Research Review

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Pollination management in horticultural crops under protected conditions: a review

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ABSTRACT

Pollination is an essential process for almost all crops and plants, playing a vital role in ensuring a successful crop yield with improved quality of fruits, seed and produce. For several years, honeybees have been the primary pollinators in most agricultural systems under open field conditions, including greenhouses and net houses up to some extent. Honeybees, especially *Apis mellifera* and *Apis cerana indica* are highly effective pollinators in natural environments, where they are able to freely forage and access flowers. However, they may not be efficient pollinators under closed environmental conditions such as greenhouses and net houses. In large areas, honeybees have shown reluctance to work under protected structures, and this has led to a decline in pollination efficacy under these environments and conditions. As a result, research on the use of alternative pollinators like bumblebees, carpenter bees, stingless bees, syrphid flies, etc. has been conducted under different structures. Henceforth pollination management under greenhouses and net houses using alternative pollinators, have been discussed.

The greenhouses and net houses are used to protect crops from harsh environmental conditions, pests, viruses and diseases. However, these structures come with some disadvantages, such as there is no entry of insect pollinator populations. The enclosed environment of greenhouses and net houses limits the movement of pollinators, leading to decreased pollination efficacy. Honeybees, which are the most efficient and commonly used pollinators in agriculture, are reluctant to work under such conditions, and this can lead to significant losses in crop yield and quality without aided pollination management by alternative pollinators. The primary reason for this is that honeybees tend to be affected by the enclosed environment of these structures, which leads to decreased pollination efficacy. For instance, temperature and humidity inside the structures may not be optimal for the honeybees, causing them to be less active and less likely to visit flowers for pollination. The limited space inside the structures can also make it difficult for honeybees to navigate and find flowers to pollinate, (Dag, 2008).

Another reason why honeybees may not be efficient pollinators under closed environmental conditions is competition for resources. When honeybees are placed in a limited area of greenhouse or net house, they may be competing with other bees for pollen and nectar. This competition may lead to a decrease in the number of flowers visited by honeybees, resulting in lower pollination efficacy under such conditions. Furthermore, use of pesticides and other chemicals in closed environmental conditions can negatively affect the foraging behaviour of honeybees. Pesticides may alter the chemical composition of flowers, making them less attractive to honeybees. The chemicals may also make the honeybees more vulnerable to diseases and other environmental stressors.

In contrast, alternative pollinators such as bumblebees, carpenter bees, and stingless bees are better adapted to the enclosed environment of greenhouses and net houses. These bees are generally more active and able to navigate the space inside the structures more efficiently. They are also less affected by the environmental conditions and competition for resources, making them ideal for pollination under closed environmental conditions, (Singh, 2002). It is well-known fact that honeybees are highly effective pollinators in natural environments, but may not be as efficient in closed environmental conditions such as greenhouses and net houses. Alternative pollinators such as bumblebees, carpenter bees, and stingless

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bees are better adapted to these environments and may be more efficient in pollinating crops grown in protected structures, (Singh, 2002).

To counteract the problem of decreased pollination efficacy of honeybees under protected conditions, alternative pollinators have been identified as an effective solution. These alternative pollinators include bumblebees, carpenter bees, stingless bees, syrphid flies, and other species. Bumblebees, for instance, have been found to be effective pollinators under protected structures. They are known for their superior pollination efficacy, indicating that they are two to three times more efficient than honeybees. Additionally, bumblebees are not as affected by environmental conditions as honeybees, making them ideal for greenhouse and net house pollination. (Singh, 2002).

Alternative pollinators such as carpenter bees, stingless bees, and bumblebees have been found to be efficient pollinators in greenhouses and net houses. Carpenter bees and stingless bees are effective pollinators in cucurbits, while bumblebees have greater efficacy in pollinating tomatoes, cherry tomatoes and strawberries. Pollination management using these alternative pollinators is essential in ensuring optimal crop yield. It is, therefore, important for farmers to consider using these alternative pollinators in protected structures to increase pollination efficacy and improve crop yield.

Honeybees as pollinators for protected conditions

Muskmelon being monoecious, bear both the staminate (male) and pistillate (female) flowers separately in a ratio of 18:1. A pistillate flower produced 4.34 - fold higher dry nectar sugar (DNS) (0.909 mg/flower) than staminate flower (0.209 mg/ flower). Maximum DNS production was found in hand pollinated flowers which might be due to stimulation of nectar situation. While minimum DNS was observed in situations devoid of bee pollination floats and stimuli, moderate quantity was found in all other bee pollination treatments. In staminate flowers, minimum DNS was produced in flowers devoid of pollination (0.186 mg/flower) and its provision though various modes significantly increased DNS production, the highest in enclosure where hand-pollination and colony permanently inside treatment were 0.219 and 0.215 mg/flower, respectively. Maximum DNS was produced in flowers at 0700h (0.307 mg/flower), declined at 1000h (0.184 mg/flower), again increased at 1300h (0.201 mg/flower) and lowest at 1600h (0.145 mg/flower). Pistillate flowers also exhibited similar pattern of DNS production in different treatments (maximum DNS production by flowers was in hand pollination (0.945 mg/flower) probably due to stimulation of nectar secretion and minimum in without bee pollination plots (WBP) (0.829 mg/flower) in absence of stimuli, but was moderate (0.915-0.29 mg/ flower) in all other bee pollination treatments. However, the diurnal pattern differed with higher DNS at early 0700h (0.944 mg/flower), peaked at 1000h (0.976 mg) followed by a gradual decline from 1300h (0.871 mg) to 1600 h (0.844 mg/flower).

Minimum fruit weight was observed in WBP plots (248.61 g), which improved in open pollination (290.12 g), hand pollination (320.51 g), and colony with addition of one brood frame @ 10-day interval (433.33 g). The highest fruits were obtained when colony with dual entrance (486.66 g) and colony placed regularly inside (496.77 g). Similarly, results were obtained for other fruit quality parameters including seed number, TSS and acidity. Pollination was also the most critical input for fruit set and its further development. In WBP plots, lack of pollination resulted in lowest fruit yields (29.83 q/ha) while exposure to various floral visitors in open pollination condition improved yields significantly (47.38 q/ ha). Moreover, ensuring pollination increased yields further to 1666.66 q/ha.

Further pollination input by addition of one brood frame to bee colony @ 10-day interval yielded 207.99 tonnes/ha. Maximum yield was obtained from treatment where bee colony was permanently kept inside enclosures (397.80 q/ha), followed by colony with dual entrance (364.99 q/ha) (AICRP on HB&P, 2020-21).

Pollination studies in muskmelon under polyhouse conditions using *Apis mellifera* and hand - pollinations were conducted at PAU, Ludhiana during summer season of 2021. In various muskmelon varieties/lines *viz.* Chand, Punjab Sharda (CY 2012-21), GG 551, MM 964, CT 2015-35 and CY 2012-01 the foraging intensity varied from 1.0 to 2.0 bees/m^2/2 mins. The forging rate varied from 0.6 to 2.1 flowers/ 2 min. *Apis mellifera* was found to be highly efficient for perfect pollination of muskmelon crop (AICRP HB&P, 2021-22).

Apis mellifera colonies placed inside polyhouse having capsicum crop showed highest darting behavior during the first 3 days which reduced thereafter. Normal colony activity started only 8 days after placement of colonies. Mean intensity of bees foraging on capsicum flowers was very low (0.34 bee/m row length/2 min). Only 5.51 per cent bees were foraging for pollen. Fruit setting in *Apis mellifera* crop was 4.5 per cent more than the crop excluded from bees. (AICRP on HB&P, 2020-21).

Alternative pollinators for protected conditions

High productivity with quality produce of any crop depends upon many factors and pollination is one of them. The most reliable and efficient form of pollination is through insects. Wild and managed bees are well documented as effective pollinators of global crops of economic importance. Non-bee pollinators include flies, beetles, moths, butterflies, wasps, ants, birds, and bats. Many insects such as honeybees, bumble bees, leaf cutter bees and solitary bees are important pollinators which are in commercial use (McGregor, 1976). Bumble bees were selected as efficient pollinators of greenhouse (Corbet *et al*., 1988). Under tropical and subtropical ecologies, we have Xylocopid bees facilitating buzz pollination. Five species of stingless bees (*Tetragonula iridipennis*, *Lophotrigona canifrons*, *Lepidotrigona ventralis*, *Tetragonula laeviceps* and *Lepidotrigona arciferal*) have been collected and maintained at the SASRD, Nagaland centre. The different stingless bees were evaluated for their pollination efficiency under protected condition.

Bumble bees are larger, more robust and furrier than honeybees. Their capacity to forage at low temperature and low light intensities makes them an important pollinator under protected conditions. Therefore, bumble bees are being used as pollinators of tomatoes, peppers, blue berries, cucumber and egg plants under protected conditions in many countries such as the Netherland, Belgium, France and Israel since 1988. Bumble bees are well adapted in confined greenhouse conditions as they do not fly against windows since other bees are less likely to forage outside the glasshouse even when windows are opened (Delplane, 1996). However, only the group of long tongued bees can be used for pollination, as short tongued bees are reported to pierce the corolla (cause infection through tear) and rob nectar without facilitating pollination. In narrow corolla tube with deep nectarines, bumble bees owing to large size are unable to enter into the flowers. One more disadvantage is that being annual in nature and farmers need to buy colonies afresh every year and bumble bees are not available to the crops blooming in winter. However, diversity would provide added advantage though restricted to tropical areas of India. The large diversity of 48 bumble bees species existing in India must be exploited through mass rearing the most commonly adapted species in the niche area towards its commercialization for customized renting-hiring service for farmers resorting to protected cultivation, during summer, monsoon and autumn seasons (AICRP on HB & P, 2012-17)

The studies in Capsicum crop under protected conditions by using indigenous bumble bees (*B. haemorrohoidalis),* conducted at YSPUHF, Solan, during 2021 recorded the average activity, 0.4, 0.53, 0.57, 0.37 and 0.23 bumble bees/five minutes during 0600-0700h, 1200-1300, 1500-1600h and 1800-1900h, respectively. The activity of incoming bumble bees initiated at 0600h to late evening. Utilization of laboratory reared *Bombus haemorrohoidalis* colony was found suitable for bell pepper grown under polyhouse conditions for efficient pollination (AICRP on HB&P, 2021-22).

Foraging behavior of bumble bees and honeybees on Strawberry (*Fragaria ananassa*)

The experiment was laid out in a randomized block design with four treatments, viz. cage with *B. haemorrohoidalis* colony, cage with *A. mellifera* colony, control (cage with pollinators) and open pollination. Laboratory reared *B. haemorrohoidalis* colony was utilized for pollination of strawberry cv. Sweet Charlie during April-May, and their role in pollination of strawberry grown under protected conditions and influence on bio-physical parameters of strawberry in comparison to open pollination and control was undertaken during the year 2020. There was maximum fruit set in cage with *A. Mellifera* colony (89.81%) which was at par with fruit set in cage having *B. haemorrohoidalis* colony (87.16%). The minimum fruit setting was recorded in the control i.e. cage without pollinators (78.96%) which was at par with open/natural pollination (80.80%). The fruit weight of strawberry cage with *B. haemorrohoidalis* pollination was at par with open/natural pollination.

Fruit weight of strawberry was maximum (14.26 g) in cage with *B. haemorrohoidalis* colony which was at par with fruit weight with *A. Mellifera* pollination (14.02 g), followed by fruit weight in open pollination

(10.87 g) which was at par with fruit weight in the control, i.e. cage without pollinators (10.54 g). (AICRP on HB&P, 2020-21).

The tomato hybrid (Lakshmi) seedlings were planted in pots on 3rd October, 2020 and the plants were maintained with proper irrigation and fertilizer application in insectary at TNAU, Coimbatore. During flower initiation phase, pots were shifted to insect proof net poly house in Insectary on 27th November, 2020. One strong stingless bee colony of *Tetragonula iridipennis* was placed inside the poly house and the plants were observed regularly for bee visitation and foraging activity of stingless bees. Initially, for few days no bee activity was observed in tomato flowers. Hence, bee colony was fed sugar syrup mixed with tomato pollen for inducing foraging. But, even during the peak flowering phase of tomato, no bee foraging activity was observed in the polyhouse. So, stingless bee colonies become gradually weakened. Hence, the study revealed that the tomato flowers are not preferred by stingless bee, *Tetragonula iridipennis* for rewards collection. The tomato flowers produce sticky pollen with poricidal anthers which require buzz pollination or scraping behaviour in bees to collect pollen from flowers. The most commercialized stingless bees species of Brazil, viz., *Melipona bicolor* and *Nannatrigona testaceicornis* were employed successfully for pollination of cherry tomatoes under protected cultivation. Whereas, another common stingless bee species *Paratamona helleri*, was found not foraging on tomato flowers (AICRP on HB&P, 2020-21).

Impact of stingless bee pollination on cucumber

The results revealed that the highest yield/plant were observed under stingless bee pollination (SBP) treatment, followed by open pollination (OP) and pollinator exclusion (PE) during both the seasons. Highest infestation on fruit fly was observed in open pollination which resulted in 45-55 % fruit damage which might be a probable reason for low yield under OP. In PE, fruits were shriveled and stunted which had negatively influenced the quality of fruit and yield.

Most of the observed bees were side workers (78%), land on the petals and proceed towards the reproductive part (stamen or stigma), while the rest of the foragers (22 % were top workers), land directly on the top of stamen or stigma. Foraging rate was highest (6.80 male flowers 5min^{-1}) during the time of initiation of foraging (0800-0900h), while maximum foraging intensity was recorded as 4.40 bees male flower^{-1} 10 min^{-1} during 1000-1100 h. Maximum time spent by pollen collectors per male flower was recorded as 44.20 sec during 1200-1300 h of the day during which maximum pollen grains were recorded from the body of bees. Irrespective of time period, stingless bee spent significantly more time on female flower compared to that of male flowers in respective time intervals.

The diurnal activity of a colony assessed in terms of total number of incoming and outgoing foragers at hive entrance revealed that their number increases with the ascent of the day, reaches a maximum during 1300-1400 h (67.00 and 58.00 numbers of incoming and ongoing foragers respectively) and then decreases thereafter. Weekly observations showed that the pollen and nectar foraging activity of stingless bees varies in a day with the peak period during 1200-1400 h. A significant positive correlation was observed between relative humidity and number of incoming foragers (r=-0.68).

There was significant increase in per cent fruit setting in stingless bee pollinated crop (76%) compared to hand pollinated one (54%) whereas the qualitative yield parameters like per cent malformed fruit, length and diameter of fruits were statistically on par. With regard to quantitative yield parameters, significantly higher single fruit weight, number of seeds per fruit and germination per cent (2DAS) (685.00 g, 344.10 seeds/fruit and 90.60% respectively) were recorded from the stingless bee pollinated crop than that of the control crop (555.00 g, 210.90 seeds/fruit and 63.00 % respectively). Higher yield was observed in augmented pollination (5.09 kg m^{-2}) compared to hand-pollination (3.16 kg m^{-2}), Apart from this, bee assisted pollination was economically feasible with a B:C ratio of 1.23 than that of the hand pollinated one (0.67). Thus, augmentative pollination with stingless bee under protected cultivation has increased the yield of salad cucumber both in terms of quantity (61% yield increase) and quality in protected cultivation, (AICRP on HB&P, 2020-21).

Pollination studies in bitter gourd conducted at DRPCAU, Samastipur, Bihar, under protected conditions by using carpenter bees (*Xylocopa fenistrata)* showed minimum fruit yield under pollinator exclusion treatment (PE), 72.10 g, whereas maximum fruit yield was recorded under carpenter bees pollinated treatment. It clearly shows that carpenter bees can be the most efficient pollinator for different cucurbitaceous vegetables under protected environment. (AICRP HB&P, 2021-22). Carpenter bees are also efficient pollinators under protected structures. They are known for their larger size, and this allows them to carry more pollen from one flower to another. Moreover, they are active pollinators, and their large size ensures that they are not affected by the wind, which can be a problem for smaller pollinators such as honeybees.(Singh, 2022).

Stingless bees, which are commonly found in tropical regions, have also been identified as effective pollinators under greenhouses and net houses. These bees are small, and their size allows them to move around easily under the enclosed environment. They are also known for their ability to pollinate a variety of crops, making them versatile pollinators.

Beneficial insects provide pollination and biological control in natural and manmade settings. Those ecosystem services (ES) are especially important for high value fruits and vegetables, including those grown under greenhouse conditions. The hoverfly *Eupeodscorollae* (Diptera: Syrphidae) delivers both ES, given that its larvae prey upon aphid pests and its adults pollinate crops. In this study, we investigated this dual role of *E. corollae* in three insect-pollinated and aphis affected horticultural crops, *i.e.* tomato, melon and strawberry in greenhouses in Hebei province (China). Overall, our work shows how augmentative releases of laboratory-reared hoverflies, *E. corolla,* can enhance yield of multiple horticultural crops while securing effective, non-chemical control of resident aphis pests, (Li *et al.*, 2023).

Syrphid flies have also shown great potential as alternative pollinators under greenhouses and net houses. These flies are not as commonly used as other alternative pollinators, but they have been found to be effective pollinators in certain crops. They are attracted to flowers, and their movement from one flower to another ensures pollination, (AICRP on HB&P, 2020-21). It clearly indicates that honeybees (*Apis mellifera*) are most efficient and effective pollinator for taking maximum yield with highest quality of fruits as compared to other pollinators under open field conditions but *Apis mellifera* and *A. cerana indica* cannot work efficiently under protected conditions due to availability of limited area for foraging mostly with high level of humidity and temperature. For effective foraging activity of honeybees (*Apis mellifera*), the greenhouses must be bigger in size and well ventilated, particularly during high temperature conditions in tropical regions, (Singh, 2022). The results of various research centers in India and abroad indicate that bumblebees are the most efficient and effective pollinators for producing highest fruit yield with quality produce even under adverse climatic conditions in tomato and cherry tomato under protected environmental conditions. One can also use electric vibrators or speed regulated air blowers for pollination of greenhouse tomatoes, but under the adverse climatic conditions this is not efficient and effective method and the efficiency under such conditions can be achieved only with combination with bumblebees, (Singh, 2002). It may also be concluded that stingless bees (*T. iridipennis*) is the most suitable and efficient pollinator for the cucurbitaceous vegetable crops under greenhouses and net houses because of their limited foraging range (200-300 m) and low height of flight and small size. Stingless bees can also perform efficient pollination in capsicum and chilli under protected conditions although for these crops no aided pollination is usually required but stingless bees can improve the yield and quality in both these crops (Singh B, 2022).

Similarly, Carpenter bees (*Xylocopa fenistrata*) have been found efficient pollinator for most of the cucurbitaceous vegetable crops but their efficiency for pollination of tomato crop under protected conditions is yet to be established through ongoing investigation and research. In conclusion, alternative pollinators are essential in ensuring effective pollination under greenhouses and net houses. Bumblebees, carpenter bees, stingless bees, and syrphid flies, among others, have been identified as ideal pollinators in these environments. These pollinators are not affected by the enclosed environment and are more efficient than honeybees. Pollination management under greenhouses and net houses using alternative pollinators is essential in ensuring successful crop yield and should be encouraged. Pollination is a crucial process for most crops, including cucurbits and tomatoes. In greenhouses and net houses, the movement of pollinators can be limited, leading to decreased pollination efficacy. Honeybees, which are the most commonly used pollinators, have shown reluctance to work under protected structures, leading to the need for alternative pollinators. Among alternative pollinators, carpenter bees and stingless bees have been found to be efficient pollinators in cucurbits, while bumblebees have shown greater efficacy in pollinating tomatoes.

Cucurbits are a diverse group of crops that include cucumbers, melons, and squashes. These crops are known to have low fruit set due to inadequate pollination, leading to decreased crop yield. Carpenter bees, which are large bees, have been found to be efficient pollinators in cucurbits. They are active pollinators, and their large size allows them to carry more pollen from one flower to another. Moreover, they are not affected by environmental conditions and can easily move around under the enclosed environment of greenhouses and net houses. Stingless bees have also been found to be effective pollinators in cucurbits. These bees are small and can move around easily, ensuring effective pollination.

CONCLUSION

In conclusion, alternative pollinators such as carpenter bees, stingless bees, and bumblebees have been found to be efficient pollinators in greenhouses and net houses. Carpenter bees and stingless bees are effective pollinators of cucurbits, while bumblebees have greater efficacy in pollinating tomatoes, cherry tomatoes and strawberries. Pollination management using these alternative pollinators is essential in ensuring optimal crop yield. It is, therefore, important for farmers to consider using these alternative pollinators in protected structures to increase pollination efficacy and improve crop yield. There is urgent need of more focused research on pollination management under different protected structures since the area under protected cultivation is on increasing trend in different regions of the country.

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Role of rootstocks in yield and quality of grapes (*Vitis vinifera*) under semi-arid tropics of India: a review

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ABSTRACT

Grape (*Vitis vinifera* L.) cultivation is gaining importance under tropical and subtropical conditions of India by adapting advance crop techniques. The problems of detoriated soil, poor and shortage of water conditions affecting the grape production on own rooted vines. There are a large number of rootstocks available in grape cultivation according to different production constraints. Rootstock not only helps in withstanding vineyard in adverse climatic conditions but also help in improving yield and quality of grapes. The rootstock Dogridge became popular among the grape growers due to its capabilities of overcoming abiotic stresses and better stionic combination. The rootstock suitable for one variety in a given location may not be suitable for the same variety on other location. Hence, choice of rootstock is varied among different cultivars. In view of better yield and quality of grapes, there should have better stock-scion compatibility which imparts high vigour into the scion.

Key Words: Rootstock, Semi arid tropics, Vinryard, Climatic conditions, Abiotic stresses, Stionic combination

Grape (*Vitis vinifera* L.) cultivation gained significance under tropical condition in India, Brazil, Venezuela and Thailand. Varietal adaptability and technological interventions facilitate successful grape growing under tropical conditions (Somkuwar *et al*., 2021). Grapes were an introduction by Mughals in 1300 (Tripathi *et al*., 2018). In India, grapes are mainly consumed as fresh fruit, while small portion is utilized for raisins, juice and wine. The grape production in India is about 31.25 lakh million tonnes from 1.40 lakh ha with a productivity of 21.00 tonnes/ha.

Rootstock has potential to manipulate the vine growth and productivity (Menora *et al*., 2018). In India, maximum grapevine production is on Y-trellis (Sharma *et al*., 2022). Traditionally grape was grown in India on its own roots. However, subsequent deterioration in soil and water, and use of rootstock has become important in semi-arid tropical climate to sustain production and fruit quality. Choice of specific rootstock for establishment of vineyard is difficult due to wider options. *Vitis* species, such as *V. champinii*, *V. rupestris*, *V. berlandierii*, *V. longii*, *V. parviflora*, etc. has capacity to synthesize biochemical constituents modulating scion physiology, root morphology, development and distribution (Somkuwar *et al*., 2012).

