterophyllus* Lam.) growing in West Garo Hills of Meghalaya, during 2014-15.Jackfruit trees are cross-pollinated and propagation is done mostly through seeds. Since there is a considerable variation in growth habit, canopy structure, leaf characters, fruit-bearing and productivity, a survey was conducted in Tikrikilla block of West Garo Hills to study the diversity. The information were collected as per the descriptors of IPGRI (International Plant Genetic Resources Institute), Rome, Italy. Out of 20 trees observed, highest yield/tree and productivity per hectare were noticed in J16, followed by J19 and J10. Highest number of fruits/tree was noted in J16, followed by J19. Highest fruit weight was recorded in J20, followed by J14, J10 and J4. These germplasm may be considered for future breeding and crop improvement programmes.

Key Words: Diversity, West Garo Hills, Tikrikilla, Meghalaya, Cross-pollinated, Propagation, Fruit bearing, Leaf characters

Jackfruit tree (*Artocarpus heterophyllus* Lam.), belonging to family Moraceae, is considered to be indigenous to the rainforests of the Western Ghats in India. It is extensively grown in West Garo Hills of Meghalaya. It is a popular fruit among the Garo tribe and is commonly known as 'Tebrong'. In spite of its various uses as food and medicine, jackfruit is still an under-exploited fruit crop in in this region. Jackfruit is propagated mostly through seeds. As a result, considerable variation is observed in trees and leaf characters, growth habit, fruit-bearing, productivity and fruit quality. Such variations provide suitable platform for further crop improvement. Characteri-zation studies on jackfruit are not yet reported from this region where jackfruit is grown extensively. Hence a survey was conducted to study the tree and leaf characters, fruit bearing and yield-attributing characters of jackfruit trees.

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MATERIALS AND METHODS

A survey was carried out in Tikrikilla block of district of West Garo Hills, Meghalaya, during 2014-2015. Twenty trees were randomly selected for observation. Various trees and leaf characters, fruiting behaviour and yield-attributing characters were observed and recorded as per the descriptors of IPGRI (International Plant Genetic Resources Institute), Rome, Italy. Statistical tools such as mean, standard deviation and standard error mean were used to analyze the data statistically. The variations among trees were determined by calculating the coefficient of variation.

RESULTS AND DISCUSSION

The tree height varied from 6.5 to 15.3 m, trunk height 0.48 to 5.7 m and trunk circumference 47 to 173 cm. The crown diameter in East-West direction ranged 3.2 to 12.8 m and in North-South direction 2.9 to 11.5 m. The highest tree height of 15.3 m was recorded in J12. Highest trunk circumference of 173 cm was noted in J16. The highest crown diameter (12.8 m) in East-West

Table 1. Tree growth characters (quantitative) in different types of jackfruit

Tree type	Tree height (m)	Trunk height (m)	Trunk circumference (cm)	Crown diameter	
				East-West (m)	North-South (m)
J1	11.8	2.31	170	12.8	10.8
J2	15.1	3.77	90	3.2	3.4
J3	13	3.1	145	10.7	10.2
J4	8.1	2.19	130	5.8	11.5
J5	12.1	1.9	170	7.5	6.3
J6	9.3	2.56	145	8.9	8.9
J7	7.5	2.2	130	7.9	10.1
J8	8.6	3.3	70	6.2	5.5
J9	7	2.2	47	4.4	4.5
J10	13	1.4	90	6.1	6.4
J11	13.1	2.7	162	11.4	10.7
J12	15.3	4.6	85	3.4	2.9
J13	10.45	2.9	150	8.6	8.28
J14	11.42	2.5	142	9.3	8.4
J15	10.3	0.48	140	7.2	5.6
J16	14.83	2	173	8.4	8
J17	11.5	2.2	110	6.5	6.3
J18	12.6	3.8	120	8.5	8
J19	8.3	1.8	80	4.6	5.9
J20	11.9	5.7	90	4.3	5.2
Mean	11.26	2.68	121.95	7.29	7.34
SD	2.51	1.15	37.12	2.64	2.52
SEM±	0.56	0.26	8.30	0.59	0.56
CV (%)	22.33	43.05	30.44	36.21	34.38

direction was recorded in J1 and in North-South directionitwas in J4 (11.5 m).Highest trunk height of 5.7 m was recorded in J20 (Table 1).

The canopy of tree showed varying shapes like pyramidal, broadly pyramidal, oblong, elliptical, spherical and irregular. Trunk surface ranged from smooth to rough and very rough. Trees of J1, J11, J13 and J7 showed spreading growth habit, while J5, J16 and J19 were semi-erect and remaining types as erect. J1, J3 and J13 exhibited verticillate branching pattern, while J2, J4, J5, J11, J12, J15, J17, J18 and J19 showed an erect branching pattern and the remaining types showed irregular branching pattern (Table 2).

The leaf length varied between 8.2 and 17.6 cm, leaf width ranged from 4.4 to 13.6 cm and petiole length varied from 11 to 28 mm. J12 showed largest leaf blade size (17.6 cm × 13.6 cm), while longest petiole was noted in J11 (Table 3). Varied leaf shapes like elliptic, narrowly elliptic, broadly elliptic and obovate were observed with acute, retuse or acuminate leaf apex; rounded, cuneate or oblique leaf base and an entire leaf margin, varying from green to light green or dark green colour, with varying intensity of leaf and midrib pubescence, (Table 4).

The fruiting season started from March and ended during July-August. All selected trees showed regular bearing habit. J10 bore fruits on main trunk; J1, J15, J16 and J17 bore fruits on main trunk, primary and secondary branches; while others showed bearing only on primary branches. J12 and J13 showed both cluster and solitary bearing; J3, J15, J17, J18 and J20 showed solitary bearing; while others bore fruits in clusters (Table 5).

Highest number of 60 fruits per plant was noted in J16, followed by J19 59 fruits plants J7 and 35 fruits. The highest average fruit weight of 5.8 kg was recorded in J20, followed by 5.5 kg in J14, 5.3 kg in J10 and 5.25 kg in J4. Highest yield per tree was recorded in J16 (225 kg/tree), followed by J19 (150.45 kg/tree) and J10 (143.1 kg/tree). The highest productivity in Tikrikilla was recorded in J16 with 22,500 kg/ha, followed by J19 with 15,045 kg/ha and J10 with 14,310 kg/ha (Table 6).

Similar observation have been recorded byMitra and Mani (2000), Sharma *et al.* (2009), Chadda (2009), Mitra and Maity (2002) and Muthulakshmi (2003).

Table 2. Tree characters (qualitative) of different types of jackfruit

Tree type	Crown shape	Trunk surface	Tree vigour	Tree growth habit	Branching pattern
J1	Broadly pyramidal	Very rough	Medium	Spreading	Verticillate
J2	Irregular	Smooth	High	Erect	Erect
J3	Irregular	Rough	High	Erect	Verticillate
J4	Irregular	Rough	Low	Erect	Erect
J5	Irregular	Rough	High	Semi-erect	Erect
J6	Spherical	Very rough	Medium	Erect	Irregular
J7	Oblong	Very rough	Low	Spreading	Irregular
J8	Irregular	Smooth	Low	Erect	Irregular
J9	Irregular	Rough	Low	Erect	Irregular
J10	Irregular	Smooth	High	Erect	Irregular
J11	Irregular	Rough	High	Spreading	Erect
J12	Irregular	Smooth	High	Erect	Erect
J13	Spherical	Rough	Medium	Spreading	Verticillate
J14	Pyramidal	Smooth	Medium	Erect	Irregular
J15	Irregular	Smooth	Medium	Erect	Erect
J16	Elliptical	Very rough	High	Semi-erect	Irregular
J17	Irregular	Smooth	Medium	Erect	Erect
J18	Irregular	Smooth	High	Erect	Erect
J19	Irregular	Smooth	Low	Semi-erect	Irregular
J20	Irregular	Smooth	Medium	Erect	Irregular

Table 3. Leaf characters (quantitative) in different types of jackfruit

Tree type	Leaf blade length (cm)	Leaf blade width (cm)	Petiole length (mm)
J1	11.8	7.2	22
J2	14.9	8.6	12
J3	11.2	5.6	12
J4	13.2	8.8	21
J5	9.7	6.2	23
J6	12.6	7.1	22
J7	16.9	7.8	23
J8	11.5	6.1	20
J9	14.2	5.7	14
10	16.3	10.4	21
J11	13	7.4	28
J12	17.6	13.6	15
J13	13	8.4	20
J14	8.2	4.4	13
J15	13.3	8	21
J16	11.7	7.4	15
J17	12	5.5	12
J18	9.1	5.8	11
J19	15.1	6	13
J20	15.5	9.8	13
Mean	13.04	7.49	17.55
SD	2.53	2.11	5.02
SEM±	0.57	0.47	1.12
CV (%)	19.43	28.15	28.61

Table 4. Leaf characters (qualitative) in different types of jackfruit

Tree type	Leaf blade shape	Leaf apex shape	Leaf base shape	Leaf blade margin	Leaf colour	Leaf upper surface pubescence	Leaf lower surface pubescence	Leaf midrib pubescence	Petiole shape	Grooves on petiole	Crotch angle of petiole
J1	Elliptic	Acuminate	Cuneate	Entire	Green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J2	Broadly elliptic	Acuminate	Rounded	Entire	Green	Intermediate	Dense	Sparsely puberulent	Rounded	Present	Acute
J3	Elliptic	Acute	Cuneate	Entire	Green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J4	Broadly elliptic	Retuse	Rounded	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J5	Broadly elliptic	Acuminate	Cuneate	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J6	Elliptic	Acuminate	Cuneate	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J7	Narrowly elliptic	Acute	Oblique	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J8	Elliptic	Acute	Oblique	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J9	Elliptic	Acute	Oblique	Entire	Green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J10	Broadly elliptic	Acuminate	Rounded	Entire	Dark green	Sparse	Sparse	Sparsely Puberulent	Rounded	Present	Acute
J11	Elliptic	Acuminate	Cuneate	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J12	Elliptic	Acuminate	Cuneate	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J13	Obovate	Acuminate	Cuneate	Entire	Green	Glabrous	Sparse	Sparsely Puberulent	Rounded	Present	Acute
J14	Broadly elliptic	Acuminate	Rounded	Entire	Dark green	Sparse	Sparse	Sparsely puberulent	Rounded	Present	Acute
J15	Elliptic	Acuminate	Oblique	Entire	Light green	Sparse	Sparse	Sparsely puberulent	Rounded	Present	Acute
J16	Elliptic	Acuminate	Cuneate	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J17	Obovate	Acuminate	Rounded	Entire	Light green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J18	Elliptic	Acute	Oblique	Entire	Dark green	Glabrous	Sparse	Sparsely Puberulent	Rounded	present	Acute
J19	Elliptic	Acuminate	Oblique	Entire	Dark green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute
J20	Narrowly elliptic	Acute	Oblique	Entire	Green	Glabrous	Glabrous	Glabrous	Rounded	Present	Acute

Table 5. Fruiting behavior of different types of jackfruit in Tikrikilla Block

Tree type	Start of fruiting season	End of fruiting season	Fruit bearing habit	Fruit bearing position	Fruit clustering habit	Fruit bearing intensity
J1	March	July	Regular	Other	Clusters	Poor
J2	March	August	Regular	Primary branch	Clusters	Medium
J3	March	July	Regular	Primary branch	Solitary	Poor
J4	March	July	Regular	Primary branch	Clusters	Poor
J5	March	August	Regular	Primary branch	Clusters	Medium
J6	March	July	Regular	Primary branch	Clusters	Medium
J7	March	August	Regular	Primary branch	Clusters	Medium
J8	March	July	Regular	Primary branch	Clusters	Medium
J9	March	July	Regular	Primary branch	Clusters	Poor
J10	March	July	Regular	Trunk	Clusters	Medium
J11	March	August	Regular	Primary branch	Cluster	Medium
J12	March	July	Regular	Primary branch	Other	Poor
J13	March	July	Regular	Primary branch	Other	Poor
J14	March	July	Regular	Primary branch	Cluster	Medium
J15	March	August	Regular	Other	Solitary	Poor
J16	March	August	Regular	Other	Cluster	Heavy
J17	March	July	Regular	Other	Solitary	Medium
J18	March	July	Regular	Primary branch	Solitary	Poor
J19	March	August	Regular	Primary branch	Cluster	Heavy
J20	March	July	Regular	Primary branch	Solitary	Poor

Table 6. Yield attributing parameters of different types of jackfruit

Tree type	Number of fruits/tree	Average fruit weight (kg)	Yield/tree (kg)	Fruit productivity (kg/ha)
J1	11	3.85	42.35	4235
J2	18	4.95	89.1	8910
J3	8	2.6	20.8	2080
J4	4	5.25	21	2100
J5	30	4.2	126	12600
J6	28	3.25	91	9100
J7	35	2.9	101.5	10150
J8	20	3.45	69	6900
J9	19	1.5	28.5	2850
J10	27	5.3	143.1	14310
J11	30	2.1	63	6300
J12	7	3.25	22.75	2275
J13	11	4.1	45.1	4510
J14	20	5.5	110	11000
J15	2	4.2	8.4	840
J16	60	3.75	225	22500
J17	25	2.45	61.25	6125
J18	15	1.3	19.5	1950
J19	59	2.55	150.45	15045
J20	3	5.8	17.4	1740
Mean	21.60	3.61	72.76	7276.00
SD	16.23	1.32	56.95	5694.95
SEM±	3.63	0.29	12.73	1273.43
CV (%)	75.15	36.52	78.27	78.27

Thus, of the 20 trees observed, highest yield and productivity hectare were noticed in J16 (225 kg / tree and 22,500 kg / ha), followed by J19 (150.45 kg / tree and 15,045 kg / ha) and J10 (143.1 kg and 14310 kg / ha). Highest number of fruits per tree was noted in J16 (60), followed by J19 (59). Highest fruit weight of 5.8 kg was recorded in J20, followed by J14 (5.5 kg), J10 (5.3 kg) and J4 (5.25 kg). These germplasm may be considered for future breeding and crop improvement programmes.

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Effect of organic coating on shelf-life and quality of organically-grown mango *(Mangifera indica)* cv. Kesar

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ABSTRACT

An experiment was conducted to find out the effect of organic coating on shelf-life and quality of oraganically grown mango *(Mangifere indica L.)* during 2013-2014 at ASPEE College of Horticulture and Forestry, Navsari Agricultural University and, Navsari, during 2013-14. The experiment was laid out in completely randomized design (CRD) with factorial concept having 16 treatment combinations, comprising four levels of organics, *viz.* 80% N through castor cake + Azotobacter+ PSB (50 g each / tree), 80% N through neem cake + *Azotobacter* + PSB (50 g each / tree), 80% N through vermi-compost + *Azotobacter* + PSB (50 gm each / tree and 80% N through biocompost + *Azotobacter* + PSB (50 gm each / tree) and four levels of organic coatings, *viz.* 75% Aloevera gel, 5% *Acacia* gum, 5% Tapioca starch and control (No coating). The treatments were repeated thrice. The effect of these treatments on different parameters of quality and shelf-life of fruits were studied. The results revealed that among different organics and coating, application of 80% N through Neem cake +*Azotobacter* + PSB (50 g each / tree) and 5% Acacia gum coating were found to be most beneficial for improving quality and shelf life of fruits. Similar trend was observed on quality parameters such as TSS, acidity, TSS: acidity ratio and firmness. Minimum physiological loss in weight was observed in the same treatment.

Key Words: Kesar, Neem cake, *Azotobacter*, PSB, and *Acacia* gum, Shelf-life, Organic coating, Organic Mango

Mango *(Mangifera indica* L.*)* trees respond well to organic manure applications. Organic manures such as vermicompost, castor cake, neem cake and biocompost are used for promoting healthy tree growth and fruit formation. Trees treated with organic manures bore large-sized leaves and formed a dense canopy with profuse rooting systems. The taste and shelf-life of such fruits were also found to be more satisfactory. The interaction of the root hairs of these trees with organic manures also increased the activity of the nitrogen-fixing bacteria in soil. The organic manures also act as a carrier medium for the development of several beneficial microorganisms such as *Azospirillum, Azotobacter, Rhizobium* and *Phosphobacteria*.

Use of refrigerated storage or controlled atmosphere storage is costly, whereas modified storage slows down ripening process but at the same time it also affect flavour of fruits. Application of various films and coatings modify the fruit atmosphere at micro level, reduce weight loss during transport and storage and extends shelf-life. It can also reduce growth of microorganisms. Coating provides semi-permeable barrier against oxygen, carbon dioxide, moisture and volatiles. Use of coating is well-known in citrus, apple, tomato and vegetables to extend shelf-life and improve appearance without adversely affecting flavour, taste and aroma. It is very cheap and effective technique and applicable at farm level.