To overcome the abiotic stresses like drought and salinity, Dogridge became popular rootstocks among growers, however in long run it induces higher vigour on scion under tropical and subtropical climate which reduces bud fruitfulness (Satisha *et al*., 2010). Thus, 110 R rootstock was recommended for hot semi-arid tropical climate (Somkuwar *et al*., 2006, a). The rootstocks, *viz.* St. George, 110R, 140Ruggeri, 1103 Paulsen and 99R possessed strong drought tolerant root structures compared with SO4 and 5C.

After Dogridge, 1613C and Salt Creek were found relatively salt tolerant under Na_2SO_4 salinity at EC levels of 9.27, 9.07 and 8.34 dS/m. To ease the identification and selection of rootstock considering production constraints. the criteria for selecting rootstocks, *viz.* phylloxera resistance, nematode resistance, adaptability to high pH and low soils pH, adaptability to saline soils, adaptability to wet or poorly drained soils, adaptability to drought came into existence (Reynolds and Wardle, 2001). On the basis of production constraints suitable rootstocks were identified for semi-arid tropical climate (Table 1).

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Table 1. Suitable rootstocks based on different production constraints

Situation/problem	Rootstock
Water shortage	1103 P, 140 Ru, 110-R, 420A, SO4, 99- R, St. George, Dogridge
Soil EC more than 2 m mohs/ cm and water EC more than 1 m mohs/cm	Ramsey, Dogridge, 140 Ru, 99 R, 110 R.
Soil ESP more than 15 per cent and/or water SAR more than 8.	140 Ru, 1613, Ramsey, Dogridge.
Free calcium content of soil is more than 12%	140 Ru, SO 4, 420 A.
Chloride content of water is more than 4 meq/litre	Ramsey, Dogridge B, 140 RU. Teleki 5-C
Poor vigor of the variety without any soil/water problem	Dogridge, St. George, SO 4, 140 RU.
For increased nitrogen, potassium uptake.	Dogridge, St. George, 34 EM, Ramsey.
For increased bud break	1613, B2-56.

In subtropical and tropical climates of India, absence of dormancy period in grapevine creating hurdle in breaking bud dormancy required special management techniques to overcome problems of low bud fertility and higher vigour. If rootstock chooses appropriately, it improves the quality, ensure uniformity and synchronise the bud sprout, ensure fruitfulness and proper grapevine vigour (Satisha *et al*., 2013) which need variety- specific research and long-term studies to monitor the effects of rootstock-scion interaction in vineyard to identify the best combination (Kose *et al*., 2014).

Grapevine is commercially produced at semi- arid tropical climate of India, facing serious problem due frequent drought and soil salinity for which rootstock is an option. In this background, understanding the rootstock-scion synergy for unlocking the productivity potential, besides safeguarding the soil, we discussed herewith the influence of rootstock on grapevine at semi-arid tropical climate of India to give desired stimulus to the productivity and quality.

Stock-scion compatibility

Movement of assimilates in grape vine is associated with growth stage, i.e. budburst to early bloom, roots and permanent woody structures etc vine provide carbon and sugar from stored reserves to new shoots (Zapata *et al*., 2004). According to Mortensen 1972, Dogridge rootstock is compatible with scion cultivars, viz. Norris, Stover, Blue Lake, FES A3-34 and FES A3-60. Chardonnay and P Auxervos grafted on clones of Kober 5-BB, developed symptoms of leaf fall and yellow vein at nursery. Rugerri and Richter rootstock resulted in better healing of grafts union in grapevine cultivars, viz. Halawani, Beiruiti Zaini and Beituni (Abu Qaoud, 1999).

The variety Tas-A-Ganesh and Thompson Seedless on Dogridge rootstock proved better for stionic combination and growth. Similarly, higher graft compatibility rate was reported by Kim *et al*. (2005) in Kyoho grapevines grafted on different rootstocks than Campbell Early in a range between 11 % (Tam-nara/ Rupestris du Lot) and 100 % (Schuyler/ Couderc 3309). The combinations of Jandali with 110R, White-Romi with 140Ru, White-Romi with 216/3 and White-Romi with 41B highly exhibited good compatibility, while Hamadani-Baladi and Zeiny showed lower compatibility (Hamdan and Basheer-Salimia, 2010).

Pusa Urvashi grafted on Dogridge rootstock was found to be most compatible compared to grafted on Salt Creek, 1613 and H-144 rootstocks (Verma *et al*., 2010). In cv. Red Globe, rootstock 140R was found better than 41B (Gargin and Altindisli, 2014). Vrsic *et al*. (2016) observed better compatibility of Welsch Riesling grapevine with 5BB, G251 and G103 rootstocks (80%). Miele and Rizzon (2017) reported that among the fifteen rootstocks Rupestris du Lot, 101-14 Mgt., 3309C, 5BB-K, 161- 49C, 1103P and Isabel were compatible with Cabernet Sauvignon grapevines. Ghule *et al*. (2019) reported better compatibility of grape varieties, viz. Crimson Seedless, Nanasaheb Purple and Manjari Naveen with Dogridge and 1103P rootstocks.

Growth parameters

Rootstock plays an important role in utilizing the reserved food material available in different wine parts, i.e. root, shoot, trunk and fruit and root carbohydrates leads to shoot and root development hence, results into a good flower bud initiation and fruit set. Yield of grape vine is a measure of vegetative vigour contributed by shoot length, shoot diameter and pruning biomass. The yield is positively correlated with the vigour obtained by stionic combination. The high pruning weight results into the maximum fruitfulness in vines due to the higher carbohydrate reserves. The rootstock suitable for one variety in a given location may not be suitable for the same variety in other location. Similarly, rootstock 420A on cv. Sangiovese Toscano (Basso and Natali, 1981); rootstock Kober 5-BB on cv. Gamay Rouge and Kobber-5BB and 1103P rootstock on cv. Chardonnay imparted higher.

In grape, grafted vines were always more fruitful than own rooted vines (Sommer *et al*., 2001). Gruner Veltliner grape had a higher wood productivity on SO4, K5BB and 5C rootstock than own rooted vines, while highest pruning weight in grape cv. Tas-A-Ganesh and Thompson Seedless on Dogridge rootstock. Thompson Seedless and Dogridge rootstock was a better combination at semi-arid tropical climate compared with own rooted vines Satisha *et al.* (2010). Satisha *et al.* (2013) reported maximum fruitful canes on 110R and own rooted vines, while minimum on Dogridge and St. George rootstock (22.73 and 18.66 %, respectively).

There was significant influence of stock:scion on pruning weight, girth of scion and stock in cv. Thompson Seedless and Tas-A-Ganesh grafted on Dogridge, Salt Creek, 1613-C, 1616-C and St. George rootstock. Similarly, Pusa Urvashi grafted on Dogridge rootstock showed highest shoot length, number of leaves and stock:scion ratio while Pusa Urvashi grafted on 1613 rootstock recorded maximum leaf area Verma *et al*. (2010). Manjuvani (2012) recorded high pruning weight (2.66 kg/vine) and number of canes (45.60) per vine in grafted vine of Thompson Seedless.

Kose *et al*. (2014) found highest shoot length, shoot diameter and internode length in cultivar Merzifon Karasi on 110R, 8B and Rupestris du Lot rootstocks. Somkuwar *et al*. (2014, b) found highest shoot length, internodal length, shoot diameter and leaf area of Thompson Seedless grafted onto Dogridge rootstock as compared with own rooted. Somkuwar *et al*. (2015) found better growth parameters in Fantasy Seedless grafted on Dogridge, followed by 110R rootstock. Cv. Red Globe recorded maximum shoot growth on Freedom rootstock, while maximum leaf area on Salt Creek rootstock Hifny *et al*. (2016). Clingeleffer *et al*. (2019) reported that Chardonnay, Cabernet Sauvignon and Shiraz vines grafted on Ramsey rootstock recorded maximum pruning weight and number of bunches/vine and also suggested to have different rootstocks for each variety to optimise scion performance and fruit composition.

The influence of rootstock on yield and physiological parameters was reported by Elaidy *et al*. (2019) and recommended Salt Creek as the best rootstock for grape cv. Superior Seedless under soil salinity condition. Ghule *et al*. (2019) reported that Dogridge and 1103P rootstock for better performance under semi-arid climate. Marin *et al*. (2019) found that Syrah and Tempranillo grafted on 3309C rootstock had highest vigour. They also noted that rootstocks had a clear effect on vegetative growth for Syrah and Tempranillo wine cultivars.

Shelake *et al*. (2019) reported that Sonaka perform well on Dogridge rootstock. Cabernet Sauvignon recorded maximum pruning weight on Dogridge and 420A rootstock while vines grafted on 3309 rootstock recorded minimum pruning weight as reported by Gautier *et al*. (2020). Ghule *et al*. (2021) found that Red Globe grapevines grafted on Dogridge followed by Salt Creek rootstock proved better for growth parameters. The response of rootstock on growth attributes at hot semi-arid tropical climate of India is depicted in Table 2.

Table 2. Promising scion:stock combination based on growth attributes

Scion:rootstock combination	Reference
Cv. Anab-e-Shahi on Dogridge and 1616	Reddy *et al*., 1992
Cv. Thompson seedless on 110R	Satisha *et al*. 2013
Cv. Pusa Urvashi grafted on Dogridge	Verma *et al*., 2010
Cv. Thompson Seedless on Dogridge	Somkuwar *et al*., 2014, b
Cv. Fantasy Seedless on Dogridge and 110R	Somkuwar *et al*., 2015
Cv. Sonaka on Dogridge	Shelake *et al*., (2019)

Photosynthetic efficiency

Rootstock influences the photosynthetic efficiency and dry matter partitioning of scion cultivars and modulate yield and quality. In grapevine rootstocks modify leaf gas exchange of scion under non-irrigated conditions, even though vine water status was not altered (Padgett-Johnson *et al*., 2000). Occurrence of drought and salt accumulation in the soil results into leaf scorching thereby affecting the photosynthetic activity of grapevine. The total nutrient availability and source-sink relationship directly affects the photosynthetic efficiency of vine.

The scion specific response of rootstock recorded lower photosynthesis rate in Chardonnay vines grafted on SO4 compared with 1103 P, while Pinot Noir similar rates of assimilation on SO4 and 1103P rootstock (Bica *et al*., 2000). Similarly, Verma *et al*. (2010) recorded highest photosynthetic rate of Pusa Urvashi on Salt Creek rootstock compared with H-144 rootstock. Among ten grape rootstock higher transpiration and photosynthesis were recorded on 1613C and St. George rootstock (Satisha *et al*., 2014). The Promising scion:stock combination based on the photosynthetic efficiency (Table 3).

Table 3. Promising scion:stock combination based on photosynthetic efficiency

Scion:rootstock combination	References
Cv. Pusa Urvashi on Salt Creek	Verma *et al*., 2010
Cv. Sauvignon Blanc on 140Ru and Fercal	Somkuwar *et al*., 2014,a
Cv. Fantasy Seedless on 110R	Somkuwar *et al*., 2015
Cv. Crimson Seedless, Manjari Naveen and Nanasaheb Purple on 1103P and Dogridge	Ghule *et al*., 2019

Sultana grapevines on Freedom rootstock showed highest net CO_2 assimilation and stomatal conductance, while lowered on Harmony rootstock (Morales *et al*., 2014). Similarly, Somkuwar *et al*., (2014,a) observed highest photosynthesis rate in Sauvignon Blanc on 140Ru followed by Fercal, whereas lowest on Salt Creek rootstock. Somkuwar *et al*. (2015) also reported the varied photosynthesis rate among the different stionic combinations ranged from 8.74 to 12.86 $\mu mol/CO_2/cm^2/s$. They recorded lowest photosynthesis rate in Fantasy Seedless on 41B rootstock, while 110R rootstock recorded highest photosynthesis rate. The rate of stomatal conductance was highest in Fantasy Seedless grafted on 41B.

According to Siamak, (2018), Asgari–Shahani combination recorded the highest chlorophyll content with maximum photosynthesis efficiency. Grape cultivars, Crimson Seedless, Manjari Naveen and Nanasaheb Purple, grafted on 1103P and Dogridge rootstock recorded higher photosynthetic activities (Ghule *et al*., 2019). Frioni *et al*. (2020) concluded that 1103P can be used to impart resilience of vines to summer drought.

Petiole nutrient

Leaf mineral nutrition varied due to rootstock in Chasselas grapevine (Bovay, 1959). The highest nitrogen and phosphorous in leaves of ten scions varieties grown on St. George rootstock showed higher accumulation of nitrogen in petioles of scion grafted on St. George (Rupesteris du Lot) was also reported by Cook and Lider (1964). The leaf N and K contents were recorded maximum on Kober-5BB rootstock and minimum on Chasselas x Berlandieri 41B and intermediate on Rupestris du Lot, while leaf P was not affected by rootstocks. Similarly, higher leaf nitrogen content in Anab-e-Shahi grafted on Dogridge and potassium content were recorded on St. George rootstock (Bhargava *et al*., 1982).

However, Cabernet Sauvignon grapevines grafted on Arman, Ruperstris Gan No.1 (AXR-1), Rupestris du Lot or 5C- Teleki rootstocks had no effect on partitioning of dry matter in vines. In rootstocks, 1613C had greater affinity for nitrogen, whereas St. George showed higher inflow rate of nitrogen (Williams and Smith, 1991). Red Globe vines grafted on Freedom rootstock had higher level of N, P and K than Harmony and 1613C (Badr, 1994). This might be due to that every rootstock having differential response for nutrient uptake.

There is variety specific differential response of rootstock on scion cultivar. There was an increase in total N from 67%, 77%, 33 % and 8.5 % in Flame Seedless, Red Globe, Thompson Seedless and in Superior Seedless, respectively, on Salt Creek rootstock (Ibacache and Carlos, 2009). The petiole P level was found doubled in all varieties on Salt Creek rootstock. Harmony and 1613C showed higher K levels by at least 60% in cv. Flame Seedless, Red Globe and Thompson Seedless than those on their own rooted vines. Dalbo *et al*. (2011) recommended that rootstock must be considered for nutritional status evaluation and fertilizer recommendation (K and Mg uptake) in grape vine and observed highest K/Mg ratio in cv. Isabella on hybrid rootstocks VR 043-43 and VR 044-4 and lowest K/Mg ratio in own rooted vine.

At critical fruit bud differentiation stage, recorded higher petiole N and K content in Thompson Seedless grafted grapevines compared to own root (Vijaya and Rao, 2015). Rootstocks has dominance in preferential absorption of Mg, Na and Zn, while scion varieties for nutrients like N, P, K, Fe and Cu and suggested that 110R and Dogridge rootstock can be used to limit the absorption of sodium in cv. Thompson Seedless, Sonaka and Clone 2A (Kalbhor *et al*., 2017). Vijaya *et al.* (2019) recorded higher petiole N content in vines grafted on Dogridge rootstock at full bloom, while effect on increasing petiole K content was recorded with Dogridge at bud differentiation stage. Considerable increase in phosphorus (P) content was recorded in vines grafted on 1103P compared to own rooted vines. Besides rootstocks, Thompson Seedless cultivar recorded higher N and P and Kishmish Chorni recorded higher K content. The Early bud break was observed with 1103P and own rooted vines among rootstocks and with Kishmish Chorni.

Cane physiology

The physiological and biochemical constituents of grape rootstocks varied significantly influencing the scion response to different stresses. Rootstocks of *Vitis berlandierii* × *Vitis rupestris,* group, *viz.* 110R, 1103P, 99R and B2-56, had significantly higher total phenols, flavon-3-ols, flaveonoids, proline and protein content in canes. Which help in reducing the incidence diseases in grape (Cetin *et al*., 2011). Cv. Red Globe recorded higher nitrogen and total carbohydrate content on Dogridge, Salt Creek, Freedom, Harmony and 1103P rootstocks compared with own rooted vines (Rizk-Alla *et al*., 2011).

Similarly, Tas-A-Ganesh grafted on Dogridge rootstock recorded higher accumulation carbohydrate, starch, protein and phenol content in canes of grafted vine as compared with own rooted vines (Somkuwar *et al*., 2013). Merzifon Karasi vines grafted on 5BB and SO4 rootstock recorded highest sugars in root, trunk and shoot, respectively, while vines grafted on 5C and 110R rootstocks recorded maximum carbohydrates and starch content in root, trunk and shoot (Kose *et al*., 2014). Thomson Seedless grapevines grafted onto 110R rootstock recorded higher total phenolic contents and other phenolic derivatives (Somkuwar *et al*., 2014,b).

Satisha *et al*. (2014) recorded highest phenol, protein and proline content in 110R rootstock, while lowest phenol content in St. George was recorded and lowest protein and proline content in 1613C rootstocks. The accumulation of phenolic compounds in these rootstocks may indicate the possible role of phenolic compounds as antioxidants for scavenging the reactive oxygen species generated during abiotic stresses to maintain normal physiological and biochemical processes. Somkuwar *et al*. (2017) found that highest protein and starch content in 110R rootstock, while maximum phenol and carbohydrate content in Dogridge rootstock.

Ulhas *et al*. (2014) observed higher proline content in cv. Merlot grafted on 1103P (1.76 μmol/ml) rootstock, carbohydrate content was higher in Syrah vines grafted on 110R and 1103P rootstocks. Phillips *et al*. (2015) observed significant difference in starch, sugars and total carbohydrate content in cane samples from different regions for various varieties (Merlot, Riesling and Vidal Blanc). The highest cane carbohydrate content (26.36 and 26.31 %) were recorded in Superior Seedless grafted on Salt Creek rootstock and lowest (15.54 and 16.11 %) on own rooted vines for two subsequent seasons Elaidy *et al*. (2019). Goufo *et al*. (2020) analysed the roots, woods, canes, stems, and leaves of grapevines and identified 183 phenolic compounds including 78 stilbenes (23 monomers, 30 dimers, 8 trimers, 16 tetramers, and 1 hexamer), 15 hydroxycinnamic acids, 9 hydroxybenzoic acids, 17 flavan-3-ols (of which 9 are proanthocyanidins), 14 anthocyanins, 8 flavanones, 35 flavonols, 2 flavones, and 5 coumarins.

Biochemical constituents

Rootstock had a significant effect on bunch physical parameters like bunch size, compactness etc. as well as on chemical parameters like total soluble solids and acidity of berries. The rootstock influences titratable acidity in warmer climates but year and soil type may have more impact on titratable acidity than rootstock (Keller *et al*., 2001). Sugar accumulation was significantly lower for vines grafted on 5C rootstock than for the other rootstocks, sugars (Brix) at harvest were similar for all rootstocks while vines grafted on 5C rootstock had lower titratable acidity (Nuzzo and Matthews, 2006).

Somkuwar *et al*. (2013) reported that quality and cane biochemistry changes in relation to cane thickness of own rooted and grafted Tas-A-Ganesh grape, observed that TSS of berries decreased with increase in berry size. Berries on grafted vines recorded lower TSS than on own-rooted vines. The reducing sugars, carbohydrate and phenols were higher in grafted vines. Miele and Rizzon (2017) studied on Cabernet Sauvignon grapevines grafted on 101-14Mgt., 161-49C, 3309C, Rupestris du Lot and Gravesac had high values of density, total soluble solids, pH and sugar:acid ratio and low titratable acidity, which was high with Cabernet Sauvignon grafted on 99R, 110R, Dogridge and 1103P rootstocks.

Sugar profiling

The primary sugars within grape berries are glucose, fructose and sucrose. Sucrose from leaf photosynthesis is transported into berries via phloem although accumulation in berries which was usually started from the veraison stage. During berry ripening, sucrose is converted primarily to glucose and fructose that continue to develop throughout berry ripening (Ribereau-Gayon *et al*., 2000).

Robredo *et al*. (2011) studied the sugar profile in three table grape varieties (Thompson Seedless, Crimson Seedless and Red Globe) and noted that sugar concentrations found in grapes were as fructose, 0.15- 8.74 g /100 g, glucose, 0.19-8.71 g /100 g and sucrose 0.02-0.91 g /100 g. Among sugars, glucose was the most abundant one in early stages and then it decreased until the harvest period, when the amount of fructose and glucose converged to an average of 47% for each sugar. Among different varieties Thomson Seedless recorded highest total sugars.

Organic acid profiling

Tartaric acid content was higher during berry formation and remains fairly stable until berry ripening (veraison). Malic acid accumulates at the end of berry formation and then begins to decline with berry ripening. Although both acids decline during veraison, the loss of tartaric acid is not as rapid and has been associated with increase in berry size. In contrast, degradation of malate is primarily due to metabolites and reduced rate of acid synthesis (Possner and Kliewer, 1985). The organic acid content was used for determining the berry chemical content and harvest intervals. In Thomson Seedless grape, berries tartaric, malic and citric acid were observed maximum with lowest bud load whereas, in Beogradska Besemena cultivar tartaric acid found maximum in lowest bud load while malic and citric acid found maximum with highest bud load (Baiano and Terracone, 2011).

Robredo *et al*. (2011) studied the organic acid profile in three table grape varieties (Thompson Seedless, Crimson Seedless and Red Globe) which varied as tartaric acid (1.28-7.45 g/L), malic acid (0.38-29.92 g /L), citric acid (traces-1.03 g/L). The organic acid profiles among varieties, with Thompson Seedless showing the lowest tartaric/malic acid ratio of 1.19. These differences are an important aspect in terms of overall flavour. Bobeica *et al*. (2015) found that developmental profiles of malic and tartaric acids were slightly affected by the source-sink modulation in Cabernet Sauvignon berries. From veraison to near harvest, the concentrations of malic and tartaric acids were higher, while no significant differences were found at harvest. Tangolar *et al*. (2016) found non-significant differences in tartaric and malic acid concentration for differential bud load.

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Research Article

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Effect of management practices and bulb sizes for quality bulb production in Lilium (*Lilium* sp.)

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ABSTRACT

An experiment was conducted at Horticulture Research Centre, BARI, Gazipur, during November 2019 - June 2021 to study the effect of management practices and bulb sizes on production of quality bulbs and bulblets of lilium (*Lilium* sp.). Two management practices, viz. removal of spikes and without removal of spikes were considered as one factor and three bulb sizes, viz. large, medium and small as another factor in a randomized complete block design. Removal of spikes produced maximum number of bulbs and bulblets/plant (1.41 and 1.81, respectively), the heaviest and largest bulb (26.02g and 4.47cm) and bulblets/plant (6.88g). Large-sized bulbs produced maximum number of bulbs and bulblets/plant (1.51 and 1.98, respectively), heaviest and largest bulb (27.80g and 4.67cm, respectively) and bulblets/plant (7.92g). The removal of spikes produced longest plant (52.58 cm), spike (64.05 cm), rachis (22.18 cm) and bud (8.69 cm) and largest bud and floret (2.80 and 16.96 cm, respectively) and maximum number of florets/stick (4.78) from bulbs obtained during first year. Considering various levels of bulb sizes, large-sized bulbs produced longest plant (53.77 cm), spike (67.22 cm), rachis (23.17 cm) and bud (8.86 cm) and largest bud and florets (2.86 and 17.14 cm, respectively) and maximum number of florets/stick (5.11) from bulbs obtained during first year. Similarly, removal of spikes and large-sized bulbs produced a good number of bulbs and bulblets during second year from bulbs obtained during first year. Large-sized bulbs combined with removal of spikes produced quality bulbs as well as flowers.

Key Words: Bulb production, Management practices, Bulb sizes, Bulblets, Spikes

Liliums (*Lilium* sp.) are normally propagated asexually by natural formation of daughter bulbs. A single bulb normally produces one or two daughter bulb and with average of 5-8 bulblets in each season. Due to a very low rate of natural multiplication of its bulb and bulblet, it results in non-availability of enough planting materials. Therefore, multiplication of bulbs through improved techniques may play an important role. Production of healthy bulb and bulblets are enhanced when all buds or flowers in spike are not allowed to grow or when spikes are harvested leaving some portions of stems in soil because opened flowers and buds draw photosynthates (food/energy) manufactured in green leaves (Almeida *et al.*, 2017; Xiujuan *et al*., 2010). Shafiullah *et al*. (2018) reported that spike removal gave efficiently more number of corms, daughter corms, corm diameter and corm weight in gladiolus flower. Keeping in view, an experiment was conducted to standardize the management practices and to determine the optimum bulb size for quality bulb and bulblet production of lilium.

MATERIALS AND METHODS

The experiment was conducted at Floriculture Division, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh, during November 2019-June 2021 under protected condition using agro shade net. Two management practices like without removing of spikes and removal of spikes were considered as one factor, while other factor consisted of three levels of bulb size (large, 4.0-4.9cm; medium, 3.0-3.9cm and small, 2.0-2.9cm). The experiment was laid out in RCB design with 3 replications. The unit plot size was 1.2 m × 1.50 m and spacing was maintained at 20cm × 15cm. The bulbs of BARI Lilium-1 (Asiatic group and flower creamy white in colour) were planted on

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15 November, 2019 as per the treatments. When lower most buds showed colour, spikes were harvested in case removal of spike treatment. Bulbs were lifted on 03 June, 2020 when leaves were brown and more or less damaged.

After cleaning and treating with Autostin (2g/L of water), the bulbs were stored at 2.1-2.4^{0}c temperature to see the performance of flowers for the next season those were planted on 12 November 2020. During flower collection, plants leaving 25-30cm stem were kept in the field for bulb development and bulbs were also lifted on 06 June, 2021. The land was well prepared by adding cocodust (50:50 soil and cocodust), 10 tonnes cowdung/ha. No chemical fertilizer up to 3 weeks of bulb planting was applied. After 3 weeks of bulb planting, NPK@30:20:20g/m^2 was applied. Urea and MoP @ 100kg/ha were topdressed before spike initiation stage and bulb lifting, respectively.

The cultural operations like weeding and watering were done as per the requirement. Mulching with straw was done when temperature got high. Netting (GI wire and nylon thread) was given to support the plants. The plants were protected from birds and other harmful animals using net made of nylon threads. 'Carbendazim' (Autostin) was sprayed @ 1g/L of water at 15 days interval starting from 20 days after planting to protect the plants from botrytis blight disease. Simultaneously, neem oil and Biomax (1 ml/L) were used to protect from aphids and beetles. The data on growth, flowering and bulb characters were recorded from ten randomly selected plants from each unit plot. The data were analyzed statistically by using R software to find out the variation among different treatments. Treatment means were compared by DMRT (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

All the parameters showed significant differences in management practices (Table 1). The treatment removal of spikes produced maximum number of bulbs and bulblets/plant (1.41 and 1.81, respectively), heaviest and largest bulb (26.02g and 4.47cm) and heaviest bulblets/plant (6.88g). That might be due to removal of spikes that helped to utilize the reserve food by rest of the plant as well as help in bulb development. Absence of spike allows the plant to divert its energies (dry matter) toward the development of corms in gladiolus, supporting the findings. The increase in number and weight of bulbs and bulblets/plant may be a result of more resource allocation to the underground sink (bulbs) which could have otherwise been used by the developing flowers.

Shafiullah *et al*. (2018) reported that, in case of spike removal, maximum number of corms/mother corm, corm weight, corm diameter, number of cormels /mother corm were observed in plants whose spikes were removed at the spike emergence stage. Qureshi *et al.* (2018) obtained higher number of corms and cormels/plant from treatment, removal of spike after 10 days of appearance than that of removal of spike at colour break stage and no spike removal treatments in gladiolus. Those plants were allowed to give flowers did not perform well.

Considering various levels of bulb sizes, large-sized bulbs produced maximum number of bulbs and bulblets/plant (1.51 and 1.98, respectively), heaviest and largest bulb (27.80g and 4.67cm) and heaviest bulblets/plant (7.92g) (Table 1). Better performances of larger bulbs might be due to availability of food materials stored in bulbs which ultimately helped the initial growth of plants as well as bulb and bulblet production. Sarkar *et al.* (2014) observed that large corms (120-125 g) increased the yield of corms and cormels as compared to the control (80-100 g) in gladiolus. Ahmed *et al.* (2009) observed that in tuberose (*Polianthes tuberosa* L. cv. Single), large bulb resulted in vigorous growth, maximum yield and a more number of bulbils as compared to small and medium-sized bulbs. Similarly, Ara (2000) showed that weight and diameter of corms were maximum (21.53g and 4.06cm, respectively) from plants grown from large-sized corms in gladiolus.

The bulb and bulblet production did not show significant variations among treatment combinations except bulblet numbers/plant (Table 2). Large-sized bulbs in combination with removal of spikes produced maximum number of bulblets/plant (2.45), whereas small-sized bulb without removing of spikes produced very poor bulblets/plant (0.89). Though other parameters did not show significant variations among the treatment combinations, large-sized bulbs combined with spike removal treatment showed better performances.

The vegetative growth and flower production influenced by management practices from bulbs obtained during first year showed significant variations (Table 3). The treatment removal of spikes produced longest plant (52.58 cm), spike (64.05 cm), rachis (22.18 cm) and bud (8.69 cm) and largest bud

Table 1. Bulb and bulblet production influenced by management practice and bulb sizes

Treatment	Bulb number/ plant	Single bulb weight (g)	Bulb diameter (cm)	Bulblet number/ plant	Bulblet weight/ plant (g)
Management practices					
Without removal of spikes (T_1)	1.22b	21.46b	3.73b	1.27b	4.40b
Removal of spikes (T_2)	1.41a	26.02a	4.47a	1.81a	6.88a
Level of significance	**	**	**	**	**
Bulb sizes					
Large (S_1)	1.51a	27.80a	4.67a	1.98a	7.92a
Medium (S_2)	1.34b	23.37b	4.17b	1.49b	5.58b
Small (S_3)	1.10c	20.05c	3.47c	1.16c	3.43c
Level of significance	**	**	**	**	**
CV (%)	9.03	6.61	5.41	13.37	20.40

Means with the same letter (s) are not significantly different at 1% level by DMRT;
**, Significant at 1% level of probability

Table 2. Bulb and bulblet production influenced by combined effect of management practice and bulb sizes

Treatment	Bulb number/ plant	Bulb weight (g)	Bulb diameter (cm)	Bulblet number/ plant	Bulblet weight/ plant (g)
$T_1 S_1$	1.42	25.53	4.29	1.52ab	6.50
$T_1 S_2$	1.25	21.0	3.79	1.42b	4.33
$T_1 S_3$	1.0	17.85	3.12	0.89c	2.37
$T_2 S_1$	1.60	30.06	5.04	2.45a	9.33
$T_2 S_2$	1.43	25.75	4.55	1.57ab	6.83
$T_2 S_3$	1.19	22.25	3.83	1.42b	4.49
Level of significance	NS	NS	NS	*	NS
CV (%)	9.03	6.61	5.41	13.37	20.40

*Significant at 5% level, NS, non-significant; T_1, without removal of spikes, T_2, removal of spikes; S_1, large, S_2, medium, S_3, small

and floret (2.80 and 16.96 cm, respectively) and also maximum number of florets/stick (4.78). This may be due to heaviest and largest bulbs obtained from treatment, removal of spikes. Those plants were allowed to give flowers showed poor performances. The removal of spikes showed better vegetative growth and flower production in gladiolus from corm obtained during first year (Khan *et al.*, 2013).

Considering various levels of bulb sizes, all the parameters of vegetative growth and flower production from bulbs obtained during first year showed significant variations (Table 3). The maximum plant height (53.77 cm) was recorded from large-sized bulbs. Medium sized bulbs gave plant height (51.11 cm) statistically similar to that of large-sized bulbs and lowest plant height (47.03 cm) was obtained from small-sized bulb. Larged-sized bulbs produced maximum plant hight which might have been due to availability of more food assimilates, resulting in plants acquiring maximum growth and better development. Akand *et al*. (2016) reported that higher reserved food resulted in better growth and ultimately maximum plant height compared to small bulbs. The large sized bulbs produced longest spike (67.22 cm) and rachis (23.17 cm).

The increased spike and rachis length from large bulb were probably due to better vegetative growth of plants. Similar results were also observed by Methela *et al*. (2019) and Hossain *et al*. (2021). The Large-sized bulbs also produced longest bud (8.86 cm), and largest buds and florets (2.86 and 17.14 cm, respectively) and also maximum number of florets/spike (5.11). Small sized bulbs showed poor performances in vegetative, flower characters and yield. This might have been due to that large bulbs have higher food reserves than small bulb. Therefore, plants produced larger bulb have better flower quality characters and yield than other ones. Similar results were reported by Almeida *et al.* (2017), Sowjanya *et al.* (2017); Sarkar *et al*. (2014), Hossein A-Dur and Al-Atrakchii (2021), Patil and Jhadav (2010); Khan *et al*. (2016).

Though vegetative growth and flower production did not show significant variations among treatment combinations, large-sized bulbs combined with removal of spikes showed better performance in plant height (55.48 cm), spike (72.22 cm), rachis (24.59 cm) and bud length (9.10 cm), bud and floret diameter (2.96 cm and 17.50 cm, respectively) and floret numbers/stick (5.72) (Table 4).

All the parameters showed significant differences by management practices on bulb and bulblet production of Lilium in the second year from bulbs obtained in the first year (Table 5). The treatment removal of spikes produced maximum number of bulbs and bulblets/plant (1.66 and 2.46, respectively), heaviest and largest bulb (48.72 g and 5.40 cm) and also heaviest bulblets/plant (8.06 g). Those plants were allowed to give flowers did not perform well compared to bulbs obtained from removal of spikes treatment.

Table 3. Vegetative growth and flower production influenced by management practice and bulb sizes from bulbs obtained during first year

Treatment	Plant height (cm)	Spike length (cm)	Rachis length (cm)	Bud length (cm)	Bud diameter (cm)	Floret number/ stick	Floret diameter (cm)
Management practices							
Without removal of spikes (T_1)	48.69b	56.0b	19.97b	8.32b	2.63b	3.81b	16.39b
Removal of spikes (T_2)	52.58a	64.05a	22.18a	8.69a	2.80a	4.78a	16.96a
Level of significance	**	**	**	**	**	**	**
Bulb sizes							
Large (S_1=4.0-4.9 cm)	53.77a	67.22a	23.17a	8.86a	2.86a	5.11a	17.14a
Medium (S_2=3.0-3.9 cm)	51.11a	59.28b	20.75b	8.47b	2.71b	4.26b	16.63b
Small (S_3=2.0-2.9 cm)	47.03b	53.57c	19.31b	8.18b	2.57c	3.50c	16.25c
Level of significance	**	**	**	**	**	**	**
CV (%)	4.53	3.71	6.94	2.81	2.07	9.74	1.43

Means with the same letter(s) are not significantly different at 1% level by DMRT; **, Significant at 1% level of probability

Table 4. Vegetative growth and flower production influenced by combined effect of management practice and bulb sizes from bulbs obtained during first year

Treatment	Plant height (cm)	Spike length (cm)	Rachis length (cm)	Bud length (cm)	Bud diameter (cm)	Floret number/ stick	Floret diameter (cm)
$T_1 S_1$	52.05	62.22	21.75	8.62	2.76	4.50	16.78
$T_1 S_2$	50.0	55.18	19.67	8.29	2.63	3.92	16.30
$T_1 S_3$	44.02	50.59	18.50	8.05	2.49	3.0	16.08
$T_2 S_1$	55.48	72.22	24.59	9.10	2.96	5.72	17.50
$T_2 S_2$	52.22	63.37	21.83	8.65	2.79	4.61	16.95
$T_2 S_3$	50.03	56.56	20.11	8.31	2.65	4.0	16.42
Level of significance	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.53	3.71	6.94	2.81	2.07	9.74	1.43

NS, Non-significant; T_1, without removal of spikes; T_2, removal of spikes
S_1, large, S_2, medium and S_3, small

Table 5. Bulb and bulblet production in second year influenced by management practice and bulb sizes from bulbs obtained during first year

Treatment	Bulb number/ plant	Bulb weight (g)	Bulb diameter (cm)	Bulblet number /plant	Bulblet weight/ plant (g)
Management practices					
Without removal of spikes (T_1)	1.33b	41.01b	5.01b	1.73b	5.23b
Removal of spikes (T_2)	1.66a	48.72a	5.40a	2.46a	8.06a
Level of significance	**	**	**	**	**
Bulb sizes					
Large (S_1)	1.72a	51.08a	5.52a	2.70a	9.12a
Medium (S_2)	1.51a	44.28b	5.20b	2.07b	6.57b
Small (S_3)	1.25b	39.23c	4.89c	1.53c	4.25c
Level of significance	**	**	**	**	**
CV (%)	12.09	6.33	2.45	9.38	13.18

Means with the same letter(s) are not significantly different at 1% level of significance by DMRT

**, Significant at 1% level of probability

Table 6. Bulb and bulblet production in second year influenced by combined effect of management practice and bulb sizes from bulbs obtained during first year

Treatment	Bulb number / plant	Bulb weight (g)	Bulb diameter (cm)	Bulblet number/ plant	Bulblet weight/ plant (g)
$T_1 S_1$	1.50	46.17	5.27	2.20b	7.40
$T_1 S_2$	1.42	40.95	5.02	1.90b	5.30
$T_1 S_3$	1.07	35.90	4.73	1.10c	3.0
$T_2 S_1$	1.93	56.0	5.78	3.18a	10.83
$T_2 S_2$	1.60	47.60	5.36	2.23b	7.83
$T_2 S_3$	1.43	42.55	5.05	1.95b	5.50
Level of Significance	NS	NS	NS	*	NS
CV (%)	12.09	6.33	2.45	9.38	13.18

NS, Non-significant, *, Significant at 1% level of probability;

T_1= without removal of spikes; T_2 = removal of spikes; S_1, large, S_2, medium and S_3, small

Khan *et al.* (2013) also showed removal of spikes in gladiolus produced large amount of corm and cormels. Considering various levels of bulb sizes, large-sized bulbs produced significantly maximum number of bulbs and bulblets/plant (1.72 and 2.70, respectively), heaviest and largest bulb (51.08 g and 5.52 cm) and also the heaviest bulblets/plant (9.12 g) (Table 5).

All the parameters related to bulb and bulblet production did not show significant variations among the treatment combinations except bulblet numbers/ plant (Table 6). Large-sized bulbs in combination with removal of spikes produced the maximum number of bulblets/plant (3.18) whereas small sized bulb without removing of spikes produced very poor bulblets/plant (1.10).

CONCLUSION

Large-sized lilium bulbs and removal of spikes independently and in combination performed very excellent with regard to quality lilium bulb production as well as flower production. Medium-sized and small-sized lilium bulbs combined with removal of spikes also showed better results compared to without removal of spike. Removal of spikes may be recommended for producing quality bulb as well as flower production of lilium using large, medium and small sized bulbs.

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Inventory of wild and ornamental plants in green space of M'sila University - Pole 2 (Algeria) — first report

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ABSTRACT

The ornamental flora of green spaces of the University of M'sila (Pole 2) includes 32 ornamental plants (tree, shrub and herbaceous), belonging to 22 botanical families and 29 genera. The greens contain 89 wild plants belonging to 29 families which find refuge at the edge and in these green spaces; of which the Asteraceae family is most abundant, in second place comes the Fabaceae and Poaceae families, then the Brassicaeae with and Euphorbiaceae on the other hand the Geraniaceae, the Plantaginaceae, the Polygonaceae are weakly represented. The chorological types of wild species show the dominance of the elements of the Mediterranean group over all other groups. The analysis of biological types of wild species reveals the dominance of therophytes over all biological types, followed by hemicryptophytes, geophytes and chamaephytes.

Key Words: Ornamental flora, Wild flora, Green space, Inventory, University of M'sila (Pole 2).

In Algeria, the works carried out on green spaces are numerous such as: Azzouzi, 2011; Benlaldj, 2016; Hamidat and Boudraa, 2017; Fergani and Moumene, 2018; Banaldjia *et al*., 2019; Boukerzaz and Guermiche, 2019; Mili *et al*., 2019. Therefore to inventory the ornamental plants and wild plants that find refuge in the green spaces of Mohamed Boudiaf University of M'sila (Pole 2), followed by a taxonomic, biological and chorological analysis of this flora from the flora of Quezel and Santa (1962-1963), the synonymic index of the Flora of North Africa by Dobillard and Chatelain (2010-2013), guides and websites dealing with ornamental plants. The positive effects of plants have been observed by numerous studies based on surveys carried out in different countries (ASTÉRES-UNEP, 2016).

MATERIALS AND METHODS

The study area is located in the North of municipality of M'sila. It is limited to the north by El Ach (Bordj Bou Arreridj) and to the east by Ouled Mansour, to the west by Maarif and Souamaa and to the south by Oueld Madhi (Fig 1).

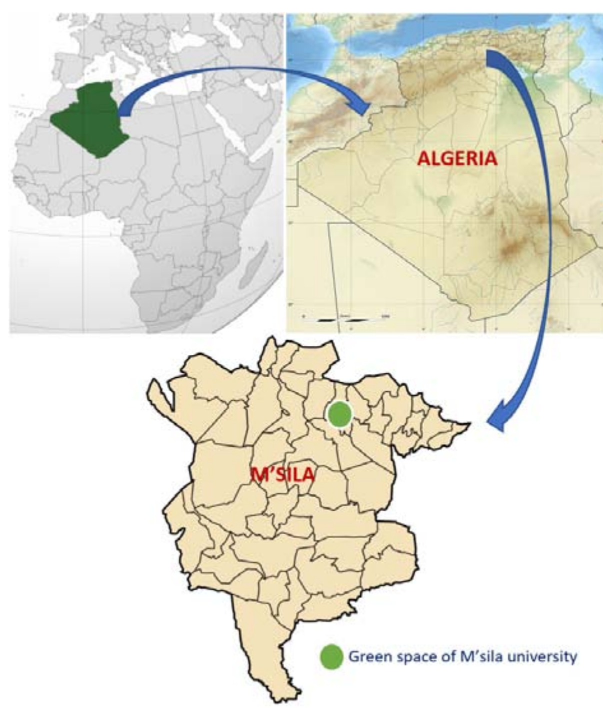

Fig 1. Geographical location of study area

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The nearest post is that of M'sila (period of 1984-2018, *source*: meteorological station of M'sila). The average annual precipitation is 221 mm at the M'sila station. January is the coldest month with an average minimum temperature of –1.50°C, while hottest month is July, with an average maximum temperature of 43.58 °C. The decreasing ranking of the total seasonal precipitation shows that the seasonal regime of the M'sila region is of the APHE type. According to Q2 and Emberger's climagram, the M'sila station is located in the arid bioclimatic stage with cold winter.

The material used for observing of plants consists of pruning shears, a black pencil and a notepad to write down all the information on the plants and study area, plastic bags, a digital camera to take photos of plants. The importance of the period during which field trips are carried out is decisive for any work aiming to inventory the vegetation. The physiognomic state of the species (flowering, fruiting, leaf fall) varies during the seasons.

Sampling consists of collecting data by choosing elements in such a way as to obtain objective information of measurable precision on the whole plant communication studied (Guinochet, 1973).

We opted for subjective sampling which enabled us to carry out two prospecting and floristic inventory trips of ornamental plants and wild plants in the green spaces of Pole 2 of the MB University of M'sila. For making of a herbarium, we collected plant samples during March - April 2022.

The results of the inventory will be presented in the form of a catalogue, following a systematic order of higher units, and alphabetically of families, genera and species. We will indicate for each taxon having changed name that which corresponds in the flora of Quezel and Santa (1962-63). The biological type of each taxon is represented using the following abbreviations: Ph: phanerophyte, Ch: chamaephyte, Hem: hemicryptophyte, Ge: geophyte, Th: therophyte. For wild flora inventoried in green spaces, different chorological types are represented as follows: Med: Mediterranean, Iber-Maur: Ibero-Mauritanian, End NA: endemic to North Africa, End Alg-Tun: endemic to Algeria -Tunisian, End Alg-Mar: Algerian-Moroccan endemics, End Alg: Algerian endemics, Sah: (Saharan, Euras: Eurasian, Eur: European, Paleo-Temp: paleotemperate, Bor: circumboreal, Atl-Med: Atlantic Mediterranean, Eur -Med: Euro-Mediterranean, Med-As: Asian Mediterranean, Med-Sah-Sind: Mediterranean-Saharo-Sindian, Med-Ir-Tour: Iranian-Turanian Mediterranean, Neo-Trop: Neo-tropical, Cosm: cosmopolitan (Miara *et al*., 2017).

The biological and chorological types were assessed through the bibliographical documents consulted (Quezel and Santa, 1962-63; Dahmani, 1997, Rebbas, 2014), as well as our personal field observations. We have used the symbol ≡ to designate the new chorological data appearing in the index of Dobignard and Chatelain (2010-11-12-13) compared to those of Quezel and Santa (1962-63). For ornamental plants, we used guides and websites that cover their descriptions and their worldwide geographical distribution.

RESULTS AND DISCUSSION

The wild plants inventoried in the green spaces of the University of M'sila (Pole 2) are grouped in the floristic list, presented by family, species, vernacular name, biological type, chorology and economic interest are assigned to each species (Table 1). The green spaces are home to 89 wild plants belonging to 29 families. The Asteraceae family is the most abundant, in second place comes the Fabaceae and Poaceae families, then the Brassicaeae with and Euphorbiaceae. Geraniaceae, Plantaginaceae, Polygonaceae are weakly represented. The rest of families are less abundant, they are only represented by one (01) or two (02) species.

Plant life forms are a valuable tool for describing the physiognomy and structure of vegetation. These elements are considered as an expression of the adaptation strategy of flora and vegetation to environmental conditions (Dahmani, 1997; Messaoudene *et al*., 2007). Biological types incorporate various essential aspects of plant life (Raunkiaer, 1934). According to McIntyre *et al*. (1995), these biological types, by their definition (position of renovation organs during the bad season), first take into account the physiology and forms of resistance of plants, hence their proven major role in the response of communities to various disturbances (Miara *et al*., 2017). Analysis of biological types clearly shows that therophytes represent major part of biological types in inventory, followed by hemicryptophytes. Geophytes and Chamephytes are scarce.