MATERIALS AND METHODS

The experiment was laid out in a completely randomized design (CRD) with factorial concept having 16 treatment combinations, comprising four levels of organics, *viz.* O_1: 80% N through castor cake + *Azotobacter* + PSB (50 g each / tree), O_2: 80% N through neem cake

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+ Azotobacter + PSB (50 g each / tree), O_3: 80% N through vermicompost + *Azotobacter* + PSB (50 g each / tree and O_4: 80% N through biocompost + *Azotobacter* + PSB (50 g each / tree) and four levels of organic coatings, *viz.* C_1: 75% *Aloe vera* gel, C_2:5% *Acacia* gum, C_3:5% *Tapioca* starch and C_4: control (no coating). The treatments were repeated thrice. The effect of these treatments on different parameters of quality and shelf-life of fruits were studied.

RESULTS AND DISCUSSION

Physiological loss in weight

The results revealed that the lowest physiological loss in weight was noted with the application of 80% N through neem cake + *Azotobacter* + PSB (50g each / tree) (Table 1). This can be attributed to phenomenon that the altered physiology and biochemistry of fruits as influenced by organic sources of nutrients might have led to the reduced respiration which in turn resulted in low PLW and highest shelf-life (Kumar and Ponuswami, 2013). The PLW indicates the progress of ripening in climacteric fruits. The reduction in weight is attributed to PLW due to respiration, transpiration of water through peel tissue and other biological changes taking place in fruit. The basic mechanism of weight loss from fresh fruits is by vapour pressure at different locations (Golhani *et al.*, 2013). The lowest physiological loss in weight was noted in the fruits coated with 5% *Acacia* gum, whereas the highest PLW was noted in fruits without coating. This reduction in weight loss was probably due to effects of coating as semi-permeable barrier against O_2, CO_2, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates (Ganvit, 2014).

Fruit firmness

The highest fruit firmness was in treatment of 5% *Acacia* gum, whereas it was lowest in fruits without coating. Softening results from cell structure deterioration and changes in composition of cellular material and cell wall (Ganvit, 2014). This is a biochemical process involving pectin and starch hydrolysis due to enzymes including wall hydrolyses. De-polymerization (shortening of chain length of pectin substances) occurs with an increase in pectinesterase and polygalacturonase activities during fruit ripening (Ali *et al.*, 2014). Maqbool *et al.* (2011) reported that banana fruits treated with gum arabic delayed fruit ripening and resulted in firmer fruits. In case of organics, it was found non-significant.

TSS (%)

The maximum TSS was noted with the application of 80% N through neem cake + *Azotobactor* + PSB (50g each / tree) (Table 1). Increase in TSS at higher levels of nitrogen might have resulted due to absorption of nitrogen may have extered regulatory role as an important constituent of endogenous factors affecting the quality of fruits in which carbohydrate is important during ripening of fruits The carbohydrate reserves of roots and stem are drawn upon heavily by fruits which

Table 1. Effect of different organics and coating on physical and chemical characters of mango cv. Kesar

Treatment	PLW (%)	Fruit firmness (kg / cm^2)	TSS (%)	Acidity (%)	TSS: acidity ratio
Organic (O)					
O_1	21.05	4.26	20.92	0.252	84.53
O_2	19.74	4.33	21.78	0.248	85.81
O_3	20.95	4.30	20.94	0.245	86.98
O_4	22.62	4.14	20.69	0.252	81.48
SEm ±	0.58	0.06	0.39	0.01	3.35
CD (5%)	1.66	NS	1.13	NS	NS
Coating (C)					
C_1	20.35	4.38	20.62	0.245	83.83
C_2	19.00	4.75	20.65	0.281	93.01
C_3	21.97	4.10	21.30	0.240	87.97
C_4	23.04	3.78	21.75	0.231	73.99
SEm ±	0.58	0.06	0.39	0.01	3.35
CD (5%)	1.66	0.16	1.13	0.03	9.67
Interaction effect (O×C)					
SEm±	1.15	0.11	0.26	0.006	2.23
CD (5%)	NS	NS	NS	NS	NS
CV (%)	9.45	4.49	2.14	4.83	4.57

might have resulted into higher TSS and sugar contents in fruits (Dadashpour and Jouki, 2009).

The changes brought about in TSS of fruits during ripening are mainly due to conversion of starch and accumulation of sugars. Fruits without coating had significantly highest TSS at ripening. The uncoated fruits had uninterrupted gaseous exchange and normal ripening processes which might be reflected as higher TSS in fruits as compared to the coated fruits. The lowest TSS was noted in fruits coated with 75% *Aloe vera* gel. Modification of gaseous exchange in 75% *Aloe vera* gel coated fruits might have decreased respiration rates which resulted in lower PLW and delayed ripening due to delayed conversion of starch to sugars at ripening and reflected as lower TSS as compared to the control. Slowdown in synthesis and use of metabolites resulting in lower TSS due to coating was reported by Ali *et al.* (2014). 'Anna' apple fruits coated with gum arabic showed similar results and supported by El-Anay *et al.* (2009).

Acidity

The minimum acidity of pulp was recorded in mango fruits without coating (Table 1). Organic acids, such as malic or citric acid, are primary substrates for respiration; a reduction in acidity is expected in highly respiring fruits. The lower acidity contents might be due to aerobic respiration and higher evapotranspiration rate (Golhani *et al.* 2013). In case of organics, it was found non-significant.

TSS: acidity ratio

The maximum TSS: acidity ratio was observed in fruits coated with 5% Acacia gum (Table 1). Similar results were also noted in mango fruits coated with *Acacia* gum by Ganvit Swati (2014). In case of organics, it was found non-significant.

Total sugars

There was highest total sugar in fruits without coating, whereas those coated with 75% *Aloe vera* gel had lowest total sugars content (Table 2). Total sugars in mango fruits increased during ripening mainly due to, conversion of starch to simple sugars (sucrose, fructose and galactose), due to activity of amylase; and biosynthesis of sucrose. Among sugars, sucrose is predominant sugar in ripe mango fruits. It is possible that due to 75% *Aloe vera* gel coating, the conversion of starch into sugars as well as biosynthesis of sucrose slowed down as a result of modified gaseous exchange and reduced respiration rates and reflected as lower total sugars content at ripening. In uncoated fruits, uninterrupted hydrolysis of starch into sugars and biosynthesis of sucrose led to higher total sugars in fruits at ripening (Ganvit Swati 2014). In case of organics it was found non-significant.

Reducing sugars

Significantly, maximum reducing sugar content was recorded in uncoated fruits, whereas minimum reducing sugars content was noted in fruits coated with 75% *Aloe vera* gel (Table 2). Hydrolysis of starch to simple sugars and rate of conversion might be higher in uncoated fruits (the control) due to normal respiration and sequences of ripening processes. But in case of 75% *Aloe vera* gel coated fruits, modified respiration processes might be delayed hydrolysis of starch to sugars. The differences in reducing sugars content among the fruits coated with different coating will probably due to differences in molecular characters and specific ability of coating materials used to modify the gaseous exchange in fruits. (Ganvit Swati 2014). In case of organics, it was found non-significant.

Non reducing sugar (%)

The fruits without coating had significantly highest content of non-reducing sugar at ripening, whereas lowest content of non-reducing sugar was measured in 75% *Aloe vera* gel (Table 2). It is proven that coating reduces respiration rates by modification in exchange of O_2 and CO_2 in fruits. The lower level of non-reducing sugar (sucrose) among 75% *Aloe vera* gel coated fruits at ripening might be due to its specific capacity to altered respiration process resulted in slow hydrolysis of starch as well as inadequate biosynthesis of sucrose during ripening. It is also possible that 75% *Aloe vera* gel affected the inversion of non-reducing sugar into reducing sugar. The higher quantity of non-reducing sugar in uncoated fruits is obvious due to normal ripening processes. (Ganvit Swati 2014). In case of organics, it was found non-significant.

Ascorbic acid

Significantly, highest ascorbic acid content was recorded in fruits coated with 5% *Aloe vera* gel solution (Table 2). This might be due to low oxygen permeability of coating which delayed the deteriorative oxidation reaction of ascorbic acid content (Golhani *et al.* 2013). Adetunji *et al.* (2012) reported that coating reduces respiration of fruits and retains the ascorbic acid in fruits. In case of organics, it was found non-significant.

Shelf-life (days)

The maximum shelf-life (Table 2) was noted with the application of 80% N through neem cake + *Azotobacter* + PSB (50 gm each/tree). This can be attributed to the phenomenon that the altered physiology and biochemistry of fruits as influenced by

Table 2. Effect different organics and coating on chemical characters of mango cv. Kesar

Treatment	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)	Ascorbic acid content (%)	Shelf-life (days)
Organic (O)					
O_1	14.69	5.23	9.46	33.73	18.95
O_2	15.08	5.47	9.61	33.99	20.00
O_3	14.97	5.40	9.57	33.93	19.87
O_4	14.48	5.19	9.29	33.59	18.62
S.Em. ±	0.13	0.16	0.14	0.13	0.25
CD (5%)	NS	NS	NS	NS	0.73
Coating (C)					
C_1	14.10	5.09	9.01	38.67	19.66
C_2	14.97	5.33	9.64	32.76	21.33
C_3	14.82	5.27	9.55	35.36	18.68
C_4	15.34	5.61	9.73	28.45	17.87
SEm ±	0.13	0.16	0.14	0.13	0.25
CD (5%)	0.40	0.46	0.42	0.37	0.73
Interaction effect (O×C)					
SEm ±	0.27	0.10	0.29	0.26	0.50
CD (5%)	NS	NS	NS	NS	NS
CV (%)	3.19	3.49	5.26	1.34	4.53

organic sources of nutrients might have led to the reduced respiration which in turn resulted in highest shelf-life (Kumar and Ponuswami, 2013).

Maximum shelf-life of mango fruits was observed in fruits coated with 5% *Acacia* gum, whereas lowest shelf-life were observed in fruits without coating. The fruits coated with 5% *Acacia* gum solution had reduced water loss which reflected as minimum per cent PLW, delayed ripening processes which resulted in longer shelf-life. These findings are also in line with 'Anna' apples coated with arabic gum (El-Anay *et al.* 2009). The uncoated fruits had recorded lowest shelf-life at ripening due to higher PLW possibly due to higher respiration rate which then hastened the ripening of fruits and reflected as earlier ripening as compared to all other treatments. As the fruits ripen early, they also crossed the shelf-life quality earlier due to climacteric nature (Patel *et al.* 2014).

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Effect of seed priming treatments on germination and seedling vigour of custard apple *(Annona squamosa)*

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ABSTRACT

The experiment was conducted to find out the effect of seed priming on germination and seedling vigour of custard apple (*Annona squamosa* L.) cv. Local, during 2014-2015 at Agricultural Experimetal Station, Navsari Agricultural University, Paria, Valsad, by using completly randomized design with 13 treatments. The seeds treated with GA_3 @ 150 mg/litre minimized the days (18.00) taken for germination and improved the germination percentage (84.33%). Similar trend was observed in growth parameters, *viz*. seedling height (6.66, 10.91 and 17.05 cm), girth of plant (0.28, 0.37 and 0.48 cm), number of leaves (4.60, 7.72 and 15.16), leaf area (4.32, 7.63 and 14.39 cm^2), fresh and dry weight of plant and survival percentage (75.97%).

KEY WORDS: PGRs, Ethrel, Thiourea, Seed priming, Vigour, Germination

Custard apple (*Annona squamosa* L.), a most suitable fruit crop for dryland horticulture, is gaining popularity with orchadists. It is being propagated by both sexual and asexual methods. The freshly harvested seeds do not germinate early even under optimum conditions and remain dormant for one or three months, causing inconvenience to growers and nurserymen for raising rootstock. In order to have uniform and prompt germination period and to avoid the problem of uneven and irregular germination and to get sapling either for planting or for as rootstock the seed priming treatment of custard apple seeds are quite important. Due to hard and thick seed coat, it requires about 35-40 days for germination. To get higher and proper germination, seeds need pre sowing treatments which helps in promotion of early and higher percentage of seed germination with healthy and vigorous seedling.

MATERIALS AND METHODS

The experiment was conducted in a net house, located at Agriculture Experimental Station of Navsari Agricultural University, Paria, Valsad, during 2014-15. The experiement was laid out with a completely randomized design having 13 treatments. The treatments were repeated thrice comprising different concentrations of plant growth regulators (PGRs) and chemicals, *viz*. GA_3 @ 100, 150 and 200 mg/litre, ethrel @ 1000, 1500, and 2000 ml/litre, thiourea @ 1000, 1500 and 2000 mg/litre and KNO_3 @ 1, 1.5 and 2 %. Fresh seeds of uniform size were collected from the local market. The healthy seeds were selected and stored for 15 days and then used for the experiment. The observations were taken on number of days taken on for germination, germination percentage, height of plant, girth of plant, number of leaves, leaf area, fresh and dry weight of plant, and survival percentage.

RESULTS AND DISCUSSION

The seed treatment with GA_3 @ 150 mg/litre recorded the least number of days taken for germination (18.00 days), followed by GA_3 @ 100 mg/litre and GA_3 @ 200 mg/litre. It might be due to stimulating effect of imbibitions on subsequent seed germination caused by increased water absorbing capacity, resulting in increased analysed activity (Table 1). Similar results were obtained by Garge *et al.* (2011) in custard apple. The germination count was significantly affected by

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Table 1. Effect of seed priming treatments on growth of seedlings

Treatment	Time required for germination (days)	Germination percentage (%)	Seedling height (cm)			Seedling girth (cm)			Number of leaves			Leaf area (cm^2)		
			60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
T_1, GA_3 100 mg/litre	20.00	80.00	6.59	10.32	15.38	0.27	0.36	0.45	4.37	7.66	14.40	4.23	7.34	12.59
T_2, GA_3 150 mg/litre	18.00	84.33	6.66	10.91	17.05	0.28	0.37	0.48	4.60	7.72	15.16	4.32	7.63	14.39
T_3, GA_3 200 mg/litre	20.00	79.33	6.00	9.25	14.99	0.27	0.35	0.47	4.13	6.99	14.47	4.15	7.18	12.41
T_4, Ethrel 1000 ml/litre	24.00	73.33	5.51	8.42	13.78	0.19	0.29	0.32	3.62	6.24	14.10	3.51	6.64	10.80
T_5, Ethrel 1500 ml/litre	26.00	77.33	5.39	8.23	12.26	0.25	0.31	0.43	3.47	6.38	13.07	2.64	5.19	12.00
T_6, Ethrel 2000 ml/litre	25.33	77.33	5.72	7.57	12.93	0.23	0.28	0.38	3.66	6.36	11.47	3.27	6.34	10.83
T_7, Thiourea 1000 mg/litre	25.33	73.33	5.18	7.51	14.15	0.25	0.31	0.44	3.97	6.49	12.60	3.25	6.22	10.20
T_8, Thiourea 1500 mg/litre	23.00	76.00	5.42	7.48	12.28	0.23	0.31	0.44	3.40	6.07	11.44	3.25	6.21	11.45
T_9, Thiourea 2000 mg/litre	26.00	75.33	5.71	7.52	11.93	0.24	0.28	0.36	3.47	6.27	11.87	2.77	5.43	11.66
T_{10}, KNO_3 (1%)	28.00	76.67	5.43	8.34	13.55	0.23	0.32	0.43	3.53	6.55	11.87	3.28	6.49	10.87
T_{11}, KNO_3 (1.5%)	21.00	78.67	5.96	9.13	14.60	0.26	0.34	0.46	4.03	6.60	13.87	3.71	7.13	12.03
T_{12}, KNO_3 (2%)	25.67	73.00	6.50	8.95	14.29	0.21	0.31	0.40	3.77	6.42	12.37	4.31	6.38	11.47
T_{13}, Control	31.00	60.67	4.33	6.33	9.54	0.16	0.21	0.30	2.71	4.70	8.93	2.15	4.53	8.37
S.Em±	0.832	2.053	0.15	0.200	0.332	0.005	0.008	0.011	0.124	0.158	0.295	0.081	0.153	0.274
CD at (5%)	2.419	5.967	0.43	0.581	0.966	0.016	0.022	0.031	0.361	0.460	0.858	0.234	0.444	0.795
CV (%)	5.98	4.69	4.52	4.09	4.24	4.04	4.28	4.47	5.73	4.22	4.01	4.05	4.15	4.13

various PGRs and chemicals. The highest germination count was recorded under the treatment T_2, *i.e.* GA_3 @ 150 mg/litre (84.33%). The early germination might be due to increase in hydrolyzing enzyme and alpha-amylase at initial stage of germination and thus facilitated the germination process. These results are in agreement with those of Chaudhary and Chakrawar (1981) in Rangpur lime, Gupta (1989) and Hore and Sen (1994).