The importance of biogeographical diversity of Mediterranean Africa is explained by the climatic modifications undergone by this region since the Miocene, which have led to migrations of tropical and extratropical flora of which some vestiges are currently found (Quézel and Médail, 2003). Quézel (1999) emphasizes that a phytogeographical study constitutes an essential basis for any attempt to conserve biodiversity.

Analysis of flora reveals a high number of elements of the Mediterranean group over all the other groups. The Mediterranean group is dominated by strictly Mediterranean elements followed by Nordic group occupying the second position and the Cosmopolitans in third position. The other groups (other species, transition species) are less represented.

We have inventoried 32 ornamental plants (trees, shrubs and herbaceous). These plants belong to 22 botanical families and 29 genera. Indications of chorology, description of plants and their economic interest have been made (Table 1).

Table 1. List of ornamental plants in green spaces of the University of M'sila (Pôle 2) (for chorology and description of plants: Aquaportail, 2022; Baumel *et al.,* 2017; Baumel *et al.,* 2018; Baumel, 2020; Breton, 2006; *Deuff, 1993;* Equipedia, 2021 ; Grué, 2010; Jaime-jardiner, 2022; Jardins-volpette, 2022; Homegarden, 2022; Maurieres *et al*., 1995; *Phytomania, 2022; Raj et al., 2017;* Sanchez, 2000; Taylor, 1994; Wikipedia, 2022)

Family	Scientific name	Economic importance	Chorology
Anacardiaceae	*Schinus molle* L.	This is also cultivated for its ornamental character in South and Central America and in Mediterranean gardens.	Native to South America
Anacardiaceae	*Schinus terebinthifolia* L.	Throughout South and Central America, Brazil pepper is considered an astringent, antibacterial, diuretic, digestive stimulant, tonic, antiviral and healing.	Native to South America
Apocynaceae	*Nerium oleander* L.	All parts of the plant contain oleandrin, a cardiotonic glycoside, the ingestion of which is fatal at low doses; indeed, a few leaves can kill an adult. In North Africa, beware of water from streams in which oleander roots have been soaked. Even the smoke from the burning of its branches is harmful.	Mediterranean basin, Asia Minor, India and Japan
Arecaceae	*Washingtonia robusta* H. Wendl.	This palm is widely grown in parks and along streets in regions with a mild climate.	Native to Baja California and Sonora
Asparagaceae	*Yucca aloifolia* L.	It is valued as an ornamental plant. The aloe-leaved yucca is a hardy plant, enjoying draining and dry soils, such as sandy shores.	Native to Mexico and the southern United States
Asteraceae	*Gazania linearis* (Thunb.) Druce	Annual plant to create beautiful points of color in rockeries, flowerbeds and flower beds. It can also be grown in pots and planters	South Africa
Asteraceae	*Gazania rigens* (L.) Gaertn.	Annual plant to create beautiful points of color in rockeries, flowerbeds and flower beds.	Native to South Africa and Mozambique
Asteraceae	*Argyranthemum frutescens* (L.) Sch.Bip.	They are more or less lignified herbaceous plants that can reach 60 cm to 1 m high depending on the cultivar.	Canary Islands but is widely used in horticulture
Asteraceae	*Osteospermum ecklonis* (DC.) Norl .	The different species include evergreen perennials, annuals, and subshrubs. When in bloom, it forms a veritable carpet of colors.	South Africa and the Arabian Peninsula

(Table continued)

(Table continued)

Family	Scientific name	Economic importance	Chorology
Asteraceae	*Dimorphotheca sinuata* DC.	Dimorphoteca (Dimorphotheca) is a perennial plant, which shows limited resistance to cold (-5°C) since heat is essential to it as a heliophilous plant (Jardinage.lemonde, 2022).	South Africa and tropical Africa
Bignoniaceae	*Podranea ricasoliana* Sprague	The Bignone rose is a persistent climbing shrub with woody and twining stems, devoid of tendrils, which can reach a height of 5 m. The species is considered invasive in Australia, New Zealand and Hawaii. Its vigorous habit and dense masses of foliage and branching tend to smother the surrounding vegetation.	Native to South Africa, Malawi, Mozambique and Zambia
Bignoniaceae	*Jacaranda mimosifolia* D.Don	It is a subtropical tree species. It has been widely planted elsewhere due to its beautiful and long-lasting blue summer bloom.	Native to south-central South America
Casuarinaceae	*Casuarina equisetifolia* L.	The casuarina tree is widely planted to stabilize coastal areas with sandy soils.	Australia
Celastraceae	*Euonymus japonicus* Thunb.	It has been frequently used to make mono-species hedges in parks and gardens.	Japan
Cupressaceae	*Platycladus orientalis* (L.) Franco	Resistant to drought, it is very often used as an ornamental tree and to make hedges because it supports all sizes very well.	Native to China but naturalized from Iran to Japan
Fabaceae	*Ceratonia siliqua* L.	It has been used since Antiquity for its fruits (carobs), for humans and livestock. This tree with beautiful foliage provides shade which is appreciated in sunny countries. In Tunisia, it is used as the basis of soft drinks called boga and El-Meddeb cider.	Native to the eastern Mediterranean region.
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	It is a fast-growing small tropical tree, used for various applications: vegetable, firewood, fibers, fodder for livestock. It is thus useful as a green manure but also to shade plantations and fight against erosion.	Native to Mexico and Central America
Lamiaceae	*Salvia rosmarinus* Spenn.	Fresh or dried, this condiment herb is found in Mediterranean cuisine, and a domesticated variety is grown in gardens.	Originating from the Mediterranean basin.
Malvaceae	*Hibiscus rosa sinensis* L.	It is a superb flowering plant that we like to use at the end of spring or summer to embellish balconies, terraces and gardens by growing it in pots, indoors. The plant will appreciate a bit of invigorating air.	Native to tropical areas of Southeast Asia
Mimosaceae	*Acacia retinodes* Schltdl.	Evergreen ornamental shrub that can flower at several times of the year. It also has the particularity of supporting calcareous soils, unlike most other species, hence its frequent use as a rootstock.	Native to the far south of Australia
Moraceae	*Ficus carica* L.	Very decorative, it can also be grown in a container and installed on a balcony. The fig that we eat is actually the receptacle of the flower that botanists call "sycone".	Afghanis -tan

(Table continued)

(Table continued)

Family	Scientific name	Economic importance	Chorology
Moraceae	*Ficus microcarpa* L.	It is commonly grown as a houseplant in temperate regions, especially as a bonsai.	Native to Asia, Southeast and Oceania
Moraceae	*Morus alba* L.	The White Mulberry was widely cultivated for its leaves, the exclusive food of the silkworm. For sericulture, white mulberry is often grown as a hedge to facilitate leaf harvesting.	Originally from China
Myoporaceae	*Myoporum laetum* G.Forst.	*Myoporum laetum* is a shrub from coastal New Zealand . It has antibacterial properties and the leaves are traditionally used by Maori to protect their skin from mosquitoes.	Originally from New Zealand
Oleaceae	*Ligustrum japonicum* Thunb	It is sometimes cultivated as an ornamental plant or for the composition of hedges. It grows fast, supports pruning well, and is often used to create topiaries . The fruit is used in herbal medicines as a cardiotonic , diuretic , laxative and tonic treatment.	Originally from southern Japan
Oleaceae	*Olea europaea* L.	Widespread across Africa, Asia and Mediterranean Europe, a variety of which has been domesticated and cultivated to become the olive tree. Representatives of the species *Olea europaea* are evergreen (evergreen) bushes, shrubs or trees up to 15 m in height.	Originally from Asia Minor where it would have developed wildly more than 14,000 years ago.
Pittosporaceae	*Pittosporum tobira* Banks ex Gaertn.	This tree is weakly hardy. Pittosporum tobira easily reaches three to five meters tall unpruned, dense growth. The branched brown trunk ends in the shape of a panicle which bears the leaves and the flowers.	Native to Pacific islands and warm regions of Asia
Platanaceae	*Platanus orientalis* L.	The Oriental plane tree is a large tree, about 30 m high, with a wide and irregular crown . It is used as an ornamental tree . Its wood can be used in carpentry.	Native to Southeast Europe and the Middle East
Poaceae	*Festuca ovina* L.	Lawn plants widely used in mixtures to create resistant lawns in dry land in particular. It can grow on very poor soil but tolerates less trampling than red fescue.	Native to temperate and cold regions of Europe and Asia.
Rosaceae	*Rosa chinensis* Jacq	This species is widely cultivated in China as an ornamental plant ; many cultivars have been selected for their flowers of various colors, with many petals (semi-double, double or full flowers).	Native to central China (Guizhou , Hubei and Sichuan)
Rutaceae	*Citrus ×limon* (L.) Burm. f.	The lemon tree was originally used as an ornamental plant in pleasure gardens in the Middle Ages , notably Islamic gardens 3 . Lemon is gradually introduced into the diet.	Its wild ancestor in the Assam region, the Indo- Burmese region or in China .
Verbanaceae	*Lantana camara* L.	The lantana tree can be planted outdoors or indoors. Note: It has an invasive plant status and It is fire resistant, and grows rapidly on burned areas, even becoming a serious obstacle to the natural regeneration of important native species.	Native to the West Indies or Central America,

CONCLUSION

The green spaces of the University of M'sila (Pole 2) contain 89 wild plants belonging to 29 families. The Asteraceae family is most abundant, followed by Fabaceae, Poaceae, Brassicaeae, Euphorbiaceae, Geraniaceae, Plantaginaceae and Polygonaceae.

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Effect of container size on yield and root morphology of different fruit crops

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ABSTRACT

The experiment was conducted to standardize container gardening techniques for guava (*Psidium guajava* L), pomegranate (*Punica granatum* L.) and citrus (*Citrus aurantifolia* L.) to meet out the nutritional requirement of city dwellers. There was maximum average plant biomass (1072 g/plant) in guava and minimum (423g) in pomegranate. Maximum shoot biomass (1012.11g) was recorded in plant grown in 45 cm × 45 cm and minimum (402.78g/plant) in 30 cm × 30 cm container. Destructive method was used to extract the root mass for analysis. Significant variation in root biomass was also recorded. There was maximum root biomass (506.11g) in guava and minimum (239.86 g) in pomegranate, however root biomass was recorded significantly maximum (509.78 g) in 45 cm × 45 cm. Root to shoot ratio was recorded maximum (0.63) in Citrus crops. The root:shoot ratio had significant correlation with stem girth and negatively correlated with fruit weight, fruit yield and root hairs diameter. Collar diameter has significantly positive correlation with plant height, fruit weight and yield. The container size as well as growing media (substrate) influenced plant growth, root and shoot biomass, fruit yield and root morphology remarkably.

Key Words: Container gardening, Lime, Pomegranate, Guava, Root morphology, Shoot ratio

Container farming is one of the micro model of farming where a family unit or households can produces fruits and vegetables in containers. The container types and volume are most important characteristics because these factors have direct impact on plant quality and production cost. The growing media or substrate has direct impact on root morphology and topology. Srivastava *et al.* (2019), reported that 35 cm × 45 cm of container top area and depth are most suitable to grow guava (*Psidium guajava* L.), and lime (*Citrus aurantifolia* L.), Andhra Pradesh ranks first in terms of production of acid lime (18.62%) (Reddy *et al.* 2022), and pomegranate (*Punica granatum* L.). Fruit crops responds well to pruning in container gardening (Srivastava *et al*. 2022). Increased in container size led increased in canopy growth (Keever and Cobb, 1987) in pear (*Pyrus pyrofolia* L.) and peach (*Prunus domestica* L.), root coiling leads to canopy growth down. Since very scanty information are available, an experiment was conducted to standardize their production technology.

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MATERIALS AND METHODS

The experiment was conducted at ICAR-CISH, during 2017-20, including guava, kagazi lime and pomegranate. Black color, UV stabilized plastic bag with of 400 gauges thickness having 45 cm × 45 cm, 30 cm × 45 cm, and 30 cm × 30 cm container top diameter and depth, were utilized. Growing media comprised garden soil, and, FYM, vermicompost in equal proportion. All the four media components were properly mixed and sterilized through solarization process. The 400-500 g neem cake and 250 g bone meal were also added. The media was filled in containers leaving 10 cm top for irrigation cup. For planting, well feathered grafted and healthy plants were selected from nursery. Before final planting in pot the earth ball of plants were dipped in Carbendazim solution @2 g/ litre of water.

The plants were planted in varying size containers during February - March 2017, and trained on small bush form promoting scaffold branches after 8-10 cm, regular pruning, heading back and thinning out practised to maintain the plants. The plants of guava were pruned in December and January. Pruning was carried out to avoid fruiting of rainy season crop in guava. All the cultural operations were practised uniformly. Plant height, collar diameter were recorded in during September-October. For root study, poly bag was removed and plant along with media ball was kept in 100 liter capacity tub and filled with water, the media become loose and washed carefully. The root biomass was measured after the separation of shoot mass. Root hairs diameter was recorded by screw gauge. The factorial RBD, replicated thrice with 4 plants per replication. Data on vegetative growth, fruit yield, tree spread, height, canopy spread, collar diameter were recorded during October-November. During summer 6-8 liters of water/pot was needed every second day, while as in autumn and winter at 7-15 days interval.

RESULTS AND DISCUSSION

Analysis of the variance showed that container sizes had significant effect on shoot weight. Overall maximum average shoot biomass (1072 g/plant) was recorded in guava, followed by citrus (519.33 g) and minimum (423g) in pomegranate. Irrespective of fruit kind maximum shoot biomass (1012.11g) was recorded in plants grown in 45 cm × 45 cm and lowest (402.78g/plant) in 30 cm × 30 cm container size. Destructive method was used to extract root mass from containerized plant. Significant variation in root biomass was recorded, maximum (506.11g) in guava, followed by citrus (356.44g) and minimum (239.86g) in pomegranate.

However, root biomass was significantly maximum (509.78g) in 45 cm × 45 cm container followed by 327.67 g in 30 cm × 45 cm, while minimum root biomass (264.97 g) was recorded in 30 cm × 30 cm container size. The root; shoot biomass was recorded maximum (0.67) in 30 cm × 30 cm container plants while it was minimum (0.52) in 45 cm × 45 cm container size. The maximum root to shoot biomass (0.63) recorded in Citrus and minimum (0.55) in guava (Table 1). Maximum plant height (117 cm) was noted in 45 cm × 45 cm container, followed by 30 cm × 45 cm, whereas lowest plant height (83.99 cm) noted in 30 cm × 30 cm containers. However, maximum average plant height (112.66 cm) recorded in guava, which was statically on a par to pomegranate and minimum height (86 cm) noted in citrus, irrespective of container size (Table 2). Significantly maximum root hairs diameter was (0.44 mm) noted in 30 cm × 45 cm, followed by root hairs diameter (0.39mm) in 45 cm × 45 cm container size and minimum root hairs diameter (0.32 mm) in 30 cm x 30 cm container size. Irrespective of container size maximum root hair thickness (0.43 mm) noted in pomegranate was on a par to citrus (0.37 mm) and minimum (0.36 mm) in guava (Table 3).

Positive effect of increased container size on plant growth was reported for many woody plant species, plant height, root collar diameter and biomass increased with increase in container size for different plant species (Apko *et al* 2014; Dumroese *et al.* 2011 and Vaknin *et al.* 2009. The fruit yield /plant revealed that irrespective of fruit kind maximum yield (3.14 kg/plant) was noted in 30 cm x 45 cm container which was on a par to 45 cm x 45 cm and 30 cm x 30 cm container size (Table 3). Haase (2008) also indicated that quality container seedlings must have shoot to root ratio of 2:1 or less.

Significant positive correlation was recorded between container size and plant biomass (R= 0.996) root mass (R= 0.989), collar diameter(R= 0.959), plant height, plant girth, root hairs diameter, root length as well as fruit yield. While it was negatively correlated

Kagazi Lime 3 years old grafted plant

Root morphology of guava

Root morphology of pomegranate

Table 1: Effect of container size on media temperature and shoot and root weight in pomegranate, citrus and guava

Crop	Shoot biomass (g)				Root biomass (g)				Root:shoot ratio		
	Pot size										
	45×45	30×45	30×30	Mean	45×45	30×45	30×30	Mean	45×45	30×45	30×30
Pomegranate	486.00	401.33	381.67	423.00	287.33	209.67	222.57	239.86	0.59	0.52	0.58
Citrus	587.33	520.00	450.67	519.33	413.33	354.67	301.33	356.44	0.53	0.68	0.67
Guava	1963.00	878.00	376.00	1072.33	828.67	418.67	271.00	506.11	0.42	0.50	0.74
Mean	1012.11	599.78	402.78		509.78	327.67	264.97		0.52	0.56	0.67
For comparing means of			S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$		S.Em±	$LSD_{0.05}$
Variety			202.31	49.08			77.06	40.43		0.02	0.09
Pot size			179.52	49.08			73.42	40.43		0.04	0.09
Interaction (variety × pot size)			169.48	85.01			62.76	70.02		0.03	0.16

Table 2: Effect of container size on root-shoot ratio, collar diameter and plant height in pomegranate, citrus and guava

Crop	Stem girth (mm)				Collar diameter (mm)				Plant height (cm)		
	Pot size										
	45×45	30×45	30×30	Mean	45×45	30×45	30×30	Mean	45×45	30×45	30×30
Pomegranate	12.62	19.14	21.02	17.60	32.90	29.47	27.67	30.01	131.00	110.67	85.33
Citrus	13.12	18.10	21.00	17.41	35.18	29.16	29.47	31.27	105.00	96.33	56.67
Guava	22.92	20.22	14.27	19.14	38.42	32.10	20.28	30.27	115.00	113.00	109.97
Mean	16.22	19.15	18.76		35.50	30.24	25.81		117.00	106.67	83.99
For comparing the means of				S.Em±	$LSD_{0.05}$	S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$
Variety				0.55	3.48	0.38	3.87			8.34	7.99
Pot size				0.92	3.48	2.80	3.87			9.75	7.99
Interaction (variety × pot size)				1.27	6.02	1.70	6.71			7.11	13.84

Table 3: Effect of container size on plant girth, root hair diameter and root length in pomegranate, citrus and guava

Crop	Root hair diameter (mm)				Root length (cm)				Fruit yield (kg/plant)		
	45×45	30×45	30×30	Mean	45×45	30×45	30×30	Mean	45×45	30×45	30×30
Pomegranate	0.39	0.49	0.40	0.43	49.67	36.10	27.17	37.64	2.62	5.59	2.74
Citrus	0.42	0.42	0.28	0.37	56.47	35.50	40.17	44.04	1.53	1.45	0.90
Guava	0.37	0.40	0.29	0.36	51.67	56.00	35.33	47.67	1.85	2.39	3.19
Mean	0.39	0.44	0.32		52.60	42.53	34.22		2.00	3.14	2.27
For comparing means of		S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$
Variety		0.02	0.07			2.93	10.96			0.68	0.95
Pot size		0.03	0.07			5.31	10.96			0.34	0.95
Interaction (variety × pot size)		0.02	0.12			3.52	18.98			0.46	1.65

with root:shoot ratio. Similarly quantity of substrate has significant positive correlation with shoot weight (R= 0.992), root weight, collar diameter, plant height, root hairs diameter and fruit yield. Negative correlation was found between stem girth and plant root hairs diameter, root length and fruits yield. The plant height has significantly positive correlation with root hairs diameter and fruit yield. Plant biomass has positive correlation with root weight (R= 0.999), collar diameter, plant height, and root hairs diameter and fruit yield (R= 0.992), while as it was negatively correlated with root: shoot ratio.

Total root mass was significantly positive correlated with collar diameter, plant height, root hairs diameters and fruit yield. The root shoot ratio had significant correlation with stem girth and negatively correlated with fruit weight, fruit yield and root hairs diameter (R= -0.992). Collar diameter has significantly positive correlation with plant height, fruit weight and yield. Stem girth was negatively correlated with root hairs diameter, fruit weight and fruit yield. Similar correlation between shoot biomass and plant height was also reported by Apko *et al*. (2014). (Ning Tian *et al*. 2017).

CONCLUSION

Thus, it can be concluded that container size as well as growing media (substrate) influenced plant growth, root and shoot biomass and root morphology. Root and shoot biomass both were high in larger container, while guava plants have high root and shoot biomass. Root-shoot ratio was higher in smaller size containers but collar diameter was noted in larger container size.

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Evaluation of genetic variability in fragrant rose (*Rosa* × *hybrida*) cultivars under open field cultivations

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ABSTRACT

Twenty-six rose (*Rosa* × *hybrida* L.) cultivars grown for open field conditions were characterized using 16 vegetative and floral traits to obtain information on the nature and magnitude of existing genetic variability. The cultivars, Night Time, Christian Dior and Pusa Abhishek were early in flowering and Local Collection 3, Local Collection 4, Kashmir Velvet and Edouard had longer flowering duration; Christian Dior and Bonne Nuit had bigger flowers; Pusa Bahadur had long flower stalk; Local Collection 3, Local Collection 4, Edouard and Kashmir Velvet were having more number of flowers per plant and Pusa Bahadur, Night Time and Christian Dior were found with higher flower weight and shall help in further selection and hybridisation. The higher genotypic and phenotypic coefficients of variation were recorded for plant height, plant spread (E-W), plant spread (N-S), stem girth, number of shoots/ plant, number of petals/ flower, flower stalk length, number of flowers/ plant and 100-flower weight, indicating that genotypic variation contributed markedly towards total variability for the above traits. There is a greater scope for selection in improving flower yield. The high heritability with high expected genetic advance over mean (GAM) was observed for plant height, plant spread (E-W), plant spread (N-S), stem girth, number of shoots/ plant, flower bud length, flower diameter and flower stalk length. This also revealed the lesser influence of environment on these traits. Therefore, simple selection based on phenotypic values for these traits could be useful in their improvement for achieving higher flower yield. The trait specification identified genotypes could ideally be used as donor parents in rose breeding programme to develop desired genotypes for open field cultivation.

Key Words: Genetic characterization, Heritability, Morphological traits, Phenotypic value, Hybridization

Rose (*Rose hybrida* L.) is bred for higher productivity and better characteristics as garden rose, potted rose, loose flower and cut flowers. However, despite the high economic importance, very limited information is available about rose genetics. This might be due to the complex genetic nature of rose cultivars, including ploidy, low seed set, poor seed germination and a high degree of heterozygosity. The choice of selection strategy for effective crop improvement requires at least sound knowledge of inheritance of the major target traits (Debener, 2003). In rose, however, genetic knowledge is still limited and research certainly does not match its economic importance (Yan, 2005). Flower yield is a quantitative trait which is affected by many genetic factors as well as environmental fluctuations (Shivaprasad, 2016 and Swaroop, 2019). Since, variability studies provide useful information, study was undertaken to assess variability in rose cultivars.

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MATERIALS AND METHODS

The experiment was conducted during 2020-21 at ICAR-Directorate of Floricultural Research, Pune. Twenty-six rose cultivars were evaluated for 16 distinguishing traits. The experiment was conducted in a randomized complete block design with three replications. Each cultivar was represented by 5 random plants per replication, which was planted at 1 m × 1 m spacing. The cultivars were: Rose Sherbet, Pusa Gaurav, Abhisarika, Raktima, Lalima, Arka Parimala, Pusa Muskan, Jantar Mantar, Kashmiri Velvet, Accession 1, Edouard , Local Collection 3, Local Collection 4, Pusa Bahadur, Pusa Abhishek, Scentimental, Barkarole, Arka Sukanya, Pusa Arun, Night Time, Bonne Nuit, Double Delight, Montreal, Oklahoma, Blue Moon and Christian Dior. Observations on days to bud initiation, days to first flowering, days to 50% flowering, plant height (cm), plant spread (E-W) (cm), plant spread (N-S) (cm), stem girth (cm), number of shoots/ plant, flower bud length (cm), flower bud diameter (cm), flower diameter (cm), number of petals/ flower, flower stalk length (cm), flower stalk girth (cm), number of flowers/ plant, and 100-flower weight (g). The standard package of practices was followed. All plant protection measures were applied.

The analysis of variance for different traits was carried out using the mean data in order to partition variability due to different sources by following Panse and Sukhatme (1961). The genetic parameters such as genotypic coefficient of variability (GCV%), phenotypic coefficient of variability (PCV%), heritability (h2), genetic advance (GA) and genetic advance as % mean (GAM) were estimated. Heritability in the broad sense was derived based on the formula given by Hansan *et al*. (1956). Genetic Advance was obtained as per Johnson *et al*. (1955). The method adopted by Burton and Devane (1953) was used to calculate phenotypic and genotypic coefficients of variation

RESULTS AND DISCUSSION

There was highly significant variation for all yield and yield related traits (Table 1), indicating sufficient variability in all traits. Relatively wide range of genetic variability was medium to high range for days to first bud initiation, days to first flowering, days to 50% flowering, plant height, plant spread (E-W), plant spread (N-S), number of shoots/ plant, flower diameter, number of petals/ flower, flower stalk length, number of flowers/ plant, and 100-flower weight. Low range of variability was observed for stem diameter, flower bud length, flower bud diameter and flower stalk diameter.

The cultivars Pusa Abhishek and Night Time were found with earliest flower bud initiation (32.5 days), whereas it was most delayed in Local Collection 3 (48.50 days). Cultivars Christian Dior and Night Time took significantly lesser number of days to first flowering (36.5), while Local Collection 4 (56.50 days) took maximum duration. The days to 50% flowering was 50.5 (Sentimental) to 75.50 (Local Collection 3 and Local Collection 4); for plant height 65.5 (Kashmir Velvet) to 165.5 cm (Pusa Arun); for plant spread (E-W) 67.0 (Double Delight) to 186.50 cm (Edouard); for plant spread (N-S) 62.5 (Double Delight) to 172.5 cm (Edouard); for stem girth 1.56 (Scentimental) to 3.65 cm (Lalima); for number of shoots/plant 8.5 (Rose Sherbet) to 33.0 (Local Collection 3); for flower bud length 1.65 (Kashmiri Velvet) to 2.82 cm (Barkarole), for flower bud diameter 1.03 (Double Delight) to 2.23 cm (Christian Dior), for flower diameter 5.6 (local collection 3) to 10.32 cm (Bonne Nuit), for number of petals/ flower 20.33 (Kashmir Velvet) to 60.33 (Local Collection 3), for flower stalk length 2.03 (Kashmir Velvet) to 31.20 cm (Pusa Bahadur); for flower stalk girth 0.5 (Lalima) to 1.08 cm (Pusa Bahadur); for number of flowers/ plant 11.5 (Montreal) to 167.5 (Local Collection 4) and for 100-flower weight is 139.45 (Barkarole) to 729.45 g (Christian Dior) (Tables 2 and 3).

Based on the data for different genetic parameters, the selection would prove promising in Night Time, Christian Dior and Pusa Abhishek for early flowering, Local Collection 3, Local Collection 4, Kashmir Velvet and Edouard for early flowering duration, Christian Dior and Bonne Nuit for bigger flowers, Pusa Bahadur for longer flower stalk, Local Collection 3, Local Collection 4, Edouard and Kashmir Velvet for high number of flowers and Pusa Bahadur, Night Time and Christian Dior for high flower weight (Table 2). These results are in agreement with the findings of Mantur *et al.* (2005), Prashanth (2010) and Shivaprasad *et al.* (2016) for variation in different traits among cultivars.

Phenotypic coefficient of variation (PCV) was found higher than genotypic coefficient of variation (GCV) for different traits, indicating higher influence of environment on the traits (Table 3). The similar results were reported by Panwar *et al*. (2012) and Verma *et al*. (2008) in rose. However, difference between phenotypic and genotypic coefficient of variation values, which reflects environmental coefficient of variance, was higher for some of the traits (days to first flowering, days to 50% flowering, stem girth, number of shoots/ plant, flower bud diameter, flower stalk diameter, number of flowers/ plant and 100-flower weight) and less in other traits (days to first bud initiation, plant height, plant spread (E-W), plant spread (N-S), flower bud length, flower diameter, number of petals/ flower).

The magnitude of difference between phenotypic and genotypic coefficients of variation for days to first flower bud initiation, plant height, plant spread (E-W), plant spread (N-S), flower bud length, flower diameter, number of petals /flower, and flower stalk diameter was found to be less indicating that these traits are least affected by environment and reflects the reliability of selection based on phenotypic performance (Table 3). Similar results were reported

Table 1. Mean sum of square for different traits in rose cultivars

Source	Df	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
Replication MSS	1	15.08	3.77	4.33	62.70	3.77	15.08	0.01	8.48	0.05	0.19	0.04	0.48	5.17	0.04	60.31	26668.11
Treatment MSS	25	35.83**	50.40**	103.06**	1062.24**	1247.59**	1396.78**	0.79**	80.62**	0.20**	0.16**	3.75**	169.45**	96.21**	0.03**	2612.16**	48534.94**
Error MSS	25	3.04	4.89	9.41	27.68	22.65	14.60	0.11	4.64	0.01	0.04	0.07	3.27	0.57	0.01	11.31	696.36
Treatment cal F value		11.80	10.31	10.96	38.37	55.08	95.69	7.33	17.37	17.04	3.62	53.37	51.86	168.88	4.12	231.01	69.70
S. Em. ±		1.23	1.56	2.17	3.72	3.37	2.70	0.23	1.52	0.08	0.15	0.19	1.28	0.53	0.06	2.38	18.66
CD (5 %)		3.59	4.55	6.32	10.84	9.80	7.87	0.68	4.44	0.22	0.43	0.55	3.72	1.55	0.18	6.93	54.35
CD (1 %)		4.86	6.16	8.55	14.67	13.27	10.65	0.92	6.00	0.30	0.58	0.74	5.04	2.10	0.25	9.37	73.56
CV (%)		4.64	5.26	5.19	4.68	4.71	4.24	12.42	10.97	4.96	12.76	3.47	5.31	9.28	12.50	7.26	8.43

X1: days to first bud initiation (days), X2: days to first flowering (days), X3: days to 50% flowering (days) X4: plant height (cm), X5: plant spread E-W (cm), X6: plant spread N-S (cm), X7: stem girth (cm), X8: number of shoots/ plant, X9: flower bud length (cm), X10: flower bud diameter (cm), X11: flower diameter (cm), X12: number of petals /flower, X13: flower stalk length (cm), X14: flower stalk girth(cm), X15: number of flowers/plant, X16: 100 flower weight (g)

Table 2. Performance of loose flower cultivars for morphological traits

Cultivar	Days to first bud initiation (days)	Days to first flowering (days)	Days to 50% flowering (days)	Flower dia. (cm)	No. of petals / flower	Flower stalk length (cm)	No. of flowers/ plant	100-flower weight (g)
Rose Sherbet	43.0	45.5	55.0	6.78	41.00	3.50	32.5	206.30
Pusa Gaurav	36.5	40.5	51.0	7.13	39.83	4.32	60.5	333.45
Abhisarika	38.5	43.5	58.5	9.12	32.50	4.20	35.0	255.25
Raktima	37.5	41.5	54.5	8.42	21.83	10.58	25.5	264.35
Lalima	33.5	39.0	58.5	8.25	31.67	6.70	21.5	240.60
Arka Parimala	36.0	38.5	55.0	8.15	27.50	5.48	21.0	270.75
Pusa Muskan	35.5	38.0	58.5	7.18	25.50	5.87	23.5	164.50
Jantar Mantar	33.5	38.5	60.5	7.60	27.00	6.90	18.5	311.35
Kashmiri Velvet	37.0	41.0	72.0	6.77	20.33	2.03	60.5	199.95
Accession 1	41.0	45.5	65.0	6.03	47.00	3.17	41.0	215.55
Edourd	43.0	48.0	71.0	5.90	41.33	3.62	103.5	217.80
Local Collection3	48.5	55.0	75.5	6.85	60.33	2.82	132.0	335.60
Local Collection 4	46.5	55.5	75.0	5.60	28.67	5.12	167.5	163.70
Pusa Bahadur	35.0	42.0	54.0	8.30	37.50	31.20	50.0	723.60
Pusa Abhisek	32.5	38.5	54.5	7.77	30.67	16.25	45.0	243.45
Scentimental	39.5	42.5	50.5	5.93	25.50	3.80	17.5	200.40
Barklore	38.5	41.5	51.5	5.87	25.17	12.75	36.5	139.45
Arka Sukanya	36.0	39.0	54.0	8.18	30.33	8.30	40.5	394.35
Pusa Arun	36.5	37.5	50.0	9.08	27.17	4.03	41.5	401.45
Night Time	32.5	36.0	61.0	6.38	39.33	9.12	52.0	546.45
Bonne Nuit	35.5	39.0	59.0	10.32	27.83	4.42	34.5	244.55
Double Delight	36.0	40.5	55.5	8.98	41.33	5.62	13.5	365.60
Montreal	39.0	45.5	60.0	6.62	44.17	12.50	11.5	453.50
Oklahoma	33.0	37.5	56.0	10.13	29.67	7.40	37.5	343.50
Blue Moon	32.5	43.0	58.0	7.67	40.67	6.02	37.5	174.30
Christian Dior	34.0	36.5	59.0	9.73	42.00	25.73	44.0	729.45

by Roychowdhury and Tah (2011) in carnation. Kumari *et al*. (2011) and Kumar *et al*. (2012) who also reported higher PCV than GCV for different traits in gerbera.

The PCV and GCV values revealed that there was significant variability present at both levels (Table 3). The higher GCV was recorded for plant height, plant spread (E-W), plant spread (N-S), stem girth, number of shoots/ plant, number of petals/flower, flower stalk length, number of flowers/ plant and 100-flower weight, indicating that variation in genotypes contributed for total variability. The higher PCV was recorded for plant height, plant spread (E-W), plant spread (N-S), stem girth, number of shoots/ plant, number of petals/ flower, flower stalk length, number of flowers/ plant and 100-flower weight. Higher PCV and GCV values were recorded for flower stalk length (85.55 and 85.04%), number of flowers/plant (78.21 and 71.87%) and flower wright (50.12 and 47.40%, respectively). Therefore, for higher GCV and PCV traits, there is a greater scope for selection to improve these traits.

Similar results were reported by Panwar *et al.* (2012) for number of flower and flower weight. The sufficient variation available for these traits can be exploited by direct selection among cultivars and could be used as selection indices for yield improvement. Further, traits or recombination of traits can be improved by involving carefully chosen parents in hybridization. There was less genetic variability for days to first flower bud initiation, days to first flowering, days to 50% flowering, flower bud diameter, flower bud length, flower diameter and flower stalk girth (Table 3). These traits had moderate GCV to low GCV values. Therefore, it is necessary to create variability through hybridization or mutagenesis. Similar results were reported by Kumar (2013).

The heritability provides upper limit possible for estimate of heritability in narrow sense. The extent of response to any selection depends on magnitude of heritability and variability available. It is possible to predict the response for given level of selection intensity if these parameters are known. High heritability was observed for days to bud initiation, days to first flowering, days to 50% flowering, plant height, plant spread E-W, plant spread N-S, stem girth, number of shoots/plant, flower bud length, flower diameter, flower stalk length. Similar results of high heritability was recorded by Panwar *et al.* (2012) for plant height, flower diameter, flower stalk length. Thus, lesser magnitude of non-genetic (environmental) variability indicates ease with which above characters can be handled for further improvement (Table 3).

The genetic advance over mean (GAM) facilitates the comparison for predicted selection response shown by different characters. The high heritability with high expected GAM was observed for plant height, plant spread E-W, plant spread N-S, stem girth, number of shoots/plant, flower bud length, flower diameter, and flower stalk length. These findings are in accordance with those of Singh (2019). This indicates the less effect of environment on these traits. Therefore, simple selection based on phenotypic values for these traits could be useful in improving these characters because of presence of additive gene action (Table 3). Moderate to high heritability with moderate to high GAM was observed for days to first budding, days to first flowering, days to 50% flowering, number of petals/ flower, flower stalk girth and number of flowers/ plant, indicating moderate role of environment on selection of these traits. Moderate heritability and GAM were observed in flower bud diameter and 100-flower weight. It is

Table 3. Estimates of Mean, range and different genetic parameters for different traits in rose.

Trait	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
Mean	37.54	42.04	59.13	112.40	100.96	90.08	2.66	19.63	2.18	1.64	7.64	34.07	8.13	0.71	46.31	313.05
Range	32.5-48.50	36.5-56.50	50.5-75.50	65.5-165.5	67-186.50	62.5-172.50	1.56-3.65	8.5-33	1.65-2.82	1.03-2.23	5.6-10.32	20.33-60.33	2.03-31.20	0.5-1.08	11.5-167.50	139.45-729.45
PCV (%)	11.74	12.51	12.68	20.77	24.96	29.49	25.35	33.25	14.88	19.40	18.08	27.28	85.55	20.01	78.21	50.12
GCV (%)	10.79	11.35	11.57	20.23	24.51	29.18	22.09	31.39	14.03	14.60	17.74	26.75	85.04	15.62	71.87	47.40
h²bs (%)	74.38	72.31	73.27	84.92	86.43	87.93	65.98	79.11	78.91	46.69	86.32	56.22	88.82	60.97	59.14	57.17
GA	7.66	7.92	11.86	35.65	40.06	43.59	0.94	9.99	0.60	0.27	2.74	12.42	6.16	0.18	24.97	34.06
GAM (%)	20.41	18.83	20.06	31.71	39.68	48.39	35.35	50.86	27.26	16.56	35.87	36.45	75.77	25.13	53.91	10.88

X1: days to first bud initiation (days), X2: days to first flowering (days), X3: days to 50% flowering (days) X4: plant height (cm), X5: plant spread E-W (cm), X6: plant spread N-S (cm), X7: stem girth (cm), X8: number of shoots/ plant, X9: flower bud length (cm), X10: flower bud diameter(cm), X11: flower diameter (cm), X12: number of petals /flower, X13: flower stalk length (cm), X14: flower stalk girth(cm), X15: number of flowers/plant, X16: 100 flower weight (g) evident, that these traits fluctuate according to the environment influence. Selection for these traits should be carefully done and monitored for better results (Table 3).

Selection shall prove promising for early flowering in Night Time, Christian Dior and Pusa Abhishek; for duration of flowering in Local Collection 3, Local Collection 4, Kashmir Velvet and Edouard, for bigger flowers in Christian Dior and Bonne Nuit, for longer flower stalks in Pusa Bahadur; for higher number of flowers in Local Collection 3, Local Collection 4, Edouard and Kashmir Velvet and higher flower weight in Pusa Bahadur, Night Time and Christian Dior. The PCV and GCV values revealed ample variability at both these levels. The higher GCV and PCV were recorded for plant height, plant spread (E-W), Plant spread (N-S), stem girth, number of shoots/ plant, number of petals flower, flower stalk length, number of flowers/ plant and 100-flower weight, indicating that variation was significant. There is a greater scope for selection to improve for these traits. The sufficient variation available for these traits can be exploited by direct selection among cultivars and could be used as selection indices for flower yield improvement. Further, these traits or recombination of traits can be improved by involving carefully chosen parents in hybridization. High heritability was observed for days to bud initiation, days to first flowering, days to 50% flowering, plant height, plant spread (E-W), plant spread (N-S), stem girth, number of shoots/plant, flower bud length, flower diameter, flower stalk length. Indicating these traits are more heritable in progenies and can be handled easily compared to other traits, while improving these traits.

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Genetic variability and divergence in okra (*Abelmoschus esculentus*)

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ABSTRACT

An experiment comprising 19 genotypes of okra {*Abelmoschus esculentus* (L.) Moench} sown in RBD with three replications was conducted during rainy season of 2019 and 2020 at Vegetable Research Farm, BUAT Banda. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were highest for days to 50% germination and lowest for first flower, days to 50% flower, days to maturity, fruit length, fruit diameter, number of seeds/fruit, fruit yield/plant, fruit yield/plot and fruit yield. The heritability estimates were high for days to 50% germination, average fruit weight, number of fruits/plant, fruit yield/ plant and fruit yield, indicating that selection based on phenotypic performance would be more operative. The high heritability coupled with high GAM was observed for days to 50% germination, average fruit weight and number of fruits/plant, indicating that additive gene effect was more important. Based on D^2 analysis, 19 genotypes were grouped into six clusters. The cluster I had seven genotypes followed by cluster II and III with six and three genotypes respectively, while the remaining clusters were monogenotypic. The cluster II recorded maximum intra cluster distance, followed by cluster I and clusters III. Maximum inter-cluster distance was observed between cluster III and VI, followed by that between cluster III and IV and between cluster I and III, suggesting that genotypes belonging to cluster III and VI, III and IV and I and III are more divergent than the rest of the clusters.

Key Words: GCV, PCV, Heritability, Genetic Divergence

Okra [*Abelmoschus esculentus* (L.) Moench] is widely consumed species of Malvaceae family. The major problems in okra cultivation in India is lack of location-specific and high-yielding varieties. (Jethaya *et al.*, 2016). Flower opening is a long process in which tubular corolla starts spreading gradually after day break. However, ready-to-open buds could be identified in all taxa. Anther dehiscence coincides with full opening of the corolla. (Joseph *et al.*, 2013). Since genetic variability and heritability are very important because phenotypic selection depends upon the range of genetic diversity, the study was undertaken to determine the extent of genetic variability, heritability, genetic advance and genetic divergence to identifying high-yielding genotypes.

MATERIALS AND METHODS

The study was carried at Department of Vegetable Science, College of Horticulture, Banda University of Agriculture and Technology, Banda, with 19 genotypes sown in randomized block design with three replications during rainy season 2019 and 2020. Each variety was planted in three rows replicated thrice with a spacing 60 cm × 30cm.

Observations were recorded from five randomly selected plants from the middle row of each variety in each replication for days to 50% germination, days to first flower, days to 50% flowering, days to maturity, plant height (cm) at 60 DAS, number of nodes at 60 DAS, number of primary branches, node to first flower appear, fruit length (cm), fruit diameter (cm), number of seeds/fruit, average fruit weight, number of fruits/plant, fruit yield/plant, fruit yield/plot and fruit yield. Mean values of five plants were used for statistical analysis.

Phenotypic and Genotypic coefficients of variability, heritability (h^2) broad sense and expected genetic advance were estimated as suggested by Burton (1952), Hanson *et al.* (1956) and Johnson *et al.* (1955) respectively. The genetic divergence among genotypes was estimated by using D2 statistics (Mahalanobis 1936). All the genotypes used were clustered into different groups by following Tocher's method (Rao 1952). The average intra and inter cluster distances were calculated by the formulae suggested by (Singh and Chaudhary 1985).

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RESULTS AND DISCUSSION

All the 16 characters showed high wide range of variation (Table 1). Days to 50% germination varied from 3.93 (P-8) to 8.19 (Pusa A-4) with mean value of 6.05 days. Days to first flower were minimum in genotype NDO-10 (41.32) and Pusa A-4 (48.79) took maximum days to first flower with mean value of 44.45 days. Days to 50% flowering was minimum in Varsha Uphar (44.71) and maximum in Kashi Vardan (54.63) with mean value of 49.59 days. Arka Nikita took minimum days to mature (49.02), whereas maximum days to maturity were taken by Kashi Vardan with mean value of 54.54 days. Genotype Varsha Uphar having maximum plant at 60 DAS (92.42 cm) whereas Hisar Unnat had minimum plant height at 60 DAS (71.31 cm) with mean value of 81.70 cm.

Genotype Kashi Vibhuti had minimum fruit diameter (1.39 cm), whereas Phule Vimukta (1.81 cm) had maximum fruit diameter with general mean of 1.67 cm. Fruit length was maximum in Varsh Uphar (12.09 cm), whereas minimum in P-8 (9.91 cm) with mean performance of 11.15 cm. Number of seeds/fruit was maximum in P-8 (57.50), whereas was minimum in Hisar Unnat (43.83) with general mean of 51.66. Average fruit weight was observed maximum in Hisar Unnat (12.61 g) and was minimum in Kashi Pragati (9.73 g) with mean performance of 11.59 g. Genotype P-8 had maximum number of fruits/plant (23.04) and Punjab Suhavani (14.73) had minimum number of fruits/plant with general mean of 18.81. Kashi Kranti, Hisar Naveen and P-8 had maximum yield per plant (0.23 kg) whereas, Azad Bhindi-1 and Punjab Suhavani had minimum yield/plant (0.19 kg) with mean value of 0.21 kg. Fruit yield was observed maximum in Hisar Naveen (129.49 q/ha) and minimum in Punjab Suhavani (106.71 q/ha) with average yield of 116.94 q/ha.

The PCV estimates were more than that of GCV for all characters, revealing the role of environment in phenotypic expression of these traits. Pooled analysis revealed that days to 50% germination exhibited higher PCV and GCV estimates than rest characters. Koundinya *et al.* (2013) reported similar of observation for number of fruits/plant and number of branches/ plant; low for days to first flower, days to 50% flower, days to maturity, fruit length, fruit diameter, number of seeds/fruit, fruit yield/ plant, fruit yield/plot and fruit yield, indicating that there is limited scope for improvement. Similar observations have been reported by Akotkar*et al.* (2010) for fruit diameter; koundinya *et al.* (2013) days to first flower, days to 50% flowering, days to maturity and fruit diameter.

The heritability estimates were high for days to 50% germination, average fruit weight, number of fruits/plant, fruit yield/plant and fruit yield, indicating that the selection based on phenotypic performance of these characters would be more operative and these were witnessed by Koundinya *et al.* (2013) for number of fruits/plant and fruit yield/plant; Vani *et al.* (2012) for yield (q/ha) and yield/plant; Mehta *et al.* (2006) for average fruit weight. Moderate for days to maturity, plant height at 60 DAS, number of nodes at 60 DAS, node to first flower appear, number of seeds/fruit and fruit yield/plot. These findings are related to those Thulasiram *et al.* (2017) for days to maturity. Low for days to first flower, days to 50% flowering, number of primary branches, fruit length and fruit diameter. These findings are in close harmony with Kumar *et al.* (2012) for fruit diameter. Similar findings with high heritability coupled with high GAM was reported by Badiger *et al.* (2017) for average fruit weight; Ramanjinappa *et al.* (2011) for number of fruits/plant. It indicated that additive gene effect was more important for these traits.