The maximum plant height (6.66, 10.91 and 17.05 cm), respectively was observed in GA_3 @ 150 mg/litre 60, 90 and 120 days after sowing, followed by GA_3 @ 100 mg/litre 60 and 90 days after sowing (Table 2). The increase in seedling height with GA_3 treatment was due to that this hormone increased the osmotic uptake of nutrients, causing cell elongation and thus increasing height of plants. Similar results are in close conformity to those of Nimbalkar *et al.*, (2012) in karonda. The maximum girth of plant was observed in GA_3 @ 150 mg/litre (0.28, 0.37, 0.48 cm, respectively) 60, 90 and 120 DAS, followed by T_1, T_3 and T_{11}. It might be due to greater cell division and elongation at the stem portion. These findings are in agreement with those of Vasantha *et al.* (2014) who reported maximum plant girth in tamarind with GA_3 @ 200 mg/litre treatment.

The maximum number of leaves were recorded in treatment, T_2, *i.e.* GA_3 @ 150 mg/litre at 60, 90 and 120 DAS (4.60, 7.72, and 15.16), followed by T_1. The maximum number of leaves might be due to higher growth of seedlings. The probable reason for increasing number of leaves might be due to activity of GA_3 at the apical meristem, resulting in more synthesis of nucleoprotein responsible for increasing leaf initiation. The observation analogues to these findings were reported by Misra *et al.* (1982) in citrus and Nimbalkar *et al.* (2012) in karonda.

The maximum leaf area was recorded in treatment, T_2, *i.e.* GA_3 @ 150 mg/litre 60, 90 and 120 DAS (4.32, 7.63 and 14.39 cm^2). The maximum leaf area might be due to increase in leaf length and leaf width, which ultimately increase in leaf area. The GA_3, also helped in invigoration of physiological process of plants and stimulatory effect to growth at faster rate. Such type of finding was also reported by Meena and Jain (2005) in papaya and Prajapati *et al.* (2014) in jackfruit.

The maximum fresh as well as dry weight were recorded in GA_3 @ 150 mg/litre 120 DAS. It might be due to overall growth of seedlings and increased rate of photosynthesis which lead to the overall assimilation and redistribution of photosynthates within seedlings and hence resulted in higher fresh weight of plants (Table 2). The similar results were found by Chaudhary and Chakrawar (1981) in kagzi lime and Sasikala and Srimathi (2006) in papaya.

The application of GA_3 @ 150 mg/litre recorded significantly maximum dry weight of shoot and root at 120 DAS (0.72 and 0.35 g). Similar results were found by Kadam *et al.* (2010) in kagzi lime and Pampana and Sulikeri (1999) in sapota. The maximum survival percentage (75.97%) was recorded 120 days under GA_3

Table 2. Effect of seed priming treatments on shoot and root characters and survival percentage of seedlings

Treatment	Fresh weight of shoots (g)	Fresh weight of roots (g)	Dry weight of shoots (g)	Dry weight of roots (g)	Survival (%)
T_1, GA_3 100 mg/litre	3.05	1.32	0.67	0.32	75.84
T_2, GA_3 150 mg/litre	3.14	1.54	0.72	0.35	75.97
T_3, GA_3 200 mg/litre	3.03	1.30	0.65	0.30	73.90
T_4, Ethrel 1000 ml/litre	2.72	1.00	0.56	0.18	60.44
T_5, Ethrel 1500 ml/litre	2.56	0.54	0.55	0.15	64.88
T_6, Ethrel 2000 ml/litre	2.62	1.08	0.46	0.20	62.21
T_7, Thiourea 1000 mg/litre	2.66	1.06	0.61	0.24	61.24
T_8, Thiourea 1500 mg/litre	2.63	0.59	0.45	0.15	65.07
T_9, Thiourea 2000 mg/litre	1.78	0.58	0.44	0.18	60.69
T_{10}, KNO_3 (1%)	2.46	0.91	0.55	0.16	65.11
T_{11}, KNO_3 (1.5%)	2.88	1.24	0.64	0.20	70.86
T_{12}, KNO_3 (2%)	2.55	0.82	0.62	0.28	65.90
T_{13}, Control	1.20	0.28	0.13	0.11	47.04
SEm±	0.081	0.032	0.018	0.005	1.797
CD (5%)	0.236	0.092	0.054	0.015	5.223
CV (%)	5.49	5.80	5.90	4.24	4.76

@ 150 mg/litre as compared to rest of the treatments. This might be due to overall performance in relation to growth parameters which ultimately increased the survival percentage. These findings are in agreement with those of Bankar (1987) in karonda and Manekar (2011) in aonla.

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Effect of nitrogen on growth, flowering and quality of China aster *(Callistephus chinensis)* cv. Kamini

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ABSTRACT

The experiment was conducted to find out the optimum dose of nitrogen required for growth, flowering and quality of flowers in China aster (*Callistephus chiensis* L. Nees) cv. Kamini. The experiment was laid out with nine levels of nitrogen (N): 50 kg/ha, 75 kg/ha, 100 kg/ha, 125 kg/ha, 150 kg/ha, 175 kg/ha, 200 kg/ha, 225 kg/ha and 250 kg/ha individually and in all combination with the control ($N_0P_0K_0$), in a randomized completely block design with three replications. Recommended dose of phosphorous (60 kg/ha) and potassium (60 kg/ha) in the form of single superphosphate (SSP) and muriate of potash (MOP), respectively, were incorporated into the soil before transplanting. Nitrogen was applied in the form of urea in two equal split doses, *i.e.* at the time of transplanting and 30 days after transplanting. Significant response in vegetative growth, flowering characters and quality parameters was observed in all the treatments over the control. The growth characters, *viz*. plant height, plant spread, stem girth and number of secondary branches showed positive response with N 150 kg/ha over all other treatments. The commencement of flowering was enhanced by higher dose of nitrogen. The days to flower initiation significantly reduced with treatment of N 150 kg/ha followed by N 225 kg/ha. Treatment of N 150 kg/ha, also showed earliness in flowering, increased flower stalk length, flower diameter, ray florets, number of flower buds/plant, duration of flower as well as field-life. However, maximum dry weight of single flower was noticed with treatment, N 175 kg/ha. The lower doses of nitrogen did not show much influence on growth, flowering characters and quality. Thus, application of N 150 kg/ha was more beneficial to get higher yield and quality flowers.

Key Words: Nitrogen, Growth, Flowering, Quality, Field-life, Flowering characters, Transplanting, Secondary franches

China aster (*Callistephus chinensis* L. Ness.) is an important commercial flower crop. The wide spectrum of forms, colours (pink, blue, violet and white) and their long vase-life have made it as popular cut flower. Nutrition plays an important role in improvement of growth, flowering and bulb production of tuberose (Rathore and Singh, 2013). Generally, China aster responds very well to the application of inorganic fertilizers. Nutritional management through nitrogen is helpful for enhancing growth, yield and quality of flowers. Verma *et al.* (2010) recorded growth and yield attributes increased with increasing levels of N. Inorganic fertilizer like nitrogen plays an important role in improving plant growth because of major constituent in chlorophyll, protein and amino acids. The main function of nitrogen is initiation of meristematic activity which accelerates cell division and cell enlargement. Studies indicate the greater influence of nitrogen on growth, flower production and quality blooms in many ornamental flowering plants. Favourable effects of nitrogen on growth and flower production were emphasized by many workers (Arora and Saini, 1976). The stunted growth of plants, reduction in number of leaves in China aster, zinnia and salvia caused due to deficiency of nitrogen and phosphorous (Bose and Das, 1966). Hence, an experiment was conducted to find out the performance

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of nitrogen on growth, flowering and quality of China aster.

MATERIALS AND METHODS

A field experiment was conducted to study the response of nitrogen on growth, flowering and quality of China aster at Department of Floriculture, College of Horticulture and Forestry, Pasighat, Arunachal Pradesh, during April 2012 - March 2013. Nine levels of nitrogen (N): 50 kg / ha, 75 kg / ha, 100 kg / ha, 125 kg / ha, 150 kg / ha, 175 kg / ha, 200 kg / ha, 225 kg / ha and 250 kg / ha individually and in all combination with the control ($N_0P_0K_0$), were compared to find out suitable dose of nitrogenous fertilizers under agroclimatic conditions of Pasighat. Recommended dose of phosphorous (60 kg / ha) and potassium (60 kg / ha) in the form of single superphosphate (SSP) and murate of potash (MOP), respectively, were incorporated into the soil before transplanting.

Nitrogen was applied in the form of urea in two equal split doses, *i.e.* at the time of transplanting and 30 days after transplanting. The experiment was laid out in a randomized completely block design (RBD) with three replications. Uniform size (10-15 cm) of China aster seedlings cv. Kamini were transplanted on raised beds at spacing 30 cm × 20 cm. The observations on vegetative and flowering characters, *viz.* plant height, plant spread, stem girth, number of primary branches, number of secondary branches, initiation of flower buds, colour break stage, days to full bloom, flower stalk length and flower diameter; quality characters, *viz.* number of ray florets / flower, number of flower buds / plant, flower duration, fresh weight of single flower, dry weight of single flower and field-life were recorded and analysed statistically as suggested by Panse and Sukhatme (1995).

RESULTS AND DISCUSSION

Both vegetative and floral characters improved by application of nitrogenous fertilizers (Barad *et al.*, 2015). Maximum plant height (54.48 cm) was associated with application of nitrogen at 150 kg / ha which was on a par with nitrogen at 225 kg / ha (53.36 cm) (Table 1). The increase in plant height at higher dose of nitrogen might be due to the increase in transport of metabolites and rate of photosynthesis in the plant, which enables the plant to have quick and better upward vegetative growth. Higher dose of nitrogen proved to be the best for attaining the maximum plant height in marigold (Jain and Gupta 2004) and number of branches in tuberose (Kishore, 2015) (Joshi *et al.*, 2013) and in chrysanthemum.

Highest plant spread (19.50 cm) was a noticed with application of nitrogen at 250 kg / ha followed by nitrogen at 225 kg / ha (17.38 cm) and nitrogen at 50 kg / ha (16.90). The plant spread with application of nitrogen at 250 kg / ha (19.50 cm) was at a par with 150 kg / ha (19.10 cm). Maximum plant spread obtained under higher dose of nitrogen might be due to formation of new cells in meristem and increased in size resulted in more production of cells (Barad *et al.*, 2015). Singh and Sangama (2000) reported that maximum plant height and plant spread in China aster cv. Kamini were obtained with highest level of N application.

A balanced supply of nitrogen promotes in translocation of plant growth hormones to shoot and increased the metabolite transport for growth which may lead to significant increase in plant height and plant spread (Marshner, 1983). However, maximum stem girth showed by nitrogen at 150 kg / ha (22.68 cm), followed by application of nitrogen at 225 kg / ha (19.30 cm) and nitrogen at 250 kg / ha (18.42 cm). The minimum

Table 1. Effect of nitrogen on vegetative growth of China aster cv. Kamini.

Treatment	Plant height (cm)	Plant spread (cm)	Stem girth (cm)	Number of primary branch	Number of secondary branch
T_1 (control)	42.50	13.70	17.02	17.40	13.80
T_2 (N, 50 kg / ha)	47.38	14.50	17.04	18.60	15.40
T_3 (N, 75 kg / ha)	48.28	15.70	18.22	18.60	18.80
T_4 (N, 100 kg / ha)	48.18	14.44	18.38	19.60	17.20
T_5 (N, 125 kg / ha)	43.90	16.90	16.82	19.00	20.00
T_6 (N, 150 kg / ha)	54.48	19.10	22.68	19.60	22.20
T_7 (N, 175kg / ha)	50.30	15.20	16.78	18.80	19.00
T_8 (N, 200kg / ha)	52.12	16.34	17.14	17.80	15.40
T_9 (N, 225kg / ha)	53.36	17.38	19.30	20.80	19.40
T_{10} (N, 250kg / ha)	45.90	19.50	18.42	19.20	16.80
CD (P=0.05)	2.79	1.45	0.94	0.65	1.02
CV (%)	4.47	6.93	9.09	5.68	10.16

stem girth was observed in the control (17.02 cm). Monish *et al.*, (2008) stated that application of nitrogen at their higher levels resulted in the tallest plant, maximum number of branches and thickest stem. Khalaj *et al.* (2012) observed that application of nitrogenous fertilizer at higher level improved the stem diameter in tuberose. Better seedling growth at nursery level was noticed in marigold with application of N (120 kg / ha) (Sastiya *et al.*, 2015).

Increased number of primary branches was observed in the plot which received nitrogen at 225 kg / ha (20.80) which was on a par with the nitrogen at 150 kg / ha (19.60) and the nitrogen at 100 kg / ha (19.60). Whereas, maximum number of secondary branches was associated with nitrogen at 150 kg / ha (22.20), followed by nitrogen at 175 kg / ha (19.00) which was on a par with nitrogen at 225 kg / ha (19.40). These results are in close conformity with the findings that application of nitrogen significantly influenced plant height and number of branches in clary sage (Yasheen *et al.*, 2014).

Earliness in flower bud initiation showed by nitrogen at 150 kg / ha (67.20 days), followed by application of nitrogen at 225 kg / ha (69.60 days) and nitrogen at 75 kg / ha (70.80 days) (Table 2). The delayed flowering was observed in the control (72.00 days). Earliness in flower bud initiation at higher level of nitrogen application was also observed by Rajput *et al.* (2014), Barad *et al.* (2011) in golden rod and Joshi *et al.* (2013) in chrysanthemum. Early emergence of flower buds might be due to increased availability of nitrogen, easy uptake of nutrients and simultaneous transport of growth-promoting substances like cytokinins to axillary buds, resulting in breakage of apical dominance and facilitated better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. The increased level of cytokinin in plants due to higher nitrogen application rate might have influenced the lateral buds to sprout and producing more number of lateral branches (Wagner and Michael, 1971).

Minimum days for colour break stage (72.00 days) was noticed with nitrogen (150 kg / ha), followed by nitrogen at 200 kg / ha (74.40 days). While, reduced number of days for bloom was associated with nitrogen at 150 kg / ha (83.60 days) which was on a par with nitrogen at 175 kg / ha (84.40 days), followed by nitrogen at 225 kg / ha (82.80 days). Reduction in days taken for flowering due to high level of nitrogen was also reported by Singatkar *et al.* (1995) in gaillardia. However, highest flower stalk length (34.00 cm) was noticed with nitrogen at 150 kg / ha, followed by nitrogen at 225 kg / ha (28.06 cm). The lowest flower stalk length was observed in the control (21.38 cm). These results corroborate with those of Gangwar *et al.* (2013) which revealed that spike and rachis length in tuberose significantly increased with application of nitrogen at higher levels.

Increase in flower stalk length associated with higher dose of nitrogenous fertilizer might be due to proper utilization of nutrients in protein synthesis and carbohydrate assimilation. Increased flower stalk length due to increased dose of nitrogen in rose was also reported by Arvind and Kale (1994). Monish *et al.* (2008) also stated that application of nitrogen at their higher levels resulted in maximum number flowers and large-sized flower. Application of nitrogenous fertilizer at higher level improved the flower stalk length and stem diameter in tuberose Khalaj *et al.* (2012).

Maximum flower diameter (46.58 cm) was associated with nitrogen at 150 kg / ha, followed by nitrogen at 175 kg / ha (42.57 cm) and nitrogen at 250

Table 2. Effect of nitrogen on flowering parameters of China aster cv. Kamini.

Treatment	Initiation of flower bud (days)	Colour break stage (days)	Full bloom (days)	Flower stalk length (cm)	Flower diameter (mm)
T_1 (control)	72.00	83.60	89.00	21.38	17.79
T_2 (N, 50 kg / ha)	72.00	79.00	87.80	25.18	33.51
T_3 (N, 75 kg / ha)	70.80	80.00	88.40	24.27	40.60
T_4 (N, 100 kg / ha)	70.80	77.20	86.00	22.89	42.38
T_5 (N, 125 kg / ha)	72.00	78.60	87.20	23.39	31.70
T_6 (N, 150 kg / ha)	67.20	72.00	83.60	34.00	46.58
T_7 (N, 175kg / ha)	72.00	82.00	84.40	24.62	42.57
T_8 (N, 200kg / ha)	68.40	74.40	87.80	22.10	38.36
T_9 (N, 225kg / ha)	69.60	77.80	82.80	28.06	38.58
T_{10} (N, 250kg / ha)	72.00	81.20	88.40	21.42	39.18
CD (P=0.05)	1.46	1.25	1.68	0.74	1.27
CV (%)	1.25	0.99	1.23	4.04	2.66

Table 3. Effect of nitrogen on quality parameters of China aster cv. Kamini

Treatment	Number of ray florets flower	Number of flower buds / plant	Duration of flower	Fresh weight of single flower (g)	Dry weight of single flower (g)	Field life (days)
T_1 (control)	57.60	18.20	17.00	1.36	0.23	10.05
T_2 (N, 50 kg / ha)	68.00	23.20	17.00	1.31	0.26	10.20
T_3 (N, 75 kg / ha)	70.60	19.00	18.80	1.52	0.29	10.60
T_4 (N, 100 kg / ha)	78.60	22.80	20.60	1.70	0.35	11.20
T_5 (N, 125 kg / ha)	66.20	21.40	18.80	1.78	0.32	13.00
T_6 (N, 150 kg / ha)	83.80	26.80	21.40	1.98	0.39	13.10
T_7 (N, 175 kg / ha)	80.00	20.20	20.20	2.18	0.42	10.20
T_8 (N, 200 kg / ha)	83.60	23.40	18.20	1.89	0.36	10.80
T_9 (N, 225 kg / ha)	82.40	24.40	20.60	1.72	0.28	11.60
T_{10} (N, 250 kg / ha)	81.80	20.00	21.00	1.62	0.30	11.60
CD (P=0.05)	1.88	0.76	0.93	0.18	0.08	0.68
CV (%)	1.95	4.97	3.21	8.34	9.96	4.71

kg / ha (39.18 cm), whereas minimum flower diameter was noticed under the control (17.79 cm). The beneficial effect on earliness in flower bud initiation, improving flower stalk length, large sized flowers and number of flower buds might be due to early breaking of apical dominance, followed by easy and better translocation of nutrients to flowers, better plant growth by increased availability of nutrients and accelerated mobility of photosynthates from source to sink as influenced by growth hormones released or synthesized from inorganic fertilizers. These results corroborate with the findings of Taher *et al.* (2013) in tuberose and Rajput *et al.*, 2014 in Golden Rod. The research revealed that application of nitrogenous fertilizer increased significantly length of florescence and number of florets.

Graded levels of nitrogen significantly differed on quality parameters (Table 3). Use of nitrogen at 150 kg / ha produced highest number of ray florets / flower (83.80) which was on a par with nitrogen at 200 kg / ha (83.60) and nitrogen at 225 kg / ha (82.40). Whereas number of flower buds / plant was associated with nitrogen at 150 kg / ha (26.80), followed by nitrogen at 225 kg / ha (24.40) and nitrogen at 200 kg / ha (23.40). Increased number of flower buds might be due to better nutrient uptake, higher photosynthetic efficiency, source-sink relationship and supply of macro and micro-nutrients, enzymes and growth hormones. Similar results were noticed by Jain and Gupta (2004) and Monish *et al.* (2008). Singh and Sangama (2000) also reported maximum length of flower stalk and number of flowers / plant in China aster cv. Kamini.

Prolonged duration of flowering was recorded with nitrogen at 150 kg / ha (21.40 days) which was a on par with nitrogen at 100 kg / ha (20.60 days) and nitrogen at 225 kg / ha (20.60 days), followed by nitrogen at 250 kg / ha (21.00 days). Use of nitrogen at 175 kg / ha showed increased fresh weight of single flower (2.18 g), followed by nitrogen at 150 kg / ha (1.98 g) and nitrogen at 100 kg / ha (1.78 g). Monish *et al.* (2008) stated that application of nitrogen at their higher levels resulted in the longest flowering duration. Higher dose of nitrogen responded for maximum number of flowers and increased fresh weight. Cell division and cell enlargement are accelerated by ample supply of nitrogen which initiates meristematic activity in crops (Crowther, 1935). Abundant supply of nitrogen at higher level might have accelerated the photosynthetic activities of plants and more assimilates may have translocated into flowers to develop, resulting in increased fresh weight of flowers.

However, nitrogen at 175 kg / ha recorded maximum dry weight of single flower (0.39 g) which was on par with nitrogen at 150 kg / ha (0.42 g) and nitrogen at 200 kg / ha (0.36 g). The minimum dry weight of single flower was associated with the control (0.23 g). These results corroborate with these of Taher *et al.*, (2013) and Rajput *et al.*, (2014). The increase in dry weight may be due to luxurious vegetative growth in terms of plant height, stem girth and number of branches. The increase in dry weight may be ascribed to effects of plant growth regulators, high rate of photosynthates from vegetative parts to reproductive parts which subsequently might have resulted in higher dry matter accumulation. Monish *et al.* (2008) reported that application of nitrogen at their higher levels resulted in maximum fresh and dry weight of flowers. Enhanced field life was noted with nitrogen at 125 kg / ha (13.00 days) which was on a par with nitrogen at 150 kg / ha (13.10 days), while lowest vase-life was associated with control (10.05 days).

Thus, it was concluded that nitrogen application at 150 kg / ha was significantly associated for growth, flowering and quality parameters of China aster. Higher levels of nitrogen enhanced growth, flowering and quality parameters of China aster as compared to lower dose.

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Characterization of variability in watermelon *(Citrullus lanatus)* for DUS testing

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ABSTRACT

The studies were undertaken to develop DUS testing guidelines of 10 varieties of watermelon [*Citrullus lanatus* (Thunb) Matsam & Nakai] during 2011-2013 at CIAH, Bikaner. The results revealed that all varieties showed considerable variation in qualitative and quantitative characters. All varieties were grouped into different categories for each character based on 27 descriptors which may be used as reference varieties. The traits like degree of primary lobing of leaf blade, fruit shape in longitudinal section, rind colour of fruit, fruit stripes, fruit size, flesh colour, seediness of fruits and colour of seed coat were identified as grouping traits. The characterization of extant varieties was completed to establish distinctness of candidate variety from all other varieties to utilize these varieties as reference material for protection of other varieties under PPV&FR Act, 2001.

Key Words: DUS, Watermelon, Characterization, Variability, Fruit shope, Flash colour, Seed coat

Watermelon [*Citrullus lanatus* (Thunb.) Matsam. & Nakai] is an important crop belonging to Cucurbitaceae family with chromosome number of 2n=2x=22. It is one of the most widely cultivated crops in the world (Huh *et al.*, 2008). Now it is no longer just a summer fruit and is becoming an everyday fruit like apples, bananas and oranges with predominant monoecious sex expression, watermelon is highly cross-pollinated and has great genetic variability in India in qualitative and quantitative characters (Choudhary *et al.*, 2012). The great variability in watermelon and true character expression in example varieties assume a greater significance under PPV&FR Act, 2001 for their protection on a set of relevant characteristics prescribed in the 'Minimal Descriptors of Vegetable Crops' for watermelon by Srivastava *et al.* (2001) and International Union for the Protection of New Varieties of Plants (UPOV), 2010.

Realizing its importance, the development of DUS (Distinctiveness, Uniformity and Stability) descriptors of watermelon has necessitated differentiating the varieties from each with the objective to register the varieties with PPV&FR Authority, New Delhi. A variety is identified on the basis of a set of morpho-physiological characteristics differing from other known varieties of that species. Therefore, present study was undertaken to develop DUS test guidelines required for describing a variety, assessing the level of uniformity of characteristics and stability of expression of those in different growing locations over the years. This will be useful and effective in utilization of watermelon genetic resource for DUS testing and further improvement of crop.

MATERIALS AND METHODS

The experimental material comprised genetically pure seed of 10 extant varieties of watermelon, *viz.* Sugar Baby, Arka Manik, Charleston Grey, Asahi Yamato, Durgapura Lal, Durgapura Kesar, Kashi Pitamber, AHW-19, AHW-65 and Thar Manak. The studies were carried out at CIAH, Bikaner, IIVR, Varanasi and IIHR, Bengaluru, during 2011-2013. The seeds of all varieties were sown with five rows of 5.6 m length keeping a row-to-row and plant-to-plant spacing of 3.0 m and 0.8 m respectively in a randomized block design, replicated thrice. All recommended package of practices were followed to raise healthy crop for DUS

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Durgapura Lal Sugar Baby

Fig. 1. Leaf blade: degree of primary lobing.

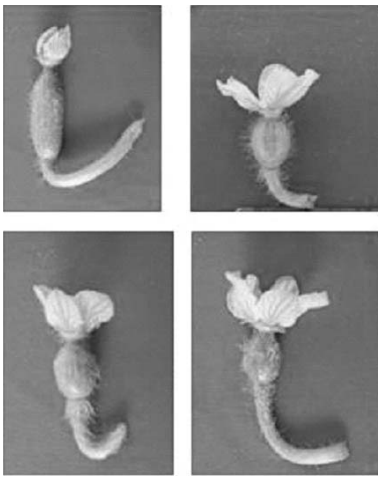
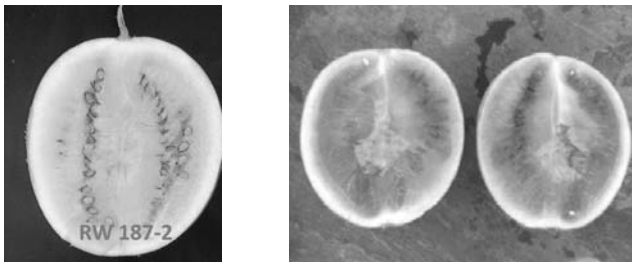
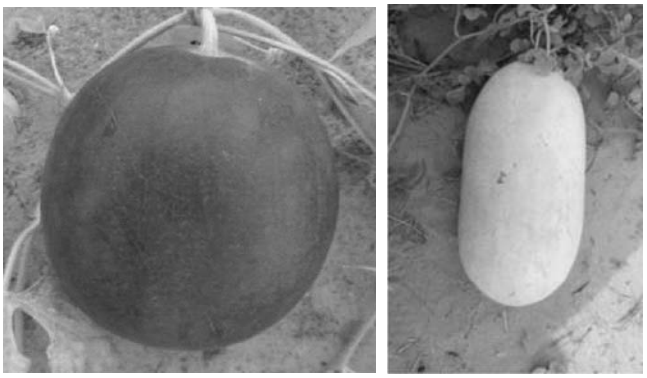


Fig. 2. Variability in ovary traits



Durgapura Kesar (yellow) Sugar Baby (dark red)

Fig. 3. Flesh colour



Sugar Baby (flat globe) Charleston Grey (cylindrical)

Arka Manik (elongated globe)

Fig. 4. Fruit shape

characterization. Different qualitative and quantitative characters were observed at specified stage of crop growth period when characters under study had full expression as suggested by Srivastava *et al.* (2001) and UPOV (2010). The observations on distinctiveness and stability were made on 10 plants or parts of plants from each replication selected randomly. The assessment of uniformity of characteristics in the plot as a whole was done visually by a single observation of a group of plants or parts of plants. The observations on cotyledon were made just before the development of first true leaf. All observations on leaf were recorded on fully developed but not old leaves, preferably between 5th and 8th node when plants had at least one fruit set while the observations on fruit traits were made on first or second well-developed mature fruit. Observations on ovary were recorded on the day of anthesis. All observations on width were recorded at the maximum point of width of the part concerned. All observations on seeds were made on fully developed, matured and dry seeds, after washing and drying.

RESULTS AND DISCUSSION

Qualitative Traits

There was considerable variation among 10 varaities for all qualitative morphological characters (Table 1). Of them, Durgapura Lal showed weak degree of primary lobing of leaf blade, whereas, Arka Manik and Durgapura Kesar showed strong degree of primary lobing (Figs. 1-4). The fruit shape in longitudinal section was expressed as flat globe in Sugar Baby, cylindrical in Charleston Grey and elongated globe in Asahi Yamato

Table 1. Qualitative traits of watermelon varieties

Character	States*	Example varieties
Cotyledon: shape	Narrow elliptic	Sugar Baby, Charleston Grey
	Medium elliptic	Arka Manik
	Broad elliptic	Asahi Yamato, Thar Manak
Leaf blade: colour	Light green	-
	Green	Asahi Yamato
	Dark green	-
Leaf blade: degree of primary lobing	Weak	Durgapura Lal
	Medium	Sugar Baby
	Strong	Arka Manik, Durgapura Kesar
Leaf blade: degree of secondary lobing	Weak	Durgapura Lal
	Medium	Sugar Baby
	Strong	Thar Manak
Sex expression (at full flowering)	Monoecious	Arka Manik, Durgapura Lal
	Andromonoecious	AHW-65
Male sterility	Absent	Sugar Baby, Durgapura Lal, Arka Manik
	Present	-
Ovary: pubescence	Sparse	Durgapura Lal
	Dense	Arka Manik, Durgapura Kesar
Ovary: colour	Yellow	Kashi Pitamber
	Green	Sugar Baby, Arka Manik
	Dark green	-
Fruit: shape in longitudinal section	Round	-
	Flat globe	Sugar Baby
	Oval	-
	Cylindrical (oblong)	Charleston Grey
	Elongated globe	Asahi Yamato, Arka Manik
Fruit: colour of rind	Yellow	Kashi Pitamber
	Light green	Asahi Yamato, Charleston Grey
	Medium green	Durgapura Kesar
	Dark green	Sugar Baby
Fruit: grooves	Absent	Sugar Baby, Asahi Yamato
	Present	Thar Manak
Fruit: stripes	Absent	-
	Weak	Asahi Yamato, Charleston Grey, Sugar Baby
	Diffused	Arka Manik
	Clearly defined	Thar Manak
Fruit: colour of Flesh	White	-
	Yellow	Durgapura Kesar
	Orange	-
	Reddish pink	-
	Light red	-
	Dark red	Sugar Baby, Asahi Yamato
Seed: colour of coat	White	Durgapura Kesar
	Grey	AHW-65, Asahi Yamato
	Red	-
	Brown	Durgapura Lal
	Black	Sugar Baby
	Others	-

*Visual assessment by a single observation of a group of plants or parts of plant.

Table 2. Quantitative traits of watermelon varieties

Character	States*	Example varieties	Type of assessment
Plant: length of internodes (cm)	Short (<7)	-	MS
	Medium (7-8.5)	Durgapura Lal, Sugar Baby	
	Long (>8.5)	Arka Manik, Charleston Grey	
Leaf blade: length (cm)	Short (<10)	Durgapura Lal, Thar Manak	
	Medium (10-14)	Asahi Yamato	
	Long (>14)	Charleston Grey	
Leaf blade: width (cm)	Narrow (<9)	Durgapura Lal	
	Medium (9-12)	-	
	Broad (>12)	Charleston Grey, Durgapura Kesar	
Petiole: length (cm)	Short (<7)	Durgapura Lal	
	Medium (7-9)	Arka Manik, Asahi Yamato	
	Long (>9)	Charleston Grey	
Appearance of first pistillate/ perfect flower in 50% plants from date of sowing (days)	Early (<45)	Sugar Baby	MG
	Medium (45-50)	Durgapura Kesar	
	Late (>50)	Arka Manik, Durgapura Lal	
Ovary: length (cm)	Short (<1)	Arka Manik	MS
	Medium (1-2)	Durgapura Lal, Thar Manak	
	Long (>2)	Charleston Grey	
Ovary: width (cm)	Narrow (upto 0.8)	Asahi Yamato, Sugar Baby	
	Broad (>0.8)	Durgapura Kesar	
Fruit: length (cm)	Short (<20)	Sugar Baby	MS
	Medium (20-30)	Arka Manik, Durgapura Lal	
	Long (>30)	Charleston Grey	
Fruit: diameter (cm)	Narrow (<15)	Charleston Grey	
	Medium (15-25)	Durgapura Lal	
	Broad (>25)	Arka Manik	
Fruit: size (kg)	Small (<3)	Sugar Baby	
	Medium (3-6)	Arka Manik, Durgapura Lal	
	Large (>6)	-	
Seediness: number of seeds/ fruit	Absent or rudimentary (<20)	-	
	Low (<150)	-	
	Medium (150- 350)	Charleston Grey, Sugar Baby	
	High (>350)	Durgapura Kesar	
Seed: length (cm)	Short (<0.6)	Arka Manik	
	Medium (0.6-1)	Sugar Baby	
	Long (>1)	Charleston Grey	
Seed: width (cm)	Narrow (<0.4)	Asahi Yamato	
	Medium (0.4-0.7)	Sugar Baby	
	Broad (>0.7)	Charleston Grey	

MS, Measurement of a number of individual plants or parts of plant.
MG, Measurement by a single observation of a group plants or parts of plant.

and Arka Manik. The rind colour of fruit has been grouped as yellow in Kashi Pitamber, light green in Asahi Yamato and Charleston Grey, medium green in Durgapura Kesar and dark green in Sugar Baby. In fruit surface, varieties have been grouped as weak (Asahi Yamato, Charleston Grey and Sugar Baby) in diffused (Arka Manik). The flesh colour was expressed as yellow in Durgapura Kesar and dark red in Sugar Baby and Asahi Yamato. The seed colour was white in Durgapura Kesar, grey in AHW65 and Asahi Yamato), brown in Durgapura Lal) and black in Sugar Baby). Among qualitative chracters, degree of primary lobing

of leaf blade, fruit shape in longitudinal section, rind colour of fruit, fruit stripes, flesh colour, and seed coat colour were grouping characters. Bell pepper (Sood *et al.,* 2011), cabbage (Singh *et al.,* 2012), French bean (Singh *et al.,* 2014) and muskmelon (Choudhary *et al.,* 2015) have been characterized for different qualitative traits for their application in DUS testing.