Koundinya *et al.* (2013) supported report for days to 50% flowering and days to maturity; Thulasiram *et al.* (2017) for days to first flower, fruit length and fruit yield.

All the 19 genotypes were grouped into six clusters. The cluster I was the largest with seven genotypes, followed by cluster II and III with six and three genotypes respectively. While, clusters IV, V and VI had one genotypes each.

The intra and inter-cluster D represent the index of genetic diversity among clusters as given in. The cluster II (13.38) recorded maximum intra cluster distance, followed by cluster I (13.11) and cluster III (11.52). Maximum inter-cluster distance was observed between cluster III and VI (188.84), followed by that between cluster III and IV (108.81) and between cluster I and III (108.47), suggesting thereby that genotypes belonging to cluster III and VI, III and IV and I and III are more divergent than the rest of the clusters. The inter-cluster distance was least between cluster IV and VI (17.10) followed by I and IV (21.21) and between II and V (21.73) suggesting close relationship among genotypes.

The genotypes of cluster V took maximum days for 50% germination (X = 8.19). The genotypes of cluster IV took minimum days for 50% germination (X = 4.32). Days to first flower was maximum in genotypes of cluster V (X = 48.79), while genotypes

Table 1: Range and mean performance of okra genotypes (pooled data) (2019-20)

Genotype	Days to 50% germination	Days to first flower	Days to 50% flowering	Days to maturity	Plant height(cm) [60 DAS]	Number of nodes (60 DAS)	Number of primary branches	Node to first flower appear	Fruit length (cm)	Fruit diameter (cm)	Number of seeds/ fruit	Number of fruits/ plant	Fruit yield (q/ha)
Kashi Vibhuti	6.73	44.82	51.00	56.43	77.36	15.69	2.94	5.68	10.91	1.39	48.50	18.81	110.39
Arka Anamika	6.65	43.62	49.44	54.13	84.19	15.06	3.10	6.40	10.83	1.85	57.33	21.45	114.49
Arka Abhay	5.91	46.66	52.13	57.27	76.83	13.49	3.69	5.57	11.34	1.56	55.67	18.75	112.29
Arka Nikita	6.76	40.69	45.06	49.02	75.34	16.68	3.09	6.36	10.66	1.69	54.83	19.57	120.41
Hisar Unnat	5.59	43.03	46.67	52.05	71.31	13.72	4.03	5.59	11.13	1.64	43.83	16.80	117.39
Kashi Pragati	7.57	44.43	49.34	53.88	84.27	16.59	3.47	4.44	12.00	1.59	47.83	21.36	113.02
Pusa A-4	8.19	48.79	53.86	59.23	81.80	16.86	3.51	6.58	10.06	1.63	53.17	16.57	117.47
NDO-10	8.07	41.32	47.69	52.31	78.08	12.77	2.53	6.02	11.83	1.73	52.33	20.10	108.87
Azad Bhindi-1	7.65	44.17	50.08	55.28	77.98	13.67	2.36	6.72	11.30	1.61	54.00	18.39	107.27
Punjab Suhavani	4.26	43.25	48.13	53.30	71.37	13.23	2.96	6.24	10.52	1.77	48.17	14.73	106.71
Pusa Sawani	6.16	47.32	51.84	57.34	88.09	18.25	3.73	4.65	11.36	1.67	45.83	16.19	123.38
Kashi Vardan	4.70	48.29	54.63	59.76	83.57	18.45	3.21	6.74	10.52	1.68	50.83	18.97	112.91
Kashi Kranti	7.10	44.32	50.51	54.70	80.39	17.04	3.37	5.52	11.49	1.54	47.50	21.47	125.95
Hisar Naveen	7.11	41.60	47.31	52.58	88.28	18.11	3.29	5.98	12.00	1.76	52.00	22.32	129.49
P-8	3.93	47.52	53.71	57.58	87.39	17.77	4.05	6.45	9.91	1.52	57.50	23.04	127.22
Phule Vimukta	4.03	43.55	47.48	52.98	88.65	18.51	3.42	6.21	11.85	1.81	57.17	15.69	121.67
Akola Bahar	4.32	45.51	48.53	53.16	85.12	17.35	3.83	5.08	10.70	1.80	49.33	16.91	111.94
Prabhani Kranti	5.13	44.38	50.12	55.68	79.92	17.26	3.65	5.98	11.31	1.75	52.83	17.42	120.48
Varsha Uphar	5.14	41.35	44.71	49.65	92.42	18.75	4.05	6.18	12.09	1.69	52.83	18.96	120.49

(Table continued)

(Table continued)

Genotype	Days to 50% germination	Days to first flower	Days to 50% flowering	Days to maturity	Plant height(cm) [60 DAS]	Number of nodes (60 DAS)	Number of primary branches	Node to first flower appear	Fruit length (cm)	Fruit diameter (cm)	Number of seeds/ fruit	Number of fruits/ plant	Fruit yield (q/ha)
Mean	6.05	44.45	49.59	54.54	81.70	16.27	3.38	5.91	11.15	1.67	51.66	18.81	116.94
CV	9.43	5.16	4.60	4.06	4.08	7.57	12.68	8.19	4.88	11.01	4.28	5.79	0.63
SE	0.23	0.94	0.93	0.90	1.36	0.50	0.18	0.20	0.22	0.07	0.90	0.45	0.30
CD (5%)	0.65	2.63	2.62	2.54	3.82	1.41	0.49	0.56	0.62	0.21	2.53	1.25	0.85
CD (1%)	0.87	3.48	3.46	3.37	5.06	1.87	0.65	0.74	0.83	0.28	3.36	1.66	1.12

Table 2: Genotypic and phenotypic coefficients of variability (GCV and PCV), heritability, genetic advance as per cent of mean for different characters in okra (pooled data) (2019-20).

Character	Mean	Range	GCV (%)	PCV (%)	h2b (%)	GA(5%)	GA as % of mean (5%)
Days to 50% germination	6.05	3.93-8.19	22.885	24.75	85.5	2.638	43.591
Days to first flower	44.45	41.32-48.79	4.981	7.171	48.3	3.169	7.128
Days to 50% flowering	49.59	44.71-54.63	5.405	7.097	58.0	4.206	8.481
Days to maturity	54.54	49.02-59.76	5.119	6.535	61.4	4.506	8.262
Plant height [(cm)60 DAS]	81.70	71.31-92.42	7.089	8.178	75.1	10.343	12.659
Number of nodes (60 DAS)	16.27	12.77-18.75	11.992	14.18	71.5	3.400	20.892
Number of primary branches	3.38	2.36-4.05	13.238	18.329	52.2	0.666	19.697
Node to first flower appear	5.91	4.44-6.74	10.537	13.346	62.3	1.013	17.136
Fruit length (cm)	11.15	9.91-12.09	5.502	7.357	55.9	0.945	8.476
Fruit diameter (cm)	1.67	1.39-1.81	5.286	12.214	18.7	0.079	4.713
No of seeds/fruit	51.66	43.83-57.50	7.561	8.686	75.8	7.004	13.559
Average fruit weight (g)	11.59	9.73-12.61	10.360	10.988	88.9	2.332	20.121
Number of fruits/plant	18.81	14.73-23.04	12.371	13.661	82.0	4.342	23.080
Fruit yield/plant (kg)	0.21	0.19-0.23	5.916	6.010	96.9	0.025	11.995
Fruit yield/ plot (kg)	8.33	7.50-9.18	5.170	6.448	64.3	0.711	8.540
Fruit yield (q/ha)	116.94	106.71-129.49	5.823	5.857	98.8	13.947	11.927

GCV: Genotypic coefficient of variation; PCV: phenotypic coefficient of variation; H^2b: Heritability in broad sense; GA: Genetic Advance of cluster VI (X = 43.25) took minimum days to first flower. The genotypes of cluster V (X = 53.86) took maximum days to 50% flowering. The genotypes with early days to 50% flowering were concentrated in cluster II (X = 47.64).

The genotypes of cluster V showed highest mean for days to maturity (X = 59.23). The genotypes with early days to maturity appeared in cluster II (52.79). The highest cluster mean for plant height was observed in cluster III (X = 85.35). Lowest mean value of plant height was found in cluster VI (X = 71.37). Cluster III (X = 17.64) showed highest cluster mean for number of nodes/plant. However, lowest value was recorded in cluster VI (X = 13.23). Cluster IV (X= 3.83) showed highest cluster means for number of primary branches. However, lowest value was recorded in cluster VI (X = 2.96).

Maximum node to first flower was observed in genotypes of cluster V (X = 6.58). However, minimum node to first flower was observed in cluster IV (X = 5.08). The highest cluster means for fruit length and diameter was observed in clusters II (X = 11.40) and IV (X = 1.80) respectively. However, lowest value was recorded in clusters V (X = 10.06) and II (X = 1.61). The highest cluster means for number of seeds/fruit was recorded maximum in genotypes of cluster V (X = 53.17). However, it was minimum in genotypes of cluster VI (X = 48.17). The genotypes of cluster VI possessed maximum average fruit weight (X = 13.28). Minimum average fruit weight was recorded in genotypes of cluster VI (X = 10.55). The genotypes of cluster III possessed maximum number of fruits/plant (X = 22.28), fruit yield/plant (X = 0.23), fruit yield/ plot (X = 9.06) and fruit yield (X = 127.55). However, genotypes of cluster VI recorded means of number of fruits/plant (X = 14.73), fruit yield/plant (X = 0.19), fruit yield/plot (X = 7.80) and fruit/yield (X = 106.71).

CONCLUSION

Thus, it can be concluded that selection and hybridization of genotypes from high divergent clusters are expected to yield potential F_{1s} and transgressive for further exploitation.

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Effect of scarification on biochemical activities of aged seeds of guava (*Psidium guajava*)

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ABSTRACT

The study was carried out on fresh, one, two and three years aged seeds of guava (*Psidium guajava* L.) L-49 (Sardar) in the laboratory of Department of Seed Science and Technology, CCS HAU, Hisar, during 2018-2019. The seeds were subjected to different seed scarification treatments, *viz.* hot water treatment at 80°C for 1 minute, concentrated sulphuric acid for quick dip and water soaking for 48 hr. The seeds were assessed for peroxidase activity, dehydrogenase activity and electrical conductivity. Hot water treatment at 80°C for 1 minute resulted into maximum peroxidase activity (710.0) and dehydrogenase activity (0.233) with minimum electrical conductivity (11.02). It is concluded that seeds treated with hot water treatment at 80°C for 1 minute showed maximum peroxidase, dehydrogenase activities and minimum electrical conductivity which reflects better seed quality.

Key Words: Seed quality, Scarification, Peroxidase, Dehydrogenase, Electrical conductivity

Guava (*Psidium guajava* L.) belonging to family *Myrtaceae,* is fifth most important fruit crop of India (Saxena and Rao, 2017). It is a rich source of vitamin C and fair source of calcium, phosphorous, roughage and is ideal fruit for nutritional security (Bairwa *et al*., 2020). Guava seeds exhibit inconsistent germination with diminished or poor germination under normal conditions. The particular type of dormancy responsible for this has not been thoroughly investigated and understood. Physical dormancy due to hard seed coat is probable cause of poor germination. However, chemical and mechanical scarification can hasten the imbibition of water by making hard seeds permeable and undergo germination. Any deficiency of water during germination strongly limits seed germination (Cavallaro *et al*. 2014; Lamichhane *et al*. 2018). Although scarification method helps to break seed dormancy and improves germination (Maldonado-Arciniegas *et al*., 2018). The gibberellins may also release seed dormancy (Kalyani *et al*., 2014). However, very little information is available on scarification, hence an experiment was conducted.

MATERIALS AND METHODS

The experiment was conducted on four seed lots, viz. fresh, one, two and three years old seed lots of L-49 (Sardar) at laboratory of Seed science and Technology Department, CCS HAU, Hisar, during 2018-2019.The seeds collected from ripe fruits, were extracted and completely cleaned, dried and stored at room temperature. The seeds were subjected to hot water treatment at 80˚C for 1 minute, quick dip in sulphuric acid and water soaking for 48 hr. The seed quality was assessed through biochemical seed quality parameters, *viz.* peroxidase activity, dehydrogenase activity and electrical conductivity test. Peroxidase activity (µmol/gmDw) was determined as per Shannon *et al.* (1966), following oxidation of O-dianisidine in presence of hydrogen peroxide (H_2O_2). The 2.0 ml of acetate buffer (pH 4.5) and 0.1 ml of O-dianisidine solution was added to 0.05 ml of enzyme extract. To initiate the reaction 0.1 ml of 0.2 M hydrogen peroxide was also added.

The observation were recorded at 470 nm wavelength after every 15 second for 1 minute and enzyme unit was expressed as the amount of enzyme required to bring about a change in absorbance of 0.01 per minute. In dehydrogenase activity test (O.D.), the basic principle for topographical tetrazolium test for seed viability is reduction of 2,

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3, 5-triphenyl tetrazolium chloride to red formazan by dehydrogenase enzyme in seed embryo. For seeds of similar viability, it is a quantitative method which is used to determine varying dehydrogenase activity and therefore, it is measure of seed vigour. Sample of 2 g seed of in three replications were ground and passed through a 20 mesh screen. The 5 ml of 1% tetrazolium solution was used to absorb 200 mg flour for 3-4 h at 38°C. Then centrifugation was done at 10,000 rpm for 3 minutes and supernatant was discarded.

The 10 ml acetone was used to extract formazan for 16 hr, followed by centrifugation and spectrophotometer was used to determine the absorbance of solution at 480 nm. These observations were expressed in optical density. For estimation of electrical conductivity (μS/cm/sample), three replications of 25 normal seeds were immersed in 75 ml distilled water in 100 ml beakers. Seeds were soaked fully in water and aluminium foil was used to cover the beakers. These samples were put at 25±1°C for duration of 24 hr. Then conductivity meter was used to measure the reading of EC of seed leachates and expressed in μS/cm/seed (AOSA, 1983). The analysis was done with the software OPSTAT available on www.hau.ac.in.

RESULTS AND DISCUSSION

The activities of dehydrogenase test (O D g^{-1} ml^{-1}) and peroxidase (mg $protein^{-1} min^{-1}$) decreased, whereas electrical conductivity of seed leachates increased with advancement of ageing period. The maximum peroxidase activity (710.0) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum peroxidase activity (525.0) among all treatments, followed by water soaking for 48 hr (475.2). Hot water treatment and water soaking of seed for 48 h and control differed significantly with each other and minimum peroxidase activity was observed in seeds quick dipped in concentrated sulphuric acid (35.15). Fresh seed lot resulted into significantly higher peroxidase activity (507.5), followed by one, two and three years aged of seed lots.

Minimum activity (201.9) was observed in three-year old seed lot. Maximum peroxidase activity (507.5) was observed in fresh seed lot when seed treated with hot water at 80 °C for 1 minute and minimum (17.90) was observed in sulphuric acid in three- year old seed lot. There was decreases in activity of peroxidase in aged seeds (Fig. 1). The general, decrease in enzyme activity in seed lowers the respiratory capacity, which in turn lowers both the energy (ATP) and assimilates supply of germinating seeds. The results are in accordance with Kapoor *et al.* (2011), Radha *et al.* (2014), Tabatabei (2015) and Cakmal *et al.*(2010).

Maximum dehydrogenase activity (0.233) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot (Fig. 1). Hot water treatment resulted into maximum dehydrogenase activity (0.127) among all treatments, followed by water soaking for 48 hr (0.084). Hot water treatment and water soaking of seed for 48 hr and control differed significantly with each other and minimum dehydrogenase activity

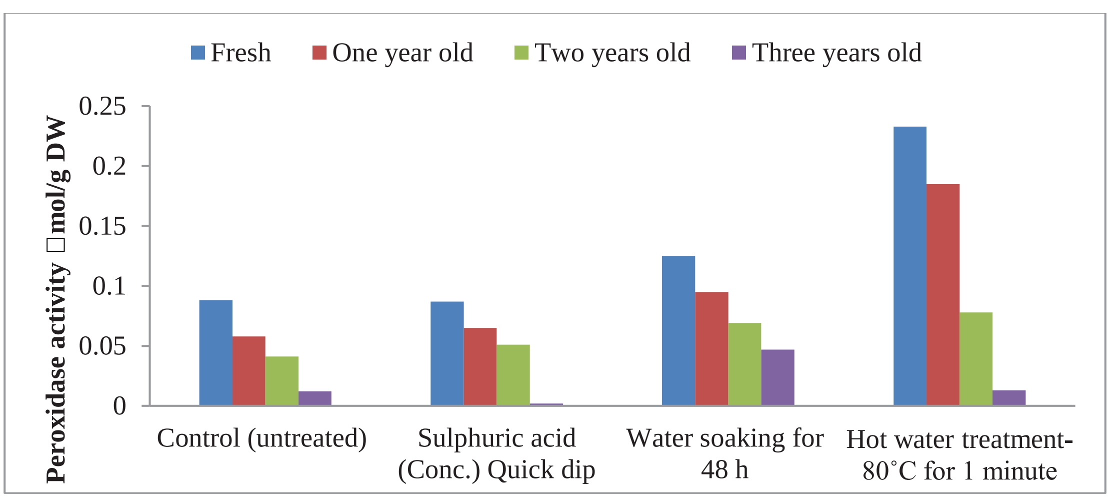

Fig. 1. Effect of scarification treatment and aging on peroxidase activity of different lots of guava seeds

was observed in concentrated sulphuric acid-quick dip (0.05) and control (0.05). Fresh seed lot resulted into significantly higher dehydrogenase activity (0.133), followed by one, two and three year aged. Minimum activity (0.019) was observed in three year old seed lot. Dehydrogenase activity was maximum (0.233) in hot water treatment at 80°C for 1 minute and minimum in concentrated sulphuric acid (0.002).

Maximum electrical conductivity (25.78) was observed in seeds treated with concentrated sulphuric acid had highest amount of seed leachtates and was significantly inferior seed to all others, followed by the control (18.40). Hot water treatment resulted into minimum electrical conductivity (11.02) among all treatments produced very less leachtates was considered good (Fig. 3). Fresh seed lot resulted into significantly very less electrical conductivity (12.83) and produced very less lechates and considered very good, followed by one, two and three -year aged of seed lots. Maximum electrical conductivity was observed in three year seed lot (18.73). Sulphuric acid treatment resulted in maximum electrical conductivity (25.78) and minimum in hot water treatment (11.02). Maximum electrical conductivity was observed in three -year - old seed lots (18.73) and minimum in fresh seed lot (12.82). These results are in accordance with those of Kalsa *et al.*(2011) and Ahmadvand *et al.*(2012).

The activities of catalase, peroxidase ascorbate peroxidase, glutathione reductase and superoxide dismutase decreased with ageing. Seed deterioration can be explained by the findings that ageing of seeds lead to lipid peroxidation that subsequently causes membrane perturbation. Such changes in membrane of aged seeds lead to electrolyte leakage. Enhanced lipid peroxidation

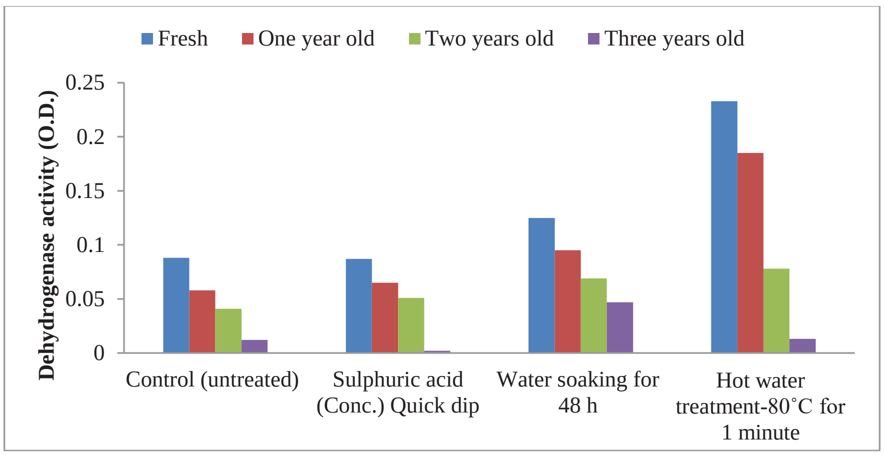

Fig. 2. Effect of scarification treatment and aging on dehydrogenase activity of guava seeds

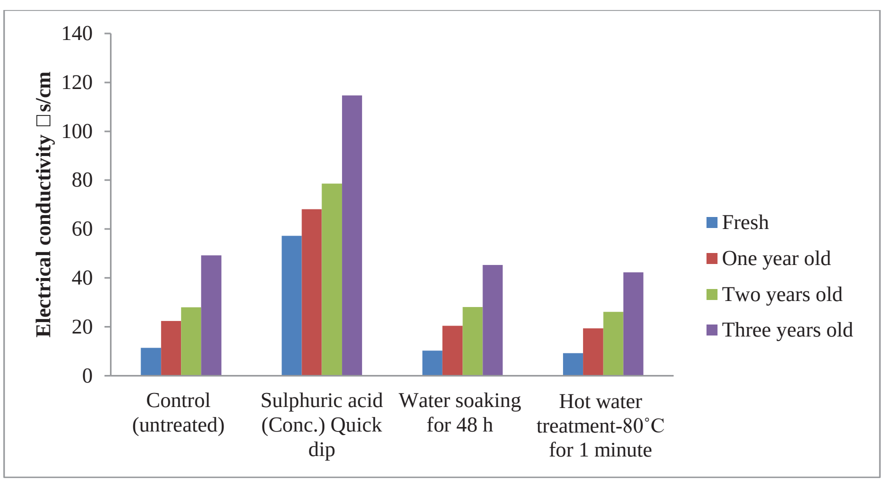

Fig. 3. Effect of different scarification treatment and aging on electrical conductivity of guava seeds

mediated by free radicals and peroxides is one of the probable reasons for seed viability loss during storage. Dehydrogenase and peroxidase activities in aged seeds decreased, while electrical conductivity increased due to harmful changes in their structure during seed ageing. The loss of enzyme activities could be responsible for higher H_2O_2 accumulation in aged seeds.