Quantitative Traits

The quantitative characters also showed wide variation among all varieties (Table 2). Since earliness is an important character, and all varieties have been categorized as early-(Sugar Baby), medium (Durgapura Kesar) and late-maturing (Arka Manik, Durgapura Lal). On the basis of ovary length, varieties have been categorized into short (<1 cm), medium (1-2 cm) and long (>2 cm), whereas small (Sugar Baby) and medium (Arka Manik and Durgapura Lal) for fruit size. Based on number of seeds / fruit, varieties with 150-350 seeds / fruit have been categorized as medium seediness (Charleston Grey and Sugar Baby) and with >350 seeds / fruit as high-seeded (Durgapura Kesar). The characters, viz. fruit size and seediness of fruits were indentified as grouping traits for DUS testing. Sood *et al.* (2011) also described the variability for quantitative traits in bell pepper; Choudhary *et al.* (2012) in watermelon; Singh *et al.* (2012) in cabbage; Singh *et al.* (2014) in French bean and Choudhary *et al.* (2015) in muskmelon for their application in distinctness, uniformity and stability testing.

Variability especifically to degree of leaf blade lobing (primary and secondary) in Durgapura Lal, yellow ovary in Kashi Pitamber, cylindrical fruit shape in longitudinal section in Charleston Grey, white seed coat in Durgapura Kesar was observed as distinct trait. Thus, it may be concluded that watermelon varieties can easily be differentiated on the basis of qualitative and quantitative traits and utilized in DUS testing as reference material for protection of other varieties under PPV&FR Act, 2001.

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Effect of scion dipping treatment of IAA, BAP and $ZnSO_4$ on sprouting, mortality and survival percentage of epicotyl grafting in *(Mangifera indica)* cv. 'Kesar'

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ABSTRACT

The experiment was conducted to find out the effect of IAA, BAP and $ZnSO_4$ on sprouting, mortality and survival percentage of epicotyl grafting in mango (*Mangifera indica* L.) cv. Kesar at Regional Horticultural Station, NAU, Navsari, during 2015-16. The results revealed that among different treatments BAP 20 mg/litre + 750 mg/litre $ZnSO_4$ was found to be beneficial for maximum number of grafts sprouted, early sprouting, lower mortality and higher survival percentage. The use of zinc sulphate alone or in combination with benzyl amino purine can be successfully utilized for producing healthy and vigorous epicotyl grafts with high survival percentage of mango cv. 'Kesar'.

Key Words: Zinc sulphate, Epicotyl graft, Survival percentage, IAA and BAP, Morality

Grafting is an ancient cloning method that has been used widely for thousands of years in agricultural practices. Graft union development is a complicated process that involves substantial changes such as organ regeneration and genetic material exchange. There is compelling evidence supporting the role played by different plant hormones in formation of a successful graft union and differentiation of cells into specialised phloem and xylem. In spite of the complexity of structure and development of the vascular tissues, there is evidence that the differentiation of both the sieve tubes and vessels is induced by two hormonal signals, namely: (i) auxin, indole-3-acetic acid (IAA), produced mainly by young leaves and (ii) cytokinin produced by root apices (Raven *et al.*, 1992).

Investigation of IAA on success of epicotyl grafting was done and conclusion was drawn that IAA concentration of 750 ppm was found to be the best (Narwadkar and Anserwadekar, 1989). Kulkarni *et al.* (1988) observed a great success of veneer grafting with low concentration of Benzyl Amino Purine (BAP). Further exploitation was carried out for the use of hormones in respect to success of grafts and promising result was noticed. Later in Japan, Yamashita *et al.* (2006) observed that zinc in combination with auxin enhanced rooting of cuttings in Taiwan native strain of mango due to callus formation. The application of hormones and zinc in the success of epicotyl grafts have not been thoroughly documented in replicated trails. For a better understanding, the study deals with the effect of growth regulators and $ZnSO_4$ on the number of graft sprouted, mortality, sprouting and survival percentage of epicotyl grafting in mango cv. 'Kesar'.

MATERIALS AND METHODS

The experiment was conducted at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, during 2015 and 2016. The treatment tested were T_1, control, T_2, distilled water, T_3, $ZnSO_4$ 500 mg/litre, T_4, $ZnSO_4$ 750 mg/litre, T_5, IAA 750 mg/litre, T_6, IAA 750 mg/litre + $ZnSO_4$ 500 mg/litre, T_7, IAA 750 mg/litre + $ZnSO_4$ 750 mg/litre, T_8, BAP 10 mg/litre, T_9, BAP 20 mg/litre, T_{10}, BAP 10 mg/litre + $ZnSO_4$ 500 mg/litre, T_{11}, BAP 10 mg/litre + $ZnSO_4$ 750 mg/litre, T_{12}, BAP 20 mg/litre + $ZnSO_4$ 500 mg/litre, T_{13}, BAP 20 mg/litre + $ZnSO_4$ 750 mg/litre.

The experiment was laid in a completely randomized design with three replications. There were 20 grafts in each replication of all the 13 treatments. Seeds were sown in July at 10 cm distance in nursery beds. Uniform seedlings of normal growth and required age were selected for grafting. Kesar variety of mango was chosen as scion for grafting. The healthy scion shoots from current season growth were defoliated 7 days prior to grafting. The grafting operation was done in first week of August. Seedlings of required age were lifted from beds along with stones and grafting was done in shade using wedge method of grafting.

Dipping cut portion of scion in beaker containing freshly prepared solution for 10-15 seconds before scions were grafted. Epicotyl grafts were planted in 12cm × 18 cm polythene bags containing potting mixture of soil, vermicompost and farmyard manure (1:1:1). The epicotyl grafting was done by wedging technique of grafting. The whole polybags were drenched with *Pseudomonas fluorescens* and *Trichoderma viride*. All the grafted plants in polythene bags were kept in polytunnel for 25-30 days. After one month of grafting polytunnel were removed and then kept in 50% shade net. The grafts were observed for initial success (sprouting) after confirming that there would not be any more sprouting. The observations on survival percentage were recorded one month after grafting.

RESULTS AND DISCUSSION

There was a significant effect on number of days taken for first sprouting by different concentrations of IAA, BAP and $ZnSO_4$ treatments (Table 1). Minimum (8.07 days) number of days taken for first sprouting was noted in BAP 20 mg/litre + $ZnSO_4$ 750 mg/litre which was at part of T_{12}. While, maximum (13.13 days) number of days to first sprouting (13.00 days) was observed in distilled water (T_2).

The greatest carbohydrate loss occurred during the first day after grafting and was twice as high in the basal part of the scion as in the apical part. Treating only the base of the scion with cytokinin and zinc sulphate produced a sink for carbohydrates and induced the translocation of sugars to the union area. This sink was observed only after callus formation was evident, since accumulation take place against a concentration gradient a direct action of cytokinin (Hartmann, 1977). Zinc aids in carbohydrate metabolism through sucrose loading and sucrose synthase activity (Brown *et al.*, 1993). Hence, less time was required for days for leaf emergence with increase in concentration cytokinin and zinc sulphate combination.

The maximum day for leaf emergence was observed in case of scion treated with distilled water. It might lead to changes in cambial activity due to the

Table 1. Effect of plant growth regulators and zinc sulphate on days taken for first sprouting, number of graft sprouted, graft success at 1 month, mortality and survival percentage in epicotyl grafting of mango cv. Kesar

Treatment	Days taken for first sprouting (days)	No. of grafts sprouted at 1 month (per 20 grafts)	Graft success (%) at 1 month	Mortality (%) at 6 MAG	Survival (%) 6 MAG
T_1	11.40	11.33	56.67 (48.84)	51.67 (45.96)	48.33 (44.04)
T_2	13.00	10.67	53.33 (46.91)	65.00 (53.76)	35.00 (36.24)
T_3	11.73	14.33	71.67 (57.86)	45.00 (42.12)	55.00 (47.88)
T_4	9.87	14.67	73.33 (58.93)	41.67 (40.20)	58.33 (49.80)
T_5	10.93	13.33	66.67 (54.75)	50.00 (45.00)	50.00 (45.00)
T_6	11.13	14.67	73.33 (59.05)	38.33 (38.24)	61.67 (51.76)
T_7	9.80	9.33	46.67 (43.09)	55.00 (47.87)	45.00 (42.13)
T_8	11.47	15.67	78.33 (62.29)	40.00 (39.23)	60.00 (50.77)
T_9	10.73	14.67	73.33 (58.93)	50.00 (45.00)	50.00 (45.00)
T_{10}	11.07	15.67	78.33 (62.29)	36.67 (37.26)	63.33 (52.80)
T_{11}	10.00	16.33	81.67 (64.69)	25.00 (30.00)	75.00 (60.00)
T_{12}	8.27	17.33	86.67 (68.66)	23.33 (28.86)	76.67 (61.14)
T_{13}	8.07	18.00	90.00 (71.57)	18.33 (25.31)	81.67 (64.70)
SEm±	0.33	0.39	1.29	0.98	0.98
CD at (5%)	0.98	1.14	3.75	2.85	2.85
CV(%)	5.52	4.75	3.83	4.25	3.39

*Values in parenthesaes are arcsine transformed values.

discontinuation moisture supply, resulting from uprooting of seedlings and distilled water does not have any effect to increase callus formation between joints.

There was a significant difference in number of grafts sprouted and graft sprouting percentage 1 month after grafting with the application of various concentrations of IAA, BAP and $ZnSO_4$ treatments (Table 1). Maximum (18.00 grafts per 20 grafts) number of grafts sprouted and graft sprouting (71.57%) at 1 month was observed with the application of BAP 20 mg/litre + $ZnSO_4$ 750 mg/litre and was statistically at par with T_{12}. While, minimum (9.33 grafts per 20 grafts) number of graft sprouted and graft sprouting (43.09 %) at 1 month was recorded with IAA 750 mg/litre + $ZnSO_4$ 750 mg/litre.

In the course of vascular development, phloem differentiation precedes that of xylem. Therefore, first element to differentiate from the procambium are the sieve elements. In tissue culture and grafting the vascular differentiation have a similar sequential pattern in which the phloem appears before the xylem (Esau, 1969). Phloem differentiation is promoted at low auxin and high cytokinin leads to better phloem formation. Cytokinin is controlling factor in sieve-tube regeneration around wounded cut surfaces (Aloni *et al.,* 1990).

Cytokinin increases the sensitivity of vascular cambial cells to auxin stimulation. Cytokinin also promotes nutrient mobilization by creating a new source-sink relationship. The nutrients (sugars, carbohydrates, amino acids, *etc.*) are preferentially transported to and accumulate in cytokinin-treated tissues acting as sink (Roitsch and Ehne, 2000). Ohkawa (1984) reported that higher sprouting with the application of BAP in rose.

Zinc regulates the activity of sucrose synthase and aldose activity which in turn regulates the formation of sucrose. Zinc also plays a role in metabolism of starch and aid in translocation of sucrose through phloem loading of sucrose (Brown *et al.,* 1993).

The combination of sink formation by cytokinin and increased activity and metabolism of starch and sucrose by zinc, might have lead to higher sprouting in BAP 20 mg/litre + $ZnSO_4$ 750 mg/litre treatment and all other combination of BAP and zinc sulphate.

The survival percentage and mortality of epicotyl graft significantly differed due to different treatments (Table 1). The maximum survival percentage (64.70 %) and minimum mortality (25.31 %) were noted in epicotyl grafts treated with BAP 20 mg/litre + $ZnSO_4$ 750 mg/litre(T_{13}). While, minimum survival percentage and maximum mortality (45.96 %) of graft after 6 months grafting (36.24 %) was observed in scions which were dipped in distilled water (T_2).

Production of new xylem and phloem permits the vascular connections between scions and rootstock. It is essential that this stage be completed much before leaf development. Otherwise, the enlarging leaf surfaces on scion shoots have little or no water to offset that lost by transpiration and scion will quickly become desiccated and die, causing low survival (Hartmann *et al.,* 2002).

Firstly high cytokinin may have acted in producing quick phloem in presence of low concentration of auxin (Aloni *et al.,* 1990). Then elemental zinc may aid in the increased tryptophan synthesis and maintenance of IAA which will lead to higher accumulation of IAA, thereby leading to formation of xylem in graft union after phloem formation (Masev and Kutacek, 1966). These have leder to higher survival percentage of graft in BAP 20 mg/litre + $ZnSO_4$ treatment and all other BAP and zinc combination.

The number of days from grafting to sprouting was negatively correlated with sprouting and survival of grafted plants, indicating that a delay in sprouting period caused a decrease in sprouting and survival of grafts. The sprouting percentage of grafts was positively correlated with survival percentage of grafts and number of leaves per grafts (Pandey and Singh, 2001). Hence, maximum survival percentage and minimum mortality was obtained with the combination of BAP 20 mg/litre, BAP + $ZnSO_4$ 750 mg/litre treatment. While, minimum survival percentage and maximum mortality was found in case of scion treated with distilled water.

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Evaluation of aonla *(Emblica officinalis)* varieties under hot semi-arid conditions of Western India

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ABSTRACT

An experiment was conducted to evaluate aonla (*Emblica officinalis* Garten) varieties for their vegetative and fruit characters at KVK, Panchmahal, Vejalpur (Godhra), Gujarat, under rainfed hot semi-arid ecosystem during 2013-14. All varieties behaved differently in their vegetative and fruit characters. The growth habit was observed as tall drooping, upright spreading, tall semi-spreading and tall upright. The plant height varied from 3.64 to 5.69 m in all varieties. The trunk colour (grey and whitish green), leaf shape (oval oblong,oblong and elliptical), leaf apex (obtuse and acute) also varied. The size of leaves in terms of length and width ranged between 1.28 cm × 0.24 cm and 48 cm × 0.33 cm, respectively. The time of fruit setting and time of fruit maturity differed considerably among all varieties. The highest fruit setting (51.95%) and fruit retention (26.40%) were recorded in NA 7, whereas it was lowest in Francis (36.56% and 11.43%). Variations in size of fruits was marked as small, medium and large. The highest fruit weight was found in NA 7, while it was lowest in Anand 2. The qualitative characters, *viz*. fruit juice content, acidity, pulp content, vitamin C content, TSS, TSS : acid ratio and stone weight were 41.56-71.62%, 2.04-2.16%, 24.57-31.76 g, 348.42-543.82 mg/100 g, 9.74-11.75% and 4.05-5.66 g and 1.96-2.09 g, respectively. The stone in fruits also varied with respect to its shape (oval, oval round and round) and size and seed (small, medium and large).

Key Words: Vegetative characters, Fruit characters, Qualitative characters, Semi-arid condition, Fruit setting, Pulp content, Stone weight, Seed size

Aonla or Indian gooseberry (*Emblica officinalis* Gaerten), is widely grown in Uttar Pradesh, Gujarat, Rajasthan, Madhya Pradesh and Tamil Nadu. It has been identified as an ideal plant for wastelands, *viz*. moisture stressed, eroded, riverbed and in undulated topography (Korwar *et al.*, 2006), due to its several specific characters like intensive and deeper root system, reduced leaf area, summer dormancy of zygote, synchronization of fruit growth and development with maximum moisture availability period (monsoon) and selective absorption of ions which enable it to grow in arid and semi-arid agroclimatic conditions. It bears two types of shoots. On the basis of shoot growth, they are characterized as long or indeterminate and short or determinate (Bajpai, 1965). The new determinate shoots emerged out during first week of April (Ram, 1971), while flowering takes place in axil of leaves. However, there are two prominent cropping seasons in South India, *i.e*. July-August and April May (Naik, 1963). The fertilized ovaries remain dormant for three-and-a-half months and resume growth in August after the onset of mansoon.

Aonla has gained momentum under hot arid region because of its hardy nature, prolific-bearing, potential fruit crop and capacity to grow under various adversities (Shukla *et al.*, 2002). After development of new cultivars, *viz*. Krishna, Kanchan, NA 6, NA 7, NA 10, Anand 1 and Anand 2, its crop has emerged as a remunerative fruit crop in India (Dhandar and Shukla, 2003). Since all cultivars of aonla did not performing equally well under the hot semi arid ecosystem, the yield and quality attributes due to extremes of high temperature and high wind velocity are not fit for fruit setting. Keeping in view, an experiment was conducted to assess the

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performance of different varieties and to select varieties for cultivation under hot arid ecosystem.

MATERIALS AND METHODS

The experiment was conducted at Krishi Vigyan Kendra, Godhra, Gujarat, during 2013-14. The annual rainfall is mainly confined in the monsoon period (July-September) and actual mean precipitation is about 750-1220 mm, and the total number of rainy days average to about 32.55. The mean summer temperature is 32.9°C while mean winter temperature is 21.3°C, indicating that area falls under hyperthermic soil regime. The mean annual maximum and minimum temperatures vary from 42 to 44°C (May) and 6 to 9°C (January), respectively. The soil of experimental site is characterized with available N (142.22-150.65 kg/ha), P (6.35-8.86 kg/ha) and K (142.55-146.25 kg/ha), and organic carbon (0.33%), EC (0.14 dS/m) and pH (8.34). The soil depth of experimental field ranged from 0.76 to 1.16 m derived from mixed alluvial basalt, quartzite, granite and layers of limestone, and falls under semi-arid hot climate.

Five varieties, *viz.* Francis, Chakaiya NA 7, Goma Aishwarya and Anand 2, were established through *in-situ* patch budding. The experiment was laid out in a randomized block design with three replications considering three plants as unit of each treatment. The uniform management practices were adopted for all cultivars. To assess growth parameters like tree habit, tree form, tree height, trunk colour, foliage, leaf size, leaf shape and leaf apex and different fruit characters, *viz*. time of fruit setting, time of fruit maturity and fruit retention percentage were observed in all varieties uniformly. Fruits were randomly selected from all directions of the plant for fruit weight, length, width, stone weight and stone shape. The juice per cent, acidity, and total soluble solids of pulp were determined by the standard methods and vitamin C was determined as per AOAC (1980). The pooled data were statistically analyzed as per method given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth attributes

The data reveals that aonla varieties had considerable difference in tree habit. It was observed tall drooping in Francis, upright spreading in, Chakaiya, tall semi-spreading in NA 7 and Goma Aishwarya, and tall upright in Aanad 2 (Table 1). Plant height was maximum (5.63 m) in Anand 2, followed by Francis (4.24 m), while it was minimum (3.83 m) in Chakaiya. The foliage in Francis and NA 7 was sparse, whereas Chakaiya, Goma Aishwarya and Anand 2 had dense foliage. The leaf shape was oblong in Chakaiya, Goma Aishwarya and Anand 2; oval oblong in Francis, and elliptical in NA 7. The leaf apex was mainly of two kinds, *i.e.* acute and obtuse. All the varieties had obtuse leaf apex excluding Chakaiya.

The leaf length was maximum (1.48 cm) in Francis followed by Chakaiya (1.46 cm), NA 7(1.42 cm), Goma Aishwarya (1.38 cm), and minimum being in Anand 2 (1.28 cm). The width of leaf was maximum in Francis (0.33 cm), followed by Chakaiya (0.31 cm), NA 7 (0.30) and Goma Aishwarya (0.29), whereas it was minimum (0.24 cm) in Anand 2. The inflorescence colour was yellowish-green in Francis, Pinkish green in Chakaiya, green to light pink in NA 7, Goma Aishwarya and light green to pinkish in Anand 2. The similar findings were also reported by Pareek and Nath (1996) in aonla under arid conditions.

However, variation in plant growth characters in different cultivars may be attributed to genetic features of individual variety and their adoptability to agroclimatic conditions (Dhandar and Shukla, 2004 Kumar *et al.* 2014) in aonla.

Fruit characters

The time of fruit setting ranged from second fortnight of February to second fortnight of March. It was noticed during second fortnight of February in NA 7 and Goma Aishwarya first fortnight of March in Francis and Chakaiya and second fortnight of March in

Table 1. Growth characters of different aonla varieties.

Character	Francis	Chakaiya	NA 7	Goma Aishwarya	Anand 2
Tree habit tree form	Tall drooping	Upright spreading	Tall semi-spreading	Tall semi-spreading	Tall upright
Tree height (m)	4. 24	3.83	4.08	3.64	5.69
Trumk colour	Grey	Grey	Whitish green	Grey	Grey
Foliage	Dense	Sparse	Dense	Sparse	Sparse
Leaf length (cm)	1.48	1.46	1.42	1.38	1.28
Leaf width (cm)	0.33	0.31	0.30	0.29	0.24
Leaf shape	Oval oblong	Oblong	Elliptical	Oblong	Oblong
Leaf apex	Obtuse	Acute	Obtuse	Obtuse	Obtuse

Table 2. Fruit characters of aonla varieties

Character	Francis	NA 7	Chakaiya	Goma Aishwarya	Anand 2
Time of fruit setting	First fortnight of March	Second fortnight of February	First fortnight of March	Second fortnight of February	Second fortnight of March
Time of fruit maturity	24-31 October	23-31 October	8-14 0November	1-8 November	23-30 November
Days to maturity	216 days	207 days	210 days	213 days	220 days
Fruit shape	Flattened round	Flattened round	Flattened round	Flattened round	Flattened oval
Fruit colour	Light green	Yellowish green	Light green	Yellowish green	Yellowish green
Flesh colour	Whitish green	Whitish Green	Whitish green	Whitish Green	Whitish green
Fruit stalk	Short and thin	Short and thick	Short and thin	Short and thick	Short and thin
Fruit stem end cavity	Shallow	Deep	Sallow	Deep	Shallow
Styler end	Levelled	Less prominent	Levelled	Less prominent	Less prominent
No. of segments in fruits	6	6	6	6	6

Anand 2. The time of fruit maturity was observed during last week of October in Francis and NA 7, first week of November in Goma Aishwarya, second week of November in Chakaiya and last week of November in Anand 2. Days of maturity in different varieties was 207-220 days (Table 2). The fruit shape of varieties was flattened round in Francis, NA 7, Chakaiya and Goma Aishwarya and flattened oval in Anand 2.

The fruit colour was light green in Francis and Chakaiya; yellowish-green in NA 7, Goma Aishwarya and Anand 2. The flesh colour of all tested varieties was whitish green. The fruit stalk was observed short and thick in NA 7 and Goma Aishwarya, and short and thin was observed in Francis, Chakaiya, and Anand 2. Fruit stem end cavity was noticed shallow and deep, it was observed shallow in Francis, Chakaiya and Anand 2, whereas it was deep in NA 7 and Goma Aishwarya. Styler end was levelled in Francis and Chakaiya; less prominent in NA 7, Goma Aishwarya and Anand 2. Number of fruit segments in all varieties was counted six. The similar findings are also reported by Kumar *et al.* (2014) in aonla.

Quantitative characters

There was highest fruit setting in NA 7 (52.55%), followed by Goma Aishwarya (48.76%), Chakaiya (37.85%), Anand 2 (37.56) and lowest being in Francis (36.62). The maximum fruit retention were recorded in NA 7 (27.30%), followed by Goma Aishwarya (24.52%), Anand 2 (19.85) and minimum being in Francis (12.55%). The fruit weight ranged from 27.75 to 34.85 g, maximum being in NA 7 (34.85 gm), followed by Goma Aishwarya (32.36 g), Chakaiya (30.66 g), Francis (30.41 g) and minimum in Anand 2 (27.75 g). The fruit length ranged 3.08 to 3.65 cm, whereas it was maximum in NA 7 (3.65 cm), followed by Goma Aishwarya (3.56 cm), Chakaiya (3.37), Anand 2 (3.11 cm), and minimum in Francis (3.08 cm) (Table 3). Among varieties, fruit width varied from 3.43 and 4.05 cm, and maximum width was observed in Chakaiya (4.05 cm), followed by NA 7 (4.05 cm), Goma Aishwarya (3.97 cm), Anand 2 (3.43 cm), whereas it was minimum in Francis (3.44 cm). The size of fruit was measured as large of Francis, medium of NA 7, Chakaiya and Goma Aishwarya and small of Anand 2. Similar kind of result also obtained in aonla by Kumar *et al.* (2014), Singh *et al.* (2012) in bael, Singh *et al.* (2014) in *Morinda tomentosa* and by Singh *et al.* (2006) in chironji.

Qualitative characters

There was maximum juice in NA 7 (71.62%), followed by Anand 2 (65.38%), Francis (60.62%), Goma Aishwarya (48.08%), minimum being in Chakaiya (41.56%). The astringency level was high in Chakaiya, medium to high in Anand 2, medium in Francis and Goma Aishwarya, and lowest in NA 7. The acidity ranged from 2.03 to 2.16% highest being in Chakaiya (2.16%), followed by Goma Aishwarya (2.13%), NA 7 (2.07%), Francis (2.05%), and lowest (2.04 %) in Anand 2. The pulp content ranged from 24.57 to 31.76 g, and it was maximum (31.76 g), in NA 7 followed by Goma Aishwarya (29.87 g), Chakaiya (28.63 g), whereas minimum pulp content was found in Anand 2 (24.57 g), followed by Francis (28.31 g) (Table 4). The vitamin C content among all varieties ranged between 348.42 and 543.82 mg / 100 g and it was maximum (543.82 mg / 100 g) in Goma Aishwarya, followed by NA 7 (454.23 mg / 100 g), Anand 2 (416.83), Chakaiya (400.52) and

Table 3. Quantitative characters of fruits in *aonla* varieties.

Variety	Fruit setting (%)	Fruit retention (%)	Fruit size (cm)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)
Francis	36.62	12.55	Large	3.08	3.44	30.41
NA 7	52.95	27.30	Medium	3.65	4.05	34.85
Chakaiya	37.85	24.52	Medium	3.37	4.06	30.66
Goma Aishwarya	48.76	23.44	Medium	3.56	3.97	32.36
Anand 2	37.56	19.85	Small	3.11	3.43	27.75
CD (5%)	3.42	1.19	–	0.05	0.21	0.70

Table 4. Qualitative characters of fruit in *aonla* varieties

Variety	Juic (%)	Astringency	Pulp (g)	TSS (%)	Acidity (%)	Vitamin-C (mg 100/ g)	TSS: acid
Francis	60.62	Medium	28.31	9.74	2.05	348.42	4.05
NA 7	71.62	Low	31.76	11.58	2.07	454.23	5.66
Chakaiya	41.56	High	28.63	10.66	2.16	400.52	5.08
Goma Aishwarya	48.08	Medium	29.82	11.75	2.13	543.82	5.55
Anand 2	65.38	Medium to high	24.57	10.27	2.04	416.83	5.07
CD (5%)	0.49	-	0.21	0.11	0.18	34.22	0.46

Table 5. Seed characters of different *aonla* varieties

Character	Francis	NA 7	Chakaiya	Goma Aishwarya	Anand 2
Stone shape	Oval	Oval round	Round	Oval round	Round
Stone size	Medium	Large	Small	Medium	Small
Stone weight (g)	2.09	1.96	2.04	2.03	2.05

minimum in Francis (348.42 mg / 100 g). The total soluble solids were recorded the maximum (11.75% Brix) in Goma Aishwarya, followed by NA 7 (11.58° Brix), Chakaiya (10.66), Anand 2 (10.27° Brix), while Francis had minimum value (9.74° Brix). TSS : acid ratio was 4.05-5.66, wherein it was maximum in NA 7 (5.66), followed by Goma Aishwarya (5.55), Chakaiya (5.08), Anand 2 (5.05) and minimum (4.05) being in Francis. These results are in agreement with those of Pathak *et al.* (1993) and Mishra *et al.* (2007) in aonla, Singh *et al.* (2012) in bael, Singh *et al.* (2014) in *Morinda tomentosa* and Mahajan and Dhillon (2000).

Seed attributes

There was wide variability in quantitative and qualitative characters in different varieties (Table 5). Stone shape was oval in Francis; oval-round in NA 7 and Goma Aishwarya; round in Chakaiya and Anand 2. The size of stone was large in NA 7, medium in Goma Aishwarya and Francis and small in Anand 2 and Chakaiya (Table 5). The stone weight ranged from 1.96 to 2.09 g. The maximum stone weight was recorded in Francis (2.09 g), followed by Anand 2 (2.05 g), Chakaiya (2.04 g), Goma Aishwarya (2.03 g) and minimum in NA 7 (1.96 g). The size seed varied from small to large; it was large in of NA 7, medium in Francis and small in Chakaiya, Goma Aishwarya and Anand 2. Thus, it may be concluded that aonla varieties varied in their morphological and fruit quality characters and can be helpful in further improvement.

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Study on combining ability for yield and yield components in okra *(Abelmoschus esculentus)*

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ABSTRACT

The combining ability in 21 F_1s of okra [*Abelmoschus esculentus* (L.) Moench] were studied for 15 characters through diallel hybridization technique without reciprocals with seven parents in RBD with three replications.Both general combining ability and specific combining ability variances were significant for plant height, internodal length, number of fruits / plant, stem diameter, fruit yield / plant and fibre content. Thus, both additive and non-additive variance are important in expression of these traits. Genotypes, GAO-5, AOL-09-02 and AOL-09-17, were good general combiner for fruit yield. The estimates of sca effect showed the cross combinations, GAO-5 × AOL-09-02, AOL-09-17 × AOL-09-02 and GAO-5 × AOL-09-17. most promising for fruit yield and other traits.

Key Words: Combining ability, Half diallel analysis, Variances, Yield components, Hybridization, Stem diameter, Genotypes

Okra is an economically important vegetable crop. One of the major problem in okra cultivation in India is lack of location-specific and high-yielding varieties. For crop improvement programme, proper choice of parents based on their combining ability is a prerequisite. The knowledge of combining ability helps in identifying best combiners, which may be hybridized either to exploit heterosis or to accumulate fixable genes through selection. The general and specific combining ability in respect of a character is the manifestation of additive and non-additive gene action, respectively. The diallel analysis is one of the most useful techniques for preliminary evaluation of genotypes for use in to identify good combiners. Hence, an experiment was conducted to study the gene action in different quantitative traits and to study the combining ability for yield and its components in okra.

MATERIALS AND METHODS

The materials for investigation comprised seven diverse genotypes of okra namely, AOL-09-02, AOL-09-17, AOL-10-22, AOL-11-34, AOL-11-49, GAO-5 and AOL-10-03. All the genotypes were crossed in diallel fashion excluding reciprocals during *kharif* 2012. Seven parents and 21 hybrids were evaluated in a randomized block design (RBD) with three replications at Regional Horticultural Research Station, Navsari Agricultural University, Navsari, Gujarat during summer 2013. The distance were maintained at 60 cm × 30 cm. All the recommended package of practices was adopted to raise a good crop. The observations were recorded on 5 competent plants for 15 quantitative traits, *viz.* days to first flowering, internodal length (cm), number of branches / plant, number of fruits / plant, plant height (cm), fruit yield / plant (g), stem diameter (cm), first flowering node, fruit length (cm), fruit diameter (mm), fruit weight (g), stalk length (cm), number of seeds / fruit, 100-seed weight (g) and fibre content (%). Combining ability analysis was performed by employing Model - I (fixed effect model), Method - II proposed by Griffing (1956).

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RESULTS AND DISCUSSION

Both gca and sca variances were significant for plant height, internodal length, number of fruits / plant, stem diameter, fruit yield / plant and fibre content (Table 1). This suggested that both additive and non-additive variance were important in the expression of these traits. The estimated variance due to sca were considerably higher than the estimated variance due to gca for all the characters except days to first flowering.

Table 1. Mean square due to general and specific combining ability for yield and its components in okra

Source of variation	d.f.	Plant height (cm)	Days to first flower-ing	Inter nodal length (cm)	Number of branches / plant	Number of fruits / plant	Stem diameter (cm)	Fruit yield / plant (g)	First flower-ing node	Fruit length (cm)	Fruit dia-meter (mm)	Fruit weight (g)	Stalk length (cm)	Number of seeds / fruit	100-seed weight	Fibre content (%)
GCA	6	53.331**	11.844**	0.896**	0.104	12.627**	0.039**	1508.988**	0.376*	0.158	0.204	0.56	20.576	4.123	0.210	0.135**
SCA	21	41.823**	2.984	0.254**	0.102	3.286**	0.056**	572.605**	0.096	0.700**	0.541	0.29	41.740	19.500**	0.236*	0.364**
Error	54	14.523	2.293	0.074	0.104	0.566	0.008	41.713	0.124	0.200	0.091	0.20	29.101	3.141	0.125	0.027
σ2 gca		4.312	1.061	0.091	0.000	1.340	0.003	163.031	0.028	-0.005	0.013	0.04	-0.947	0.109	0.009	0.012
σ2 sca		27.299	0.692	0.180	-0.002	2.720	0.049	530.891	-0.028	0.501	0.450	0.09	12.640	16.359	0.111	0.338
σ2 gca / σ2 sca		0.158	1.535	0.508	-0.024	0.493	0.071	0.307	-0.985	-0.009	0.028	0.45	-0.075	0.007	0.085	0.035

Table 2. General combining ability *(gca)* effects for different characters in okra

Source of variation	Plant height (cm)	Days to first flower-ing	Inter nodal length (cm)	Number of branches / plant	Number of fruits / plant	Stem diameter (cm)	Fruit yield / plant (g)	First flower-ing node	Fruit length (cm)	Fruit dia-meter (mm)	Fruit weight (g)	Stalk length (cm)	Number of seeds / fruit	100-seed weight	Fibre content (%)
AOL-09-02	1.688	-1.181*	0.367**	0.078	1.167**	0.016	13.162**	-0.125	-0.246	0.185	0.303*	1.481	0.010	0.049	0.139**
AOL-09-17	1.277	-0.247	-0.262**	0.152	0.641**	0.044	4.869*	-0.251*	0.090	0.132	0.244	0.741	-0.056	0.040	0.047
AOL-10-22	-0.441	1.513**	-0.348**	-0.135	-1.259**	-0.041	-7.437**	0.304**	0.082	-0.107	-0.332*	1.852	-0.314	-0.252*	-0.098
AOL-11-34	-1.667	1.407**	0.141	-0.099	-1.129**	0.043	-8.894**	0.014	-0.045	0.011	-0.228	-0.370	-0.172	-0.020	-0.042
AOL-11-49	-3.306**	-0.031	-0.159	-0.050	-0.962**	-0.132**	-15.064**	0.202	0.060	-0.150	-0.155	-0.741	-0.148	-0.082	0.014
GAO-5	3.887**	-1.473**	0.441**	0.092	1.685**	0.031	20.069**	-0.191	0.136	0.119	-0.021	-2.593	1.427*	0.256*	0.136**
AOL-10-03	-1.437	0.012	-0.181*	-0.038	-0.144	0.039	-6.706**	0.047	-0.077	-0.190	0.188	-0.370	-0.747	0.010	-0.196**
S.E (gi) +	1.796	0.713	0.128	0.151	0.354	0.041	3.044	0.166	0.210	0.141	0.212	2.542	0.835	0.166	0.077