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Suppression of bacterial wilt in susceptible scion of tomato (*Solanum lycopersicum*) and brinjal (*Solanum melongena)* using *Solanum torvum* as resistant rootstock

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ABSTRACT

The autografts of tomato (*Lycopersicon esculentum* L.), brinjal (*Solanum melongena* L.) chilli (*Capsicum* sp.), and citrus (*Citrus* spp.), showed 86, 87, 84, and 88 % graft efficiency respectively. Moreover, homograft of tomato, brinjal and citrus showed 83, 81 and 84% graft efficiency respectively. *In vitro* microgafting protocol performed within 8 days after seed germination and had up to 97% success rate without use of any phytohormones. Moreover, tomato and brinlal grafted on *S. torvum* rootstock showed the resistance to bacterial wilt. However, non -grafted tomato and brinjal showed bacterial wilt symptoms. The developed microgarted protocol helps in the production of bacterial wilt resistant tomato and brinjal by the use of *S. torvum* as a rootstock.

Key Words: Bacterial wilt, Brinjal, Micrografting, Rootstock, *S. torvum*

Tomato (*Lycopersicon esculentum* L.) and brinjal (*Solanum melongena* L.) are very popular vegetables; in India (Tomar and Saha, 2018). They suffer from several biotic and abiotic stresses. Among these, bacterial wilt caused by *Ralstonia solanacearum* is most devastating. The several efforts has been taken to overcome these stresss. However, grafting was utilized to manage bacterial wilt in tomato crops worldwide (Ganiyu *et al.,* 2018). The use of tolerant rootstocks for grafting brinjalt varieties is most effective approach to control bacterial wilt disease (King *et al.,* 2008). Resistance to *R. solanacearum* has been identified in various accessions (Rotino *et al.,* 2014). There are some reports of improving production and productivity of guava (*Psidium guajava* L.) and pomegranate (*Punica granatum* L.) (Nowrozy, 2017; Kholia *et al*., 2022). However, there is no report on *in vitro* micrografting of tomato, brinjal, chilli, and citrus. Therefore, an experiment was conducted.

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MATERIALS AND METHODS

The seeds of brinjal (Shirish and *Solanum torvum*; resistance to bacterial wilt), tomato [(Arka Meghali; sensitive to bacterial wilt (Konappaa *et al*., 2016)], chilli (selection) and citrus (Sai Sarbati and Jambheri, mostly used as rootstock in citrus breeding) were collected form UHS, Banglore, and Mahatma Phule Krishi Vidyapeeth, Rahuri. Bacterial wilt pathogen (*R. solanacearum*) was collected from commercial biofertilizer unit, Vidhya Pratishthan, Baramati.

The 50 seeds of tomato, brinjal, chilli, and citrus, were surface sterilized as per Dsapute *et al* (2019) in 70% (v/v) ethanol for 5 min, followed by 1% sodium hypochlorite for 5 min and rinse the seeds five times with 1to 50 ml sterile water. Seeds were transferred on ½ Murashige and Skoog (MS) plates/bottels with the help of sterilized forceps in a laminar chamber. Plates/bottels were placed in a growth chamber in vertical position at 26±2^{o}C, light/dark of 16h/8h photoperiod and 1600 lux intensity light and relative humidity of 60-70% for 7 - 10 days until cotyledons were fully expanded. The micrografting protocol was followed as per the Gebhardt and Goldbach (1988) with minor modification.

Briefly, 40 seedlings of each plant were micrografted under sterile conditions in a laminar chamber, stem of rootstock and scion were cut very close to true leaves. The scion and rootstock were placed very close to each other in ½ MS medium without any phytohormons and keep the plates in vertical at all times. The autografting of tomato [Arka Meghali/Arka Meghali; brinjal (Shirish/Shirish), chilli (chilli1/chilli1) and citrus (Sai Sharbati/ Sai Sharbati) performed between the scion and rootstock of the same plants of same species (here after autograft plants). Also, homografting of tomato (Arka Meghali/*S.torvum*), brinjal (Shirish/*S.torvum*) and citrus (Sai Sharbati/ Jambheri) performed between scion and rootstock of different plants of same species (here after homograft plants).

Auto- and homo- grafts were grown for 5 - 10 days at 23°C under light and dark condition of 16 / 8 h, until roots were well developed. After 10 days, grafting efficiency (%) of each plant was calculated based on the formula given below (Fig. 1). The 15 days old grafted plants transferred to pot containing cocopeat and utilized for further purpose. The graft (%) efficiency= (Final Graft No. /Initial Graft No.) × 100

A single colony of *R. solanacearum* was inoculated in conical flask containing 500 ml luria broth and incubated at at 28 ^{O}C for 48 hrs on rotary shaker at 150 rpm. Culture broth was centrifuged at 10,000 rpm for 12 min at 10 ^{O}C. The pellet was resuspended in distilled water and bacterial suspensions were spectrophotometrically adjusted to O.D 600 nm = 0.1 [approximately1 × 108 colony forming unit (cfu) ml^{-1}] (Bhavana *et al.,* 2016).

After 15 days of growth, tomato and brinjal grafts were transplanted into pots containing cocopeat and soil in 1:1 proportion. When grafted plants exhibited 3–4 true leaves, *R. solanacearum* inoculums was applied using root damage infused inoculum method as described by Namisy *et al.* (2019) and Bhavana *et al*., 2016. Briefly, Roots of tomato grafts were injured with the help of a knife by cutting through soil 1–2 cm away from the stem base before inoculation. The 20 ml of *R. solanacearum* suspension was poured into each pot and the inoculated grafts were kept in greenhouse chamber for 45 days. Non-inoculated graft plants were included with water and used as the control. Grafts were watered in excess two times a day after inoculation to maintain the soil moisture high till the end of the experiment, approximately 2 month. All grafts were kept in a greenhouse after inoculation and bacterial wilt symptoms were observed once a week for three weeks and percentage (%) of wilt incidence was calculated by using the formula.

% wilt incidence = (No. of plants wilted / total no. of plants used for inoculation) × 100.

RESULTS AND DISCUSSION

Out of 50 seedlings, 40 equal size of seedling of each plant were used as scion and rootstock for micrografting. The grafts were observed after every 2 days up to 10 days and graft efficiency was calculated. After 2 days of grafting the formation of callus tissue was observed at grafting site. The micrograft efficiency was 97- 68% in auto and homo grafts. The very high micrograft efficiency was recorded in autograft of citrus (88%), brinjal (87%) tomato (86%) and chilli (84%). However, homo grafts of tomato brinjal and citrus showed 83, 81 and 84 percent grafting efficiency respectively (Fig.1). These results showed that developed protocol has very good grafting efficiency without use of any phytomormons and can be applicable for broad range of plant species.

The autograft of tomato (Arka Meghali/Arka Meghali) showed symptoms of plants wilted and died rapidly, 2 weeks after inoculation of *R. solanacearum.* The autografted plants showed 100% wilt incidence and indicated susceptibility to bacterial wilt. However, homograft of tomato (Arka Meghali/*S. torvum*) could not show any symptoms of bacterial wilt, 2 weeks after inoculation of *R. solanacearum.* The homograft plants of tomato showed only 0% wilt incidence and indicated resistance to bacterial wilt. The control auto and homo grafts observed as healthy plants. Similarly, autograft of brinjal (Shirish/ Shirish) showed 95% wilt incidence with the symptoms of plants wilted and died rapidly after inoculation. However, only 5% of brinjal homograft (Shirish/*S.torvum*) showed symptoms of bacterial wilt. The control auto and homo grafts showed healthy plants. These results suggested that use of rootstock in homograft of wild brinjal are resistance to *R. solanacearum,* and tomato and brinjal inoculated with *R. solanacearum* could not show any symptoms of bacterial wilt.

The resulting union often results in a more productive plant (Tamilselvi and Pugalendhi, 2015). Grafting has primarily been used to reduce the occurrence of soil-borne disease in non-native fruit vegetable plants, primarily tomato, brinjal, pepper

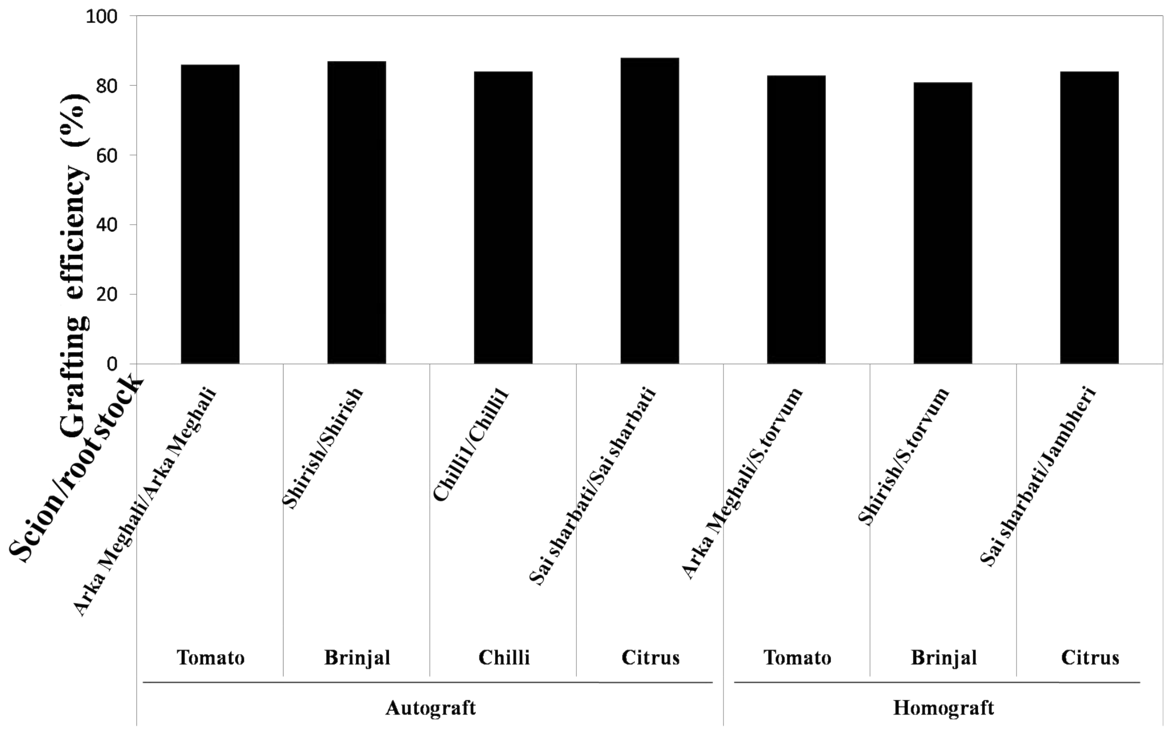

Fig. 1. Grafting efficiency of auto- and homo- grafts of various plants. The grafting efficiency was calculated by using successfully grafts and total number (#40) of graft performed.

and production of virus-free plants in citrus (Singh *et al.*, 2019). Although a disease tolerant rootstock can generally improve tolerance of a susceptible scion. The grafting of tomato and citrus has been utilized for protein movement, response to salinity and phosphate homeostasis (Spiegelman *et al.*, 2015). We developed first time *in vitro* micrografting protocol for tomato, chili, brinjal and citrus without use of any phytohormones.

We observed that formation of callus like tissues 2 days after grafting and this is responsible for joining of grafts. The wound callus is formed by division of parenchyma cells from cambium, phloem, xylem, and pith near the wounded surface. In herbaceous plants, callus cells are first formed at vascular bundles and cortex, with only a few in the pith. Mixing of wound callus cells of both graft partners can lead to further connection between scion and rootstock. The secondary plasmodesmata are able to connect cells between rootstock and scion to form a continuous symplast. Thus, substance exchange between adjacent cells and cell communication can be achieved. There was very high rate of microgafting efficiency (70-90 %) were observed in used plants (Fig.1). Singh *et al.* (2019) found the effect of various phytohormones such as kinetin, N6-benzylaminopurine (BAP) indole-3-acetic acid (IAA) on efficiency of citrus micrograting and observed maximum 56.8% graft efficiency.

Tomato and brinjal homografts grafted on rootstock of *S. torvum* showed resistance to *R. solanacearum.* The *Solanum melongena* complex has three species, namely, *S. melongena*, *S. incanum* and *S. insanum*. Wild relatives of Solanum, viz. *Solanum torvum*, *S. indicum*, *S. insanum*, *S. surattense*, *S. pubescens*, *S. gilo*, and *S. khasianum* are widely distributed in South India, Shivalik hills and North-eastern region (Reddy *et al.*, 2022). Rootstock of *S. torvum* showed highly resistance to bacterial wilt and resulted in a good fruit yield in scion (Ramesh *et al.*, 2016). The *S. torvum* as resistant to bacterial wilt was recomanded (Bainsla *et al.*, 2016). Besides, *S. torvum* has been also found compatible with tomato and displayed high level of waterlogging tolerance (Bahadur *et al.*, 2015). The *S. torvum* rootstock can be used in grating of tomato and brinjal to develop bacterial wilt resistance. This micrografting protocol can be used in the production of tomato and brinjal against the bacterial wilt.

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Performance of ajwain (*Trachyspermum ammi*) varieties at varying nitrogen levels under semi-arid tropics of Northern Karnataka

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ABSTRACT

An experiment was conducted at University of Horticultural Sciences, Bagalkot, Karnataka, during *Kharif* 2016 and 2017 to study effect of ajwain (*Trachyspermum ammi* L. Sprague) varieties and nitrogen levels on its plant growth and yield attributes in semi-arid tropics of Northern Karnataka. The experiment was laid out in a split plot design with three replications by keeping varieties in main plots (Ajmer Ajwain 1, Ajmer Ajwain 93, Lam Selection 1, Lam Selection 2 and Local cultivar) and nitrogen levels in sub plots (50, 75, 100 and 125 kg/ha). The growth and yield attributes were significantly higher in improved varieties compared to local cultivar. Ajmer Ajwain 1 recorded highest plant height (81.82 and 80.56cm), number of secondary branches (52.36 and 50.98), plant spread (72.66 and 50.98cm), number of umbels/plant (177.15 and 171.88), number of umbellate/umbel (11.81 and 11.65), seed yield (14.44 and 14.26 q/ha, during both year, respectively), which was on a par with Lam Selection-1 (13.93 and 13.56 q/ha, respectively). Earliest 50 per cent flowering was observed in Ajmer Ajwain 93. Application of nitrogen up to 125 kg/ha significantly increased growth and yield attributes which were on a par with 100 kg N/ha. Maximum seed yield g/plant, seed yield q/ha and essential oil yield kg/ha were recorded with 125 kg N/ha. Earliest 50 per cent flowering was observed under 50 kg N/ha application. Ajmer Ajwain1 and Lam Selection 1 were found better with an optimum dose of 100 kg N/ha.

Key Words: Nitrogen, Varieties, Essential oil, Yield, Secondary branches, Plant spread

Ajwain (*Trachyspermum ammi* L. Sprague) is a well-known seed spice with multiple medicinal properties. It is grown in *rabi* season and prefers a cool and dry climate. However, farmers are growing crop by using available cultivars, with or without a very low rate of nitrogenous fertilizers. Owing to its cultivation in marginal lands and non-availability of improved varieties, its productivity is very low in semi-arid tropics of Northern Karnataka. Therefore, an experiment was conducted to identify suitable varieties with optimum use of nitrogenous fertilizers for semi-arid tropics.

MATERIALS AND METHODS

The experiment was laid out in a split-plot design with three replications, main plots consisting of five varieties (Ajmer Ajwain1, Ajmer Ajwain 93, Lam selection-1, Lam selection-2 and Local cultivar) and nitrogen levels in subplots (50, 75, 100 and 125 kg/ha) and conducted during *kharif* 2016 and 2017 at University of Horticultural Sciences, Bagalkot, Karnataka. The soil was sand loamy, poor in fertility and water-holding capacity, having pH 8.61 and organic carbon 0.63%, available N 246.18 kg/ha, P_2O_5 17.35 kg/ha, K_2O 185.6 kg/ha. The crop was sown in second week of June during both years with a seed rate of 5 kg/ha.

Half of the nitrogen as per the requirement of respective treatment along with a common dose of phosphorus and potassium @ 40 kg/ha was applied as a basal dose at sowing. The remaining half of nitrogen was applied in two equal split doses at monthly intervals. All recommended cultural and plant-protection measures were followed. The data on growth and yield attributing characters and seed yield were recorded and analyzed statistically.

RESULTS AND DISCUSSION

The varieties, Ajmer Ajwain 1 and Lam Selection 1, performed better and produced significantly higher growth and seed yield than other varieties. Ajmer

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Ajwain 1 showed significantly higher plant height (82.82 and 80.56 cm), number of secondary branches (52.36 and 50.98), plant spread (72.66 and 71.84 cm), number of umbels/plant (177.15 and 171.88), number of umbellate/umbel (11.81 and 11.65), seed yield/ plant (18.01 and 17.54g) and seed yield (14.44 and 14.26 q/ha, during both years, respectively) which was on a par with Lam Selection-1. The present findings are confirmed by Wahab, Mahamed (2007) and Prem *et al.* (2008), Bhardwaj and Kumar (2016) and Thakral and Tehlan (2006), Phurailatpam *et al*. (2016) and Lal and Singh (2016).

The maximum essential oil was recorded in Lam Selection 1. (61.96 and 59.39 kg/ha during both years), which was at par with Lam Selection 2 (60.72 and 58.29 kg/ha), Ajmer Ajwain 1 (60.51 and 60.86 kg/ha) and Ajmer Ajwain 93 (54.41 and 53.77 kg/ha). The essential oil content varied significantly with different varieties (Fig 1). The maximum essential oil content was recorded in local cultivar (5.21 and 5.14 % during both years), while minimum essential oil content was recorded in Ajmer Ajwain 1 (4.20 and 4.13%, respectively). Similar results were found by Singh *et al*. (2003) and Rathore *et al*. (2016) and Phurailatpam *et al*. (2016).

All the varieties showed significant differences in fresh and dry weight of plants 30 days after sowing (DAS). The highest fresh weight was obtained from Ajmer Ajwain 1 (26.01 and 24.63 g/ plant) and dry weight (4.10 and 3.85 g/plant during both years, respectively) which were on a par with Lam Selection-1 (25.07 and 23.85 g/plant fresh weight) and (4.02 and 3.78 g/plant dry weight, respectively).

Reproductive parameters

The early flowering was recorded in Ajmer Ajwain 93 (50.06 and 51.38 days during both years) (Table 2). Lam Selection1 (75.00 and 76.03 days), Lam Selection 2 (76.60 and 77.33 days) and Ajmer Ajwain 1 (77.62 and 78.60 days, respectively) noticed medium flowering. The late flowering was observed in Local cultivar (105.55 and 106.87 days, respectively). On account of days to 50% flowering Ajmer Ajwain 93 (63.71 and 64.91 days) and minimum number of day's maturity (131.75 and 131.80 days during both years, respectively). Local cultivar recorded maximum number of days to 50% flowering (123.69 and 124.67 days) and late maturity (178.52 and 179.78 days, respectively) reported by Sanjay *et al.* (2022). The maximum biological yield was recorded in Ajmer Ajwain 1 (65.82 and 65.60 q/ha during both years), which was on a par with Lam Selection 1 (63.88 and 63.39 q/ha, respectively). Local cultivar recorded maximum straw yield (53.71 and 53.70 q/ ha during both years). The maximum harvest index was recorded in Ajmer Ajwain 1 (21.89 and 21.69 %), which was on a par with Lam Selection 1 (21.78 and 21.35%) and Lam Selection 2 (21.62 and 21.22 %, respectively).

Effect of nitrogen levels

Application of 125 kg N/ha recorded highest plant height (82.44 and 80.40 cm), number of secondary branches/plant (53.60 and 53.92), plants spread (70.91 and 69.63 cm), number of umbels/ plant (189.61 and 185.22), umbellets/umbels (11.95 and 11.86), seed yield/plant (17.62 and 17.08 g), seed yield (13.85, 13.65 q/ha), essential oil content (4.67 and 4.62%) and oil yield (64.00 and 62.61 kg/ ha, during both years, respectively) which was at par 100 kg N/ha application. Mourya and Kushwah (2018); Asharf and Noman (2006); Wahab and Mohamed (2007); Nath *et al*. (2008) support the findings. It was observed that maximum fresh and dry weight were obtained from the application of 125 kg N/ha (26.31 and 24.88 g fresh weight) and 4.08 and 3.86 g dry weight, respectively), which were on a par with 100 kg N/ha. (25.44 and 24.01 g fresh weight) and (3.92 and 3.72 g dry weight, respectively). The straw yield and harvest index were significantly affected by different nitrogen levels during both years (Table 1). The maximum biological, straw yield and harvest index were recorded with application of 125 kg N/ha, which was on a par with 100 kg N/ha application.

CONCLUSION

It is concluded that Ajmer Ajwain 1 and Lam Selection 1 are most suitable varieties for semi-arid tropics of Northern Karnataka.