Table 3. Specific combining ability (sca) effects for different characters in okra

Source of variation	Plant height (cm)	Days to first flower-ing	Inter nodal length (cm)	Number of branches / plant	Number of fruits / plant	Stem diameter (cm)	Fruit yield / plant (g)	First flower-ing node	Fruit length (cm)	Fruit dia-meter (mm)	Fruit weight (g)	Stalk length (cm)	Number of seeds / fruit	100-seed weight	Fibre content (%)
AOL-09-17 × AOL-09-02	9.889**	-2.244	0.650**	-0.201	2.842**	-0.303**	40.080**	0.034	1.268**	0.286	0.424	1.111	6.194**	0.709*	0.258
AOL-10-22 × AOL-09-02	-1.493	-2.01	-0.298	-0.457	-1.924**	-0.181*	9.029	-0.357	0.748	-0.838**	0.622	0.000	-3.111	-0.245	0.073
AOL-11-34 × AOL-09-02	-10.251**	-0.058	0.046	-0.080	-0.554	0.294**	-29.674**	0.025	1.096**	0.216	-0.093	5.556	-0.120	-0.371	-0.489**
AOL-11-49 × AOL-09-02	-4.478	0.789	0.280	-0.186	-0.387	-0.060	-37.524**	0.342	0.147	0.025	0.430	2.593	1.153	-0.263	-0.533**
GAO-5 × AOL-09-02	8.729*	-1.365	-0.120	0.595*	3.412**	-0.070	37.623**	-0.186	0.951*	-0.364	0.072	1.111	2.718	0.734*	0.383*
AOL-10-03 × AOL-09-02	-6.564	1.360	-0.065	-0.011	-0.889	-0.261**	-2.328	0.192	-1.416**	0.604	-0.626	-11.111*	2.299	-0.751*	0.141
AOL-10-22 × AOL-09-17	-1.836	1.002	-0.702**	0.502	-2.199**	0.194*	-24.868**	-0.125	-0.661	0.105	-0.788*	-5.926	0.908	0.081	-0.912**
AOL-11-34 × AOL-09-17	-2.357	1.145	-0.057	0.272	-0.962	0.146	-10.718	-0.052	-0.533	-0.787**	0.242	-7.037	-2.891	0.338	-0.914**
AOL-11-49 × AOL-09-17	-7.484*	0.216	-0.891**	-0.113	0.105	-0.068	-22.594**	-0.309	-1.871**	-1.096**	-0.336	-10.000*	-2.991	-0.434	0.353*
GAO-5 × AOL-09-17	8.540*	-2.198	0.443	0.248	2.724**	-0.121	30.630**	-0.220	0.435	-1.118**	0.279	-1.481	8.174**	0.409	0.382*
AOL-10-03 × AOL-09-17	-5.653	3.443	0.998**	-0.312	0.420	-0.052	-16.955**	0.078	0.279	0.180	0.235	-0.370	-1.495	-0.795*	0.500**
AOL-11-34 × AOL-10-22	-1.739	2.081	-0.239	0.016	3.338**	-0.028	2.374	-0.020	-0.429	-0.601*	-0.915*	5.185	2.734	-0.173	0.577**
AOL-11-49 × AOL-10-22	6.167	2.039	-0.339*	0.390	0.172	0.404**	7.111	0.169	0.409	-0.493	0.031	2.222	-5.629**	-0.392	0.437**
GAO-5 × AOL-10-22	-1.426	0.635	0.394	-0.275	-1.009	-0.213*	-3.111	0.045	-0.324	0.058	-0.983*	-2.593	-0.535	-0.099	0.586**
AOL-10-03 × AOL-10-22	9.155**	-3.134	0.517*	-0.005	1.553*	-0.081	10.477	0.220	0.256	-0.520	0.336	1.852	4.473**	0.277	-1.309**
AOL-11-49 × AOL-11-34	6.643	-2.132	-0.094	-0.306	-0.225	0.213*	32.811**	-0.221	0.190	-0.535*	0.041	-5.556	4.415**	0.703*	0.079
GAO-5 × AOL-11-34	-0.110	0.994	0.172	-0.078	-2.172**	-0.144	-5.351	0.178	-0.557	0.499	-0.559	-3.704	3.963	-0.738*	0.519**
AOL-10-03 × AOL-11-34	7.340*	0.769	-0.139	-0.342	-1.976**	0.118	15.494**	0.759	0.497	-0.619	-0.094	-2.593	2.354	-0.089	0.462**
GAO-5 × AOL-11-49	-7.494*	1.069	0.372	-0.364	-0.705	0.245**	-36.948**	0.461	0.295	0.981*	-0.033	-10.000*	2.913	0.167	-0.909**
AOL-10-03 × AOL-11-49	-1.287	-1.080	0.128	0.489	0.624	-0.383**	-2.626	-0.491	-0.108	-0.190	-0.108	4.444	-4.036*	0.183	0.162
AOL-10-03 × GAO-5	-6.146	0.949	-0.672**	-0.093	0.123	0.167*	6.531	-0.052	-0.111	0.147	0.491	-0.370	-1.248	0.339	0.578**

Table 4. Top three significant specific combiners for fruit yield and its *gca* status of parents

Hybrid	Mean Yield / plant (g)	SCA effect	GCA effect		Significant heterosis in other traits over standard check in desirable directions
			P_1	P_2	
GAO-5 × AOL-09-02	261.57	37.623**	20.07**	13.162**	No. of fruits / plant, fibre content
AOL-09-17 × AOL-09-02	248.83	40.080**	4.869*	13.162**	No. of fruits / plant, fruit diameter, fibre content
GAO-5 × AOL-09-17	246.28	30.630**	20.07**	4.869*	No. of fruits / plant, fibre content

The supports the predominance of non-additive gene effects in governing the expression of those traits. Similar findings were also obtained by Sharma and Mahajan (1978) for stalk length; Dahake and Bangar (2006) for stem diameter; Singh and Sanwal (2010) for days to first flowering, internodal length, number of branches / plant, plant height, first flowering node, fruit length, fruit diameter; Adiger *et al.* (2013) for days to first flowering, internodal length, number of branches / plant, plant height, fruit yield / plant, fruit length, fruit diameter, fruit weight; Laxman *et al.* (2013) for fruit yield / plant, number of seeds / fruit and 100-seed weight.

The estimated gca variance has been found to be higher than estimated sca variance for days to first flowering, which means predominant role of additive gene action for inheritance of this trait (Table 2). Similar findings were reported by Kumar *et al.* (2005), Srivastava *et al.* (2008), Singh *et al.* (2009), Reddy *et al.* (2011) and Laxman *et al.* (2013).

Among seven parents, three parents, *viz* GAO-5, AOL-09-02, AOL-09-17, were good general combiner for fruit yield. In addition to fruit yield, parent GAO-5, was also found good general combiner for plant height, internodal length, number of fruits / plant, fruit yield / plant, number of seeds / fruit, 100-seed weight and fibre content; the parent, AOL-09-02, for internodal length, number of fruits / plant, fruit yield / plant, fruit weight and fibre content; the parent, AOL-09-17, for number of fruits / plant and fruit yield / plant.Thus, these three parents were observed to be good combiners for fruit yield along with most of the other yield-contributing traits. These parents could be useful in future breeding programme to generate more number of desirable segregants for fruit yield and its component traits.The parent, AOL-10-22, was good general combiner for days to first flowering and first flowering node. While the parent AOL-11-34 was good combiner for days to first flowering. So these parents could be utilized in future breeding prgramme. On the other hand, the parent AOL-11-49 was observed to be average or poor combiner for most of the traits.

The estimates of specific combining ability effects (Table 3) indicated that none of the hybrids was found to be superior for all the traits.However, five crosses registered significant and positive sca effects for fruit yield per plant. Of these, top three were GAO-5 × AOL-09-02, AOL-09-17 × AOL-09-02 and GAO-5 × AOL-09-17. All the top three crosses which exhibited high sca effects for fruit yield. The ranking of crosses based on SCA effects was also same (Table 4). All top three parents are good general combiner. Similar findings were also obtained by Biju *et al.* (2004), Mehta *et al.* (2007), Srivastava *et al.* (2008) and Reddy *et al.* (2011). In okra where improved varieties are under cultivation, these crosses could be evaluated further and utilized to get desirable segregants for improvement.

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Effect of N and K on growth, flowering and multiplication of Dahlia *(Dahlia variabilis)* cv. 'Giani Zail Singh'

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ABSTRACT

The experiment was conducted to see the effect of nitrogen and potassium on growth, flowering and multiplication of dahlia (*Dahlia variabilis* Wild.) cv. 'Giani Zail Singh'. The experiment was laid out in a randomized block design (factorial) using four levels of nitrogen (0, 10, 20 and 30 g/m^2) and potassium (0, 8, 16 and 24 g/m^2), replicated thrice. Half dose of nitrogen and full dose of potassium along with common dose of phosphorus (12.5 g/m^2) and 5 kg/m^2 FYM was applied as a basal dose and the remaining half dose of nitrogen was given 30 days after planting. Maximum plant height (137.18 cm), duration of flowering (127.00 days), size of flowers (17.587 cm), stem length (110.26 cm), number of cut stems/plant (10.53), weight of tuberous roots/plant (849.73 g), size of tuberous root and total number of tuberous roots/plant (22.66) were recorded when nitrogen was applied at the rate of 30 g/m^2 along with potassium at the rate of 24 g/m^2. However, earliest flowering was observed without fertilizer application (the control).

Key Words: Dahlia, Nitrogen, Potassium, Growth, Flowering, Multiplication, Plant height, Size of flowers

Dahlia (*Dahlia variabilis* Wild.) is a native to Mexico and was originally discovered by Aztecs who called it cocoxochitl (Bose and Yadav, 1989). Out of 20,000 cultivars, 2,000 are expected to be under commercial cultivation all over the world. Tubers of dahlia contain significant amount of insulin (Zubaidah and Akhadiana, 2013) and fructose, and small quantities of medicinally active compounds, such as phytin and benzoic acid (Bose and Yadav, 1989). It has a great potential for export market, especially during winter for European countries, which may fetch better market price. The nitrogen plays an important role in proper growth and development of crops (Marschner, 1983). Though the quality of cut flower is primarily a varietal trait, it is greatly influenced by climatic, geographical and nutritional factors among which the nutrition plays a very crucial role. Among major nutrients required for optimum growth, development and flowering of dahlia, nitrogen (N) has greater influence right from cell division to development of vegetative and reproductive organs. It is one of the most mobile of all the mineral nutrients absorbed by the plants.

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In determining the yields of flower crops, potassium (K) is one of the major and crucial limiting factors. Thus, it has been called as the key to life because it is directly involved in most life processes. Deficiency of potassium may adversely affect the plant in maintaining the full supply of N and P and excess application of K may result in various nutritional problems including Ca and Zn deficiency. Till date a very little work has been done to ascertain the efficiency of fertilizers on commercial bulbous ornamental crops, particularly in dahlia under midhill conditions of Himachal Pradesh, an experiment was conducted to study the effect of nitrogen and potassium on growth, flowering and multiplication of dahlia.

MATERIALS AND METHODS

The experiment was conducted at the Department of Floriculture and Landscape Architecture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during 2014-15. The tuberous roots of dahlia cv. 'Giani Zail Singh' were planted in beds at a spacing of 30 cm × 30 cm. The experiment was laid out in a randomized block design (factorial)

consisting of 16 treatment combinations of four different doses of nitrogen (0, 10, 20 and 30 g / m^2) and potassium (0, 8, 16 and 24 g / m^2) and was replicated thrice. Half dose of nitrogen and full dose of potassium along with common dose of phosphorus (12.5 g / m^2) and 5 kg / m^2 FYM were applied as a basal dose and the remaining half dose of nitrogen was given 30 days after planting. The days taken for shoots emergence, plant height, days taken for flowering, duration of flowering, size of flowers, number of cut stems / plant, stem length, weight of tuberous roots / plant, size of tuberous roots / plant and total number of tuberous roots / plant were studied. Data were subjected to analysis using OPSTAT Software of CCS Haryana Agricultural University, Hisar, Haryana (Sheoran *et al.*, 1998).

RESULTS AND DISCUSSION

Growth parameters

Different levels of nitrogen and potassium significantly influenced growth parameters, *viz*. days taken for emergence of shoot and plant height (Table 1). The plants of maximum height (124.29 cm) were recorded with an application of 30 g N / m^2. This may be attributed that nitrogen is an essential part of chlorophyll and nucleic acid, which might have played major role in promoting plant growth. Further, it encourages above the ground growth of plants. These results are supported by those of Bhattacharjee and Mukherjee (1983). The results further support to those of Gani (2007). Dorajeerao *et al.* (2012) also found that application of 150 kg / ha nitrogen increased plant height and number of branches / plant in chrysanthemum (*Chrysanthemum coronarium* L.).

The application of K also increased plant height (116.09 cm) and early (16.08 days) emergence of shoot. This might be due to that K plays essential role in plants, it is an activator of enzymes responsible for all processes as energy metabolism, starch synthesis, nitrate reduction and sugar degradation. Further, it helps regulate opening and closing of stomata in leaves and water uptake by root cells (Brady, 1996). The results can be explained in light of observations made by Barman and Pal (1999). They recorded maximum plant height, number of leaves and number of suckers / plant in chrysanthemum cv. 'Chandrama' with application of 20 g K / m^2. Beneficial effects of K on growth of plants have also been reported by Amin *et al.* (2013) in tuberose and Sable and Kale (1994) in rose.

The effects of N and K in combination have influenced various vegetative parameters. A combined dose of 30 g / m^2 of N and 24 g / m^2 of K have resulted in taller plants (137.18 cm) and days taken for emergence of shoots (13.93 days). With increase in N and K application, availability of nutrients might have increased and finally resulted in optimum absorption by roots. These results are in conformity with those of Kokate *et al*. (2011). Javid *et al.* (2005) also found significant effect of NPK combination on plant height and number of shoots / plant in zinnia and maximum with application of 30 g / m^2 nitrogen 20 g / m^2 each of P and K.

Table 1. Effect of N and K on growth parameters of dahlia

Treatment	Shoot emergence (days)	Plant height (cm)
N_0 (control)	20.28	87.78
N_1 (10 g / m^2)	18.23	102.58
N_2 (20 g / m^2)	16.11	117.00
N_3 (30 g / m^2)	14.58	124.29
C D (0.05)	0.29	5.67
K_0 (control)	18.30	103.12
K_1 (10 g / m^2)	17.83	103.84
K_2 (20 g / m^2)	17.00	108.60
K_3 (30 g / m^2)	16.08	116.09
C D (0.05)	0.29	5.67
N_0 K_0	21.93	87.40
N_0 K_1	20.93	81.20
N_0 K_2	19.80	89.15
N_0 K_3	18.46	93.37
N_1 K_0	19.06	96.37
N_1 K_1	18.66	99.85
N_1 K_2	18.33	103.11
N_1 K_3	16.86	110.99
N_2 K_0	17.33	111.38
N_2 K_1	16.73	114.15
N_2 K_2	15.33	119.64
N_2 K_3	15.06	122.82
N_3 K_0	14.86	117.32
N_3 K_1	15.00	120.16
N_3 K_2	14.53	122.49
N_3 K_3	13.93	137.18
C D (0.05)		
N × K	0.58	NS

Flowering parameters

Various flowering parameters like days taken for flowering, duration of flowering, size of flowers, stem length and number of cut stems / plant were significantly influenced by N and K (Table 2). Duration of flowering (124.08 days) and flower size (16.10 cm) were maximum with application of nitrogen at the rate of 30 g / m^2. Duration of flowering might be due to maximum vegetative growth with application of 30 g / m^2 of N, which could have resulted in vigorous growth, making

Table 2. Effect of N and K on flowering parameters in dahlia

Treatment	Days for flowering (days)	Duration of flowering (days)	Size of flower (cm)	Stem length (cm)	Number of stems / plant
N_0 (control)	108.83	117.83	10.19	65.12	4.66
N_1 (10 g / m^2)	111.00	119.91	12.77	78.45	5.90
N_2 (20 g / m^2)	113.08	122.08	14.62	93.38	8.13
N_3 (30 g / m^2)	115.08	124.08	16.10	106.95	10.15
C D (0.05)	0.43	0.42	0.10	5.32	0.50
K_0 (control)	110.08	116.00	12.47	82.49	7.20
K_1 (10 g / m^2)	111.41	117.33	12.98	83.55	7.18
K_2 (20 g / m^2)	112.58	118.66	12.86	87.00	7.10
K_3 (30 g / m^2)	113.91	119.33	14.38	90.86	7.36
C D (0.05)	0.43	0.42	0.10	5.32	NS
$N_0 K_0$	107.00	118.33	9.40	61.56	4.73
$N_0 K_1$	108.33	119.66	9.42	64.66	4.26
$N_0 K_2$	109.66	120.66	10.47	60.66	5.06
$N_0 K_3$	110.33	121.00	11.48	73.60	4.60
$N_1 K_0$	109.33	120.00	11.40	73.63	5.66
$N_1 K_1$	110.66	121.66	12.64	76.60	6.13
$N_1 K_2$	111.66	122.66	13.57	79.93	5.80
$N_1 K_3$	112.33	124.00	13.49	83.63	6.00
$N_2 K_0$	111.00	122.00	14.13	95.13	8.06
$N_2 K_1$	112.66	123.00	14.49	89.83	8.46
$N_2 K_2$	113.66	124.33	14.90	92.60	7.66
$N_2 K_3$	115.00	127.00	14.99	95.96	8.33
$N_3 K_0$	113.00	122.00	14.97	99.63	10.33
$N_3 K_1$	114.00	123.00	15.37	103.10	9.86
$N_3 K_2$	115.33	124.33	16.49	114.80	9.86
$N_3 K_3$	118.00	127.00	17.58	110.26	10.53
C D (0.05)					
N × K	0.87	0.84	0.20	NS	NS

plant to flower for longer duration. Increase of flower size might have resulted due to increased accumulation of photosynthesis in leaves as result of luxuriant vegetative growth which resulted in utilization of photosynthates from leaves (source) to flower (sink). Similar results of increased number of flowers and flower size have been reported by Bhattacharjee and Mukherjee (1983) in dahlia variabilis cv. 'Black Out' with application of 40 kg N / acre. Similar trend have also been reported by Sehrawat *et al.* (2003) and Jain and Gupta (2004) in marigold, Sawwan *et al.* (1999) and Sharma *et al.* (2006) in chrysanthemum. Duration of flowering, number of primary and secondary side shoots / plant were maximum with application of 30 g N / m^2. Bose and Das (1966) also found maximum duration of flowering with increasing dose of nitrogen in aster, salvia and zinnia. The results further get support from Kaur and Kumar (2001) in verbena.

Flowering characters have also been influenced significantly with the application of K. Plants of *Dahlia variabilis* Wild. took more number (113.91 days) of days to flowering, maximum duration of flowering (122.83 days), size of flowers (14.38 cm), stem length (90.86), and number of cut stems / plant (7.36) with 30 g K / m^2. Plants responded significantly to K application and maximum number of cut stems / plant (7.36) were observed with 24 g K / m^2. The present results support the findings of Singh *et al.* (1993). The results further support those of Amin *et al.* (2013) in tuberose and Chanda *et al.* (2000) in gladiolus.

Interactions exhibited significant response for various flowering parameters (duration of flowering, size of flower, stem length, and number of cut stems / plant) except days taken for bud formation and days taken for flowering. The application of N and K in combination delayed bud formation (97.06 days) and flowering (118.00 days) as compared to the control. Duration of flowering (127.00 days), size of flower (17.58

cm), and number of cut stems / plant (10.53) were found maximum with application of 30 g nitrogen / m^2 and 24 g / m^2 of K. Results are in conformity with those of Singh *et al.* (1993) in dahlia.

Root parameters

Application of N and K showed significant effect on various tuberous root parameters like weight of tuberous roots, size of tuberous roots and number of tuberous roots / plant (Table 3).

The number (19.00), weight (740.95 g) and size (width 46.68 mm and length 165.23 mm) of tuberous roots / plant were maximum with the application of 30 g N / m^2. This may be due to that N application might have lead to improvement of nutrients availability to plants. When optimum N was supplied to a plant, greater translocation of photosynthetic material occurred from leaves to sink sites (bulbs), resulting in better bulb yield. These findings are similar to those of Singh (2001) in gladiolus. The results are in accordance with the findings of Khalaj and Edrisi (2012), who found that application of 200 Kg / ha N can improve growth and yield of tuberose in terms of bulb weight.

The number (15.58), weight (609.77 g) and size of tuberous root (width, 41.62 mm and length, 146.41 mm) / plant increased significantly with increasing levels of K. The weight and size of tuberous root, increased, which might be due to K increased number of large and medium-sized tubers and decreased number of small-sized tubers. The present results support those of Mahgoub *et al.* (2006).

The increase in weight (849.73 g), number of tuberous roots / plant (22.66) and size of tuberous roots (width, 56.06 mm and length, 178.50 mm) increased

Table 3. Effect of N and K on tuberous root parameters

Treatment	Weight of tuberous roots / plant (g)	Size of tuberous root		Number of tuberous roots / plant
		Width of tuberous root (mm)	Length of tuberous root (mm)	
N_0 (control)	432.72	30.33	108.40	10.91
N_1 (10 g / m^2)	514.06	35.63	132.51	12.33
N_2 (20 g / m^2)	585.93	39.09	141.72	14.83
N_3 (30 g / m^2)	740.95	46.68	165.23	19.00
C D (0.05)	16.70	4.17	8.14	1.35
K_0 (control)	506.59	34.83	126.35	13.00
K_1 (10 g / m^2)	568.06	36.83	134.23	13.75
K_2 (20 g / m^2)	589.25	38.45	140.88	14.75
K_3 (30 g / m^2)	609.77	41.62	146.41	15.58
C D (0.05)	16.70	4.17	8.14	1.35
N_0 K_0	365.71	26.08	87.65	10.33
N_0 K_1	413.66	30.48	102.34	10.66
N_0 K_2	464.33	31.94	118.10	11.00
N_0 K_3	487.20	32.82	125.53	11.66
N_1 K_0	419.83	34.07	127.98	11.66
N_1 K_1	496.93	35.13	132.15	12.33
N_1 K_2	568.33	36.35	134.02	12.66
N_1 K_3	571.16	36.96	135.89	12.66
N_2 K_0	565.08	37.40	137.63	14.00
N_2 K_1	646.00	38.42	140.45	15.00
N_2 K_2	601.66	39.93	143.08	15.00
N_2 K_3	531.00	40.64	145.71	15.33
N_3 K_0	675.73	41.80	152.13	16.00
N_3 K_1	715.66	43.29	161.97	17.00
N_3 K_2	722.70	45.58	168.34	20.23
N_3 K_3	849.73	56.06	178.50	22.66
C D (0.05)				
N × K	33.41	NS	NS	NS

when application of N and K combination at the rate of 30 g / m^2 of N and 24 g / m^2 of K were applied. This might be due to that inorganic nutrients are structural and physiological constituent of plant and with increased availability of those to the plant enhanced the vegetative plant growth which in turn leads to superior tuberous root quality. Similar trends have also been reported earlier by Khan *et al*. (2012). They found that application of N (150 kg / ha) and K (200 kg / ha) produced highest corm number and cormel yield (1,20,000 and 1.66 tonnes / ha, respectively) in gladiolus.

Thus, it was concluded that plant height (137.18 cm), duration of flowering (127.00 days), size of flowers (17.58 cm), stem length (110.26 cm), number of cut stems / plant (10.53), weight of tubers / plant (849.73 g), size of tubers and total number of tubers / plant (22.66) were maximum when nitrogen was applied at the rate of 30 g / m^2 along with K at the rate of 24 g / m^2. However, earliest flowering was recorded when no fertilizer application was done. Hence, N and K should be applied at the rate of 30 g / m^2 and 24 g / m^2 respectively, to get quality flowers in dahlia.

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Effect of IPNM packages on quality parameters of bottle gourd *(Lagenaria siceraria)*

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ABSTRACT

An experiment was conducted to study the change in quality of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] under different IPNM packaging materials at progressive farmers' fields located at Village, Khajua, Post Mahsanw, districts, Rewa in Madhya Pradesh, during winter seasons of 2013-14 and 2014-15. Bottle gourd variety, Puna Naveen, was used. The highest total soluble solids (TSS) content, titratable acidity, ascorbic acid content and lowest moisture content were secorded under T_{11} (100% RDF of NPK + FYM @ 5 tonnes / ha + vermicompost @ 10 tonnes / ha), followed by T_9 (100% RDF of NPK + FYM @ 5 tonnes / ha + vermicompost @10 tonnes / ha). The minimum TSS, titratable acidity, ascorbic acid contents and highest moist were recorded in T_{16} (Azospirillum@ 2 kg / ha) during both years.

Key Words: TSS, Acidity, Ascorbic acid, Vermicompost, Azospirillum, FYM

Bottle gourd [*Lagenaria siceragia* (Mol. Standl] belonging to family Cucurbitace, is largely cultivated in tropics and subtropics. Its fruits in green and tender stage are used as vegetable. The application of pre-harvested treatments like organic and inorganic production system may also play important role in improving the fruit quality. Mishra *et al.* (1999) further attributed that different sources of nutrients such as organic / inorganic and integrated had significant effect on physiological and biochemical changes in its fruits. Therefore, an experiment was conducted to find out the effect of IPNM packages on quality parameters of bottle gourd.

MATERIALS AND METHODS

The experiment was conducted at progressive farmers 'fields located at Village Khajua; Post' Mahsanw; district, Rewa in Madhya Pradesh during winter seasons of 2013-14 and 2014-15. Bottle gourd *cv*. Pusa Naveen was used. The experiment on 16 IPNM treatments consisted of T_1 : normal dose of NPK 120: 60: 60 kg / ha; T_2: FYM@20 tonnes / ha; T_3: vermicompost @ 10 tonnes / ha; T_4: poultry manure @ 5 tonnes / ha; T_5: 50% RDF of NPK + FYM @ 20 tonnes / ha; T_6: 100% RDF of NPK + FYM @ 10 tonnes / ha + vermicompost @ 5 tonnes / ha; T_7: 50% RDF of NPK + vermicompost @ 2.5 tonnes / ha + poultry manure @ 5 tonnes / ha; T_8: 100% RDF of NPK + FYM @ 5 tonnes / ha + Azospirillum @ 1 kg / ha; T_9: 100% RDF of NPK + FYM @ 5 tonnes / ha + vermicompost @ 10 tonnes / ha; T_{10}: 100% RDF of NPK + FYM @ 5 tonnes / ha + vermicompost @ 2.5 tonnes / ha + Azospirillum @ 1 kg / ha; T_{11}: 100% RDF of NPK + FYM @ 10 tonnes / ha + vermicompost @ 5 tonnes / ha + poultry manure @ 2.5 tonnes / ha; T_{12}: 100% RDF of NPK + FYM @ 5 tonnes / ha + vermicompost @ 2.5 tonnes / ha + poultry manure @ 1.25 tonnes / ha; T_{13}: 50% RDF of NPK + vermicompost @ 10 tonnes / ha; T_{14}: 100% RDF of NPK + vermicompost @ 5 tonnes / ha; T_{15}: 100% RDF of NPK + vermicompost @ 2.5 tonnes / ha; T_{16}: Azospirillum @ 1 kg. The extracted juice in two layered muslin cloth was subjected to measurement of TSS with hand refractometer (0-32%). Vitamin C content of freshly harvested and stored fruits was calculated by the reduction of 2, 6 Dichloroindophenol dye as described by Ranganna (1986).

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Table 1. Effect of different IPNM packages on quality parameters of bottle gourd

Treatment	TSS (°Brix)		Ascorbic acid (mg/100 g of dried flesh of fruit)		Acidity		Moisture content	
	2013	2014	2013	2014	2013	2014	2013	2014
T_1: Normal dose of NPK 120: 60: 60 kg/ha	2.05	2.31	6.07	6.15	0.34	0.32	98.56	98.73
T_2: FYM @ 20 tonnes/ha	2.07	2.73	6.09	6.17	0.38	0.37	98.32	98.41
T_3: Vermicompost @10 tonnes/ha	2.31	3.01	6.39	6.48	0.35	0.34	97.67	97.85
T_4: Poultry manure @5 tonnes/ha	2.14	2.48	6.13	6.20	0.37	0.35	97.91	98.25
T_5: 50% RDF of NPK + FYM @ 20 tonnes/ha	2.12	2.44	6.11	6.13	0.40	0.39	98.21	98.36
T_6: 100% RDF of NPK + FYM @ 10 tonnes/ha + vermicompost @ 5 tonnes/ha	3.01	3.41	7.79	7.83	0.44	0.45	90.15	90.39
T_7: 50% RDF of NPK + vermicompost @ 2.5 tonnes/ha + poultry manure @ 1.25 tonnes/ha	2.27	2.61	6.21	6.30	0.37	0.37	97.80	97.88
T_8: 100% RDF of NPK + FYM @ 5 tonnes/ha + Azospirillum @ 1 kg/ha	2.35	2.77	6.87	6.93	0.41	0.41	97.41	97.45
T_9: 100% RDF of NPK +FYM @ 5 tonnes/ha + vermicompost @ 10 tonnes/ha	3.03	3.72	8.28	8.31	0.46	0.46	88.24	89.16
T_{10}: 100% RDF of NPK + FYM @ 5 tonnes/ha + vermicompost @ 2.5 tonnes/ha + Azospirillum @ 1 kg/ha	2.78	2.98	7.30	7.10	0.42	0.41	93.34	94.14
T_{11}: 100% RDF of NPK + FYM @ 10 tonnes/ha + vermicompost @ 5 tonnes/ha + Poultry manure @ 2.5 tonnes/ha	3.18	3.95	8.69	8.74	0.46	0.47	86.23	87.41
T_{12}: 100% RDF of NPK + FYM @ 5 tonnes/ha + vermicompost @ 2.5 t.ha + poultry manure @ 1.25 tonnes/ha	2.76	3.07	7.27	7.25	0.43	0.42	92.43	92.87
T_{13}: 50% RDF of NPK+ vermicompost @ 10 tonnes/ha	2.62	2.99	6.52	6.82	0.36	0.34	95.46	95.87
T_{14}: 100% RDF of NPK + vermicompost @ 5 tonnes/ha	2.64	2.98	6.88	6.89	0.39	0.38	93.54	93.82
T_{15}: 100% RDF of NPK + vermicompost @ 2.5 tonnes/ha	2.59	2.94	7.17	7.84	0.40	0.39	96.32	97.53
T_{16}: Azospirillum @ 2 kg/ha	2.04	2.18	6.07	7.06	0.34	0.31	98.56	98.50
SEm±	0.03	0.04	0.09	0.10	0.34	0.32	0.84	0.85
CD (P=0.05)	0.09	0.11	0.25	0.28	0.38	0.37	2.44	2.46

RESULTS AND DISCUSSION

The highest total soluble solids (TSS) content, titratable acidity, ascorbic acid contents and lowest moisture content were recorded under T_{11} (100% RDF of NPK + FYM @ 5 tonnes/ha + vermicompost @ 10 tonnes/ha), followed by T_9 (100% RDF of NPK + FYM @ 5 tonnes/ha + vermicompost @ 10 tonnes/ha). The minimum TSS, titratable acidity, ascorbic acid contents and highest moist were recorded under T_{16} (Azospirillum @ 2 kg/ha) during both the years (Table 1). The results are in accordance with those of Mostakin *et al*. (2000). Higher content of TSS, ascorbic acid, and percentage of acidity and lowest percentage of moisture content were observed in fruits where plot receiving 100% RDF of NPK+FYM @ 10 tonnes/ha+vermicompost @ 5 tonnes/ha + poultry manure @ 2.5 tonnes/ha) under treatment T_{11}.

The organically managed crop have usually higher TSS, ascorbic acid and acidity than the conventional fertilized crop because when a plant exposed with more N, it increases protein production and reduces carbohydrates synthesis. Since TSS, ascorbic acid and acidity are synthesized from carbohydrates, its levels are also reduced. In organically managed soil, plants are generally exposed with comparatively lower amount of N and several plant nutrients are released slowly over time. Therefore, organic crop would be expected to contain higher value of these quality traits and carbohydrates and less protein. Further, soil micro-organism affected soil dynamics and plant metabolisms and ultimately resulted in plant composition and

nutrition quality. Worthington (2001) and Bahadur *et al*. (2003) are also of similar view. Increased in ascorbic acid and TSS content of fruit in these treatments could be attributed to combined application of organic, inorganic fertilizers along with biofertilizers (Azospirillum) which helped in better uptake of NPK nutrients including micronutrients which inturn influence the quality traits in bottle gourd.

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