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Table 1: Effect of varieties and nitrogen levels on fresh and dry weight, reproductive parameters, biological, straw yield and harvest index of ajwain

Treatment Varieties (V)	Fresh weight (g/plant) @ 30 DAS		Dry weight (g/plant) @ 30 DAS		Initiation of flowering		Days taken to 50 % flowering		Days to maturity		Biological yield (q/ha)		Straw yield (q/ha)		Harvest index (%)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
V_1	26.01	24.63	4.10	3.85	77.62	78.60	91.19	92.48	161.27	161.37	65.82	65.60	51.38	51.34	21.89	21.69
V_2	23.56	22.29	3.74	3.49	50.06	51.38	63.71	64.91	131.75	131.80	62.15	61.12	49.57	48.78	20.16	20.11
V_3	25.07	23.85	4.02	3.78	75.00	76.03	89.56	90.73	153.46	153.24	63.88	63.39	49.95	49.83	21.78	21.35
V_4	23.72	22.69	3.80	3.64	76.60	77.33	89.91	91.11	153.73	153.59	62.40	61.93	48.89	48.77	21.62	21.22
V_5	23.75	23.04	3.83	3.64	105.55	106.87	123.69	124.67	178.52	179.78	62.67	62.77	53.71	53.70	14.29	14.40
S Em±	0.42	0.45	0.07	0.06	1.78	1.53	2.09	2.12	3.20	2.62	0.77	0.74	0.63	0.53	0.25	0.29
CD (5%)	1.38	1.46	0.22	0.20	5.79	5.00	6.81	6.91	10.43	8.55	2.51	2.42	2.04	1.74	0.81	0.94
Nitrogen levels (kg/ha)																
N_1	21.74	21.20	3.72	3.50	74.82	75.91	89.50	90.35	152.93	153.22	57.31	57.36	46.57	46.88	18.72	18.25
N_2	24.20	23.12	3.87	3.64	76.47	77.60	91.32	92.26	155.27	155.44	62.78	62.66	50.31	50.21	19.85	19.85
N_3	25.44	24.01	3.92	3.72	77.24	78.33	92.42	93.26	156.30	156.53	65.68	64.98	52.01	51.66	20.80	20.50
N_4	26.31	24.88	4.08	3.86	79.33	80.32	93.22	95.24	158.50	158.64	67.76	66.84	53.91	53.19	20.42	20.42
S Em±	0.35	0.33	0.06	0.05	1.37	1.22	1.62	1.64	2.38	2.23	0.78	0.77	0.68	0.65	0.19	0.19
CD 5%	1.02	0.96	0.16	0.15	3.96	3.51	4.68	4.74	6.88	6.44	2.24	2.23	1.96	1.89	0.54	0.54
N X V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V X N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot: varieties (V)		**Sub plot: nitrogen levels (N)**	
V_1 : Ajmer Ajwain 1	**V_4** : Lam Selection 2	**N_1** : 50 kg N/ha	**N_3** : 100 kg N/ha
V_2 : Ajmer Ajwain 93	**V_5** : Local cultivar	**N_2** : 75 kg N/ha	**N_4** : 125 kg N/ha
V_3 : Lam Selection 1	**NS:** Non-Significant		

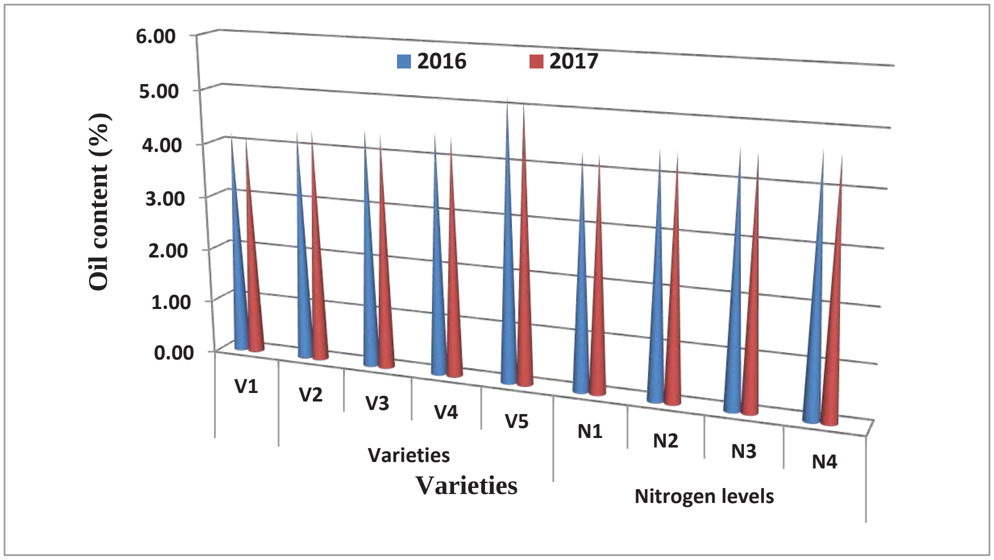

Fig. 1: Oil content of ajwain varieties as influenced by different levels of nitrogen during *kharif* 2016 and 2017

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Effect of boron on growth and flowering in gladiolus (*Gladiolus* sp.)

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ABSTRACT

The experiment was conducted to find out the optimum dose of boron in maximizing growth and improving flowering attributes in gladiolus (*Gladiolus sp.)* cv. Malaviya Shatabdi at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh during 2020-21. The treatments were given as: the control (distilled water), 0.1% boron, 0.2% boron, 0.3% boron, 0.4% boron, 0.5% boron, 0.6% boron, 0.7% boron, 0.8% boron, 0.9% boron and 1.0% boron, applied at 60 and 75 days after planting. There was maximum number of leaves/plant (13.94), maximum width of scape (2.67 cm) was noted at 0.3% of B, maximum plant height was recorded with foliar application of 0.5% B (70.42 cm), whereas leaf length (65.50 cm) and leaf width (2.63 cm) were maximum at 0.6% of B as compared to other treatments. The earliest spike emergence and colour were noted in 68.44 days and 77.88 days respectively at 0.2% of B spray. Earliest opening of first and fifth florets was seen with 0.6% of B (85.06 and 90.00 days respectively). Maximum length (9.72 cm) and diameter (7.81cm) of first floret was observed in 0.2 % and 0.3% B treatments, whereas, maximum length (8.62 cm) and diameter (7.40 cm) of fifth floret was detected in 0.6% and 0.5% B treatments respectively. Results also showed that application of B significantly reduced flowering duration among all the treatments as compared to the control.

Key Words: Corms, Boric acid concentrations, Foliar spray, Vegetative and floral characters.

Gladiolus (*Gladiolus* sp.*)* is highly valued for its elegant flowers. The productivity needs standard cultural practices at different growth stages. It needs proper nutrients for high yield. Among different micronutrients, boron (B) is important for normal growth of plants (Shireen *et al*., 2018). The essential minerals are required in trace amounts for better growth, development and metabolic activity of plants (Gowthami *et al*, 2022). As a cut-flower, it should have better shelf life. The genetic variability is observed among genotypes (Swaroop *et al*., 2019). Varieties with novel colours and new adaptive characters are developed every year (Rocktim and Sunil, 2022). Keeping in view, a field experiment was conducted.

MATERIALS AND METHODS

The experiment was conducted at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, during 2020-2021. The experiment was laid out in randomized block design with four replications and eleven treatments of different boric acid (B) concentrations. Manure and fertilizers were given as per the recommendation. Gladiolus corms (cv. Malaviya Shatabdi) of uniform shape and size were selected as planting material. Corms were planted at a uniform spacing of 30 cm × 20 cm and depth of 10-15 cm in furrows. Intercultural operations, earthing-up, weeding, hoeing and irrigation were done according to need.

Boron was used in the form of boric acid and applied through foliar spray. Different concentrations of boric acid, i.e. 0.1% B, 0.2% B, 0.3% B, 0.4% B, 0.5% B, 0.6% B, 0.7% B, 0.8% B, 0.9% B and 1.0% B were used. Lime was used for neutralizing boric acid solutions. The boron solutions of different concentrations were sprayed twice, at 3 and 6 leaf stages. Statistical analysis was done at 5% level of significance. Growth parameters were recorded 75 days after planting, i.e., at 6 leaf stage. The number of plants/hill, number of leaves/plant, plant height, leaf length, leaf width and width of scape were recorded. The observations were taken for each tagged plant in respective replication.

Flowering parameters, viz. days to spike emergence, days to colour show, opening and withering of first, third, fifth and last florets, length and diameter of first, third and fifth florets, spike

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length, rachis length, inter nodal length, number of florets/spike, number of opened florets/spike, flowering duration of first, third, fifth and last florets and total duration of flowering. These parameters were recorded timely.

RESULTS AND DISCUSSION

There was maximum number of plants/hill with 0.4% B treatment (2.56). It may be as a result of assemblage of photosynthates in soil owing to presence of boron. (Muthanna *et al.,* 2017). Maximum number of leaves/plant (13.94) was recorded in 0.3% B. This may be due to transport of starch and sugars by boron affecting physiological processes. These findings supported to those of Singh *et al*. (2018); Reddy and Chaturvedi (2009) and Halder *et al*. (2007a) (Table 1). Maximum plant height (70.42 cm) was attained with foliar application of 0.5% B. This finding contradict those of Chopde *et al*. (2016). It may be due to different climatic and soil conditions prevailing in the region. Leaf length was maximum (65.50 cm) with treatment of 0.6% B and was significant with other treatments.

Maximum leaf width was obtained in plants treated with 0.6% B (2.63 cm) and was significant to other treatments. This may be the result of accumulation of boron in leaf tissues causing cell elongation. Maximum width of scape was obtained with treatment of 0.3% B (2.67 cm). Also, cell wall synthesis and stability increases with components of cell wall like pectins, polyols and polyhydroxyl polymers. This finding is in accordance with those of Muthanna *et al.* (2017).

Boron (0.2%) resulted in earliest spike emergence (68.44 days) and colour show (77.88 days), while plants treated with 0.8% B resulted in late spike emergence (77.25 days) and colour show (84.19 days). This might be due to toxic effects of boron causing late spike emergence and colour show at higher concentrations. Similar findings were obtained by Singh *et al*. (2018) and Kumar *et al*. (2010). Earliest opening of first, third, fifth and last florets was observed with treatments of 0.6% B (85.06 days), 0.2% B (87.56 days), 0.6% B (90.00 days) and 0.2% B (95.38 days) respectively. On the contrary, withering of first floret was earliest with 0.6% B treatment (90.69 days), while withering of third, fifth and last floret was earliest with treatment 0.2% B each (93.00 days, 94.44 days and 94.44 days respectively). The results are in confirmation with those of Fahad *et al*. (2014), Chopde *et al*. (2016) and Ahmad *et al*. (2010).

Maximum diameter of first floret (7.81 cm) was observed with 0.3% B treatment, maximum diameter of third floret (7.74 cm) at 0.2% B and maximum diameter of fifth floret (7.40 cm) with 0.5% B treatment (Table 2). Maximum length of first floret (9.72 cm) was observed with plants treated with 0.2% B, maximum length of third floret (9.36 cm) was in 0.3% B and highest length of fifth floret (8.62 cm) was noted in plants of

Table 1. Effect of boron on number of plants/hill, number of leaves/plant, plant height, leaf length, leaf width and width of scape

Treatment	Number of plants/hill	Number of leaves/ plant	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Width of scape (cm)
Control (distilled water)	1.19	7.06	64.15	59.82	2.28	2.34
0.1% B	2.44	12.00	64.03	60.20	2.28	2.29
0.2% B	1.94	10.75	63.52	59.39	2.38	2.55
0.3% B	2.50	13.94	69.67	64.84	2.47	2.67
0.4% B	2.56	12.94	68.41	62.32	2.49	2.53
0.5% B	2.50	13.38	70.42	64.44	2.62	2.63
0.6% B	2.25	10.94	70.07	65.50	2.63	2.53
0.7% B	1.88	11.19	63.03	58.94	2.43	1.66
0.8% B	1.81	9.19	59.10	56.02	2.28	2.04
0.9% B	1.94	11.31	65.04	61.48	2.53	2.45
1.0% B	2.00	10.81	61.69	58.35	2.25	2.10
CD (5%)	0.30	1.55	2.53	1.86	0.26	0.28

Table 2. Effect of boron on flowering duration of first, third, fifth and last florets, total duration of flowering, length and diameter of first, third, fifth and florets, spike length, rachis length and inter nodal length

Treatment	Flowering duration of floret (days)				Total duration of flowering (days)	First floret (cm)		Third floret (cm)		Fifth floret (cm)		Spike length (cm)	Rachis length (cm)	Internodal length (cm)
	1st	3rd	5th	last		Length	Diameter	Length	Diameter	Length	Diameter			
Control (distilled water)	5.69	5.56	5.38	2.94	4.00	9.40	7.57	8.52	6.96	8.55	6.37	69.63	31.43	3.48
0.1% B	4.63	5.00	4.13	4.00	4.00	9.41	7.38	8.59	6.64	8.30	6.28	67.32	30.85	3.39
0.2% B	5.50	5.44	4.38	4.00	4.00	9.72	7.64	8.96	7.74	8.20	6.83	63.40	30.45	3.24
0.3% B	5.25	4.88	4.25	4.00	4.69	9.46	7.81	9.36	7.04	8.57	6.65	68.54	29.67	3.46
0.4% B	4.88	4.88	4.13	3.75	3.75	9.22	7.48	8.37	6.67	8.09	6.41	62.47	29.52	3.33
0.5% B	5.56	5.19	3.88	3.81	3.81	8.39	7.57	8.92	7.31	8.42	7.40	71.05	30.90	3.41
0.6% B	5.63	5.69	5.13	3.75	3.75	8.46	7.48	8.88	7.21	8.62	6.78	73.50	34.30	3.46
0.7% B	4.75	5.25	4.63	4.00	4.00	9.02	6.74	8.40	6.39	8.54	6.76	61.25	27.77	2.72
0.8% B	4.69	4.25	3.88	2.75	2.50	8.73	7.46	7.94	6.38	7.41	6.28	65.44	28.52	3.16
0.9% B	5.38	4.88	4.75	3.94	3.94	9.13	7.20	9.08	7.46	7.54	6.52	70.17	34.18	3.63
1.0% B	4.56	5.44	4.63	3.63	3.38	9.00	7.37	8.51	6.83	8.24	6.43	68.83	33.54	3.50
CD (5%)	0.86	0.81	0.85	0.75	0.87	0.71	0.70	0.75	0.78	0.63	0.54	7.31	4.18	0.45

0.6% B treatment. The element stimulates, inhibits, or stabilize enzymes; it is involved in transport of sugars across the membrane, lignin and flavonoid synthesis, and metabolism of auxins, nitrogen compounds, and phenols (Milka *et al*., 2020). These results may be due to increased activity of boron in cell division and cell elongation of florets, resulting in increased length and diameter. The number of florets/spike and opened florets/spike were maximum with 0.9% B (13.13 and 11.81, respectively). Appearance of the spike is also determined by number of florets opened at a time. Opened florets at a time was maximum with 0.2% B (6.88) treatment.

Longest spikes and rachis were obtained with treatment of 0.6% B each (73.50 cm and 34.30 cm respectively) (Table 2). It might be due to effect of boron when applied at higher concentration, resulting in cell division and elongation, whereas longest inter nodal length was obtained with 0.9% B (3.63 cm). This was in accordance with those of Devi *et al*. (2017). Maximum flowering duration of first, third, fifth and last florets was attained with application of 0.6% B (5.69 days), 0.6% B (5.69 days), 0.6% B (5.38 days) and 0.7% B (4.00 days). Total duration of flowering was higher with 0.3% B treatment (4.69 days).

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Response of mango (*Mangifera indica*) cultivars to agro-chemicals for growth and flowering

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ABSTRACT

An experiment was conducted during 2015-16 and 2016-17 at Agricultural Research Station, Banswara district of Rajasthan to study the response of different agro-chemicals for growth and flowering of mango (*Mangifera indica*). The plants were planted in a square system of planting with a 10m × 10m spacing. Agro-chemicals, calcium chloride, potassium nitrate, paclobutrazol and sorbitol were used. The treatment combinations were applied as the control (water spray), calcium chloride (0.3, 0.6 and 0.9%), potassium nitrate (1, 2 and 3%), paclobutrazol (500, 1000 and 1500 ppm) and sorbitol (1.5, 2.0 and 2.5%). Application of different agro-chemicals were applied at different stages and times. Effect of agro-chemicals was found significant for growth and flowering parameters. Paclobutrazol (1500 ppm) was found better for shoot length and diameter, tree spread, canopy volume and days of fruit setting from flower initiation and flowering characters, *viz.* date of flower initiation, per cent fruit setting and retention, days to harvest from fruit setting and first flush after fruiting.

Key Words: Calcium chloride, Potassium nitrate, Paclobutrazol, Sorbitol, Agro-chemicals

Mango (*Mangifera indica* L.) is popular fruit in world. The KNO_3 is suggested to induce ethylene production and efficacy of KNO_3 is suppressed by ethylene biosynthesis inhibiters, the involvement of ethylene appear an important factor in mango flower process (Upreti *et al.*, 2014). Paclobutrazol help for regular bearing in biennial habits of mango cultivars. It helps in getting more number of reproductive shoots (Muhammad *et al.*, 2010) and also increase the perfect flowers panicle^{-s} in mango. Hence, an experiment was conducted to see the response of mango to agro-chemicals for growth and flowering.

MATERIALS AND METHODS

The experiment was conducted in Banswara district of Rajasthan (Maharana Pratap University of Agriculture and Technology). The region falls under agro- climatic zone IVb "Humid Southern Plain Zones of Rajasthan'' at an altitude of 302m above mean sea-level and lies between 23°11′ N to 23°56′ N latitude and 73°58′ E to 74°49′ E longitude. Soils are predominantly reddish medium, well drained calcareous, shallow on hills and deep in valleys. The experiment consisted of 13 treatments along with the control and replicated thrice in a randomized block design. The 15-year-old mango orchard consisting of Dashehari, Langra and Kesar was selected.

Plants were planted in square system of planting at 10m × 10m spacing. Calcium chloride, potassium nitrate, paclobutrazol and sorbitol were applied. The treatment combinations, control (water spray), calcium chloride (0.3, 0.6 and 0.9%), potassium nitrate (1, 2 and 3%), paclobutrazol (500, 1000 and 1500 ppm) and sorbitol (1.5, 2.0 and 2.5%) were applied. The calcium chloride was applied one month prior to harvesting (7-8 May during both the years), potassium nitrate at marble-sized stage (27 February and 1-March during both the years), paclobutrazol at fruit-bud differentiation stage (11 October) and sorbitol at pea nut size (19 January).

The observations were recorded on shoot length, shoot diameter, tree spread (E-W) and (N-S), canopy volume, date of flower initiation, days of fruit setting

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from flower initiation, per cent fruit set, per cent fruit retention, days of harvest from fruit set and first flush after fruiting.

RESULT AND DISCUSSION

The minimum shoot length (24.63 cm) was observed in Kesar, followed by Langra (26.71 cm) and maximum (29.34 cm) in Dashehari. The shoot diameter showed decreasing trend, 0.77, 0.70 and 0.62 cm in Dashehari, Langra and Kesar, respectively. Maximum shoot diameter was observed under treatment V_1 (Dashehari) and minimum in V_3 (Kesar). It might be attributed to genetic make-up of cultivars. These results are in line with these of (Sarolia *et al.,* 2013-14). The minimum shoot length (24.72 cm) was observed in T_9 (PBZ 1500 ppm), followed by (25.09 cm) T_{12} (sorbitol 2.5%) and maximum (29.28 cm) by T_4 (KNO_3 1%), followed by T_0 (29.20 cm) (Table 1). When paclobutrazol @ 1500 ppm (V_3T_9) was applied in conjunction on Kesar, there was significant reduction in shoot length (22.76 cm) and canopy volume (138.13 m^3). Kesar showed strong biennial behaviour over Dashehari and Langra (Upreti *et al.,* 2013).

The minimum shoot diameter (0.56 cm) was observed in treatment T_7 (PBZ 500 ppm), followed by (0.58 cm) T_8 (PBZ 1000 ppm) and maximum (0.84 cm) under T_{12} (sorbitol 2.5%). It is clear that treatment combination V_3T_7 (Kesar + PBZ 500 ppm) resulted in lowest shoot diameter (0.50 cm), followed by V_3T_8 (0.52 cm) which were at par with each other. Further, highest shoot diameter (0.91 cm) was obtained from treatment combination V_1T_0 (Dashehari + water spray), V_1T_{12}, followed by V_1T_{11} (0.87 cm) which were statistically at par with treatment V_1T_0 (Dashehari + control). Tree spread (E-W) and (N-S) showed non-significant effect during both the years.

The stimulation on such growth characters were attributed to application of different agro-chemicals. The influence of applied agro-chemicals on these characters may be ascribed to its catalytic or stimulatory or suppression effect on most of the physiological and metabolic processes of plants. Paclobutrazol is a broad spectrum plant growth retardant that selectively controls tree vigor (Uperti *et al.*, 2013). Thus, application of paclobutrazol, suppress vegetative growth and development of plant and helps in getting more number of reproductive shoots (Muhamad *et al.*, 2010).

There was maximum canopy volume (253.50 m^3) in Dashehari than in Langra (184.07 m^3) and was recorded under cv. Kesar (148.47 m^3). The minimum canopy volume (181.08 m^3) was observed under T_9 (PBZ 1500 ppm). Interaction effect of cultivars and agro-chemicals showed significant influence (Table 1). The maximum canopy volume (292.27 m^3 and 285.22 m^3) was recorded in combination V_1T_0 (Dashehari + water spray) and minimum (139.19 m^3 and 138.13 m^3) in V_3T_9 (Kesar + PBZ 1500 ppm). Treatment combination V_3T_9 (Kesar + PBZ 1500 ppm) recorded 48% lower canopy over tree V_1T_0 (Dashehari + water spray).

Reduction in shoot growth by PBZ is primarily as a consequence of reduced internodal elongation associated with GA biosynthesis inhibition and increasing synthesis of inhibition like ABA. Abscisic acid also produced through the terpenoid pathway. Treatment with PBZ promotes the production of ABA much like phytol production. The PBZ also interferes with the normal breakdown of ABA. The combined effect on both production and breakdown of ABA resulted in enhanced concentration of ABA in leaves. The ABA caused stomata to close, reduced shoot growth and water loss through transpiration (Srilatha *et al.*, 2014).

Kesar recorded most early initiation of flower (8 December during 2015-16 and 3 December during 2016-17), followed by Dashehari (18 December during 2015-16 and 10 December during 2016-17) and cultivar Langra (26 December during 2015-16 and 15 December during 2016-17) in T_9 (PBZ 1500 ppm). T_9 (PBZ 1500 ppm) recorded early flower initiation, while late flower initiation recorded under the control. Treatment T_9 recorded about 20-32 days early flowering initiation over the control in different mango cultivars. Paclobutrazol increased flowering by reducing the effectiveness of gibberellic acid by preventing shoot elongation and also causes rapid development of reproductive buds by interfering with gibberellins metabolism which otherwise promotes vegetative growth. The PBZ blocks the terpenoid pathway at several steps inhibiting the gibberellins synthesis (Srilatha *et al.,* 2014). Soil application of paclobutrazol exhibited less number of vegetative flushes/shoot, checking vegetative growth with paclobutrazol by inhibiting the biosynthesis of gibberellins in plants by blocking the conversion of kaurene and kaurenoic acid is possible reason for restricting the more vegetative flush per shoots (Shankaraswamy *et al.,* 2015).

The highest fruit setting (1.15%) was recorded in V_2 (Langra), followed by (1.10%) V_1 (Dashehari), while minimum (1.08%) was noted in V_3. The fruit setting indicates that different agro-chemicals had

Table 1: Response of mango cultivars to agro-chemicals with respect to growth and flowering parameters

Treatment / Observation	Shoot length (cm)	Shoot diameter (cm)	Tree spread		Canopy volume (m^3)	Days of fruit set from flower initiation	Per cent fruit set	Per cent fruit retention	Days to harvest from fruit set	First flush after fruiting (days)
			E-W(m)	N-S (m)						
Varieties										
V_1 (Dashehari)	29.34	0.77	9.06	8.73	253.50	21.17	1.10	1.52	87.09	87.81
V_2 (Langra)	26.71	0.70	9.14	8.86	184.07	22.80	1.15	1.56	93.52	80.97
V_3 (Kesar)	24.63	0.62	9.10	8.81	148.47	19.77	1.08	1.39	90.78	62.45
SEm±	0.127	0.003	0.045	0.046	1.159	0.34	0.01	0.01	0.44	0.238
CD (5%)	0.354	0.009	NS	NS	3.237	0.94	0.02	0.03	1.22	0.664
Agro-chemicals										
T_0 (Control) WS	29.20	0.83	9.34	9.08	213.59	22.41	0.69	0.86	103.33	68.00
T_1 ($CaCl_2$ 0.3%)	27.57	0.69	9.16	8.79	196.53	22.40	0.85	1.31	97.61	81.94
T_2 ($CaCl_2$ 0.6%)	26.88	0.71	9.11	8.72	192.07	22.26	0.85	1.32	97.22	81.39
T_3 ($CaCl_2$ 0.9%)	26.61	0.73	9.07	8.67	188.69	22.16	0.87	1.33	96.61	80.94
T_4 (KNO_3 1%)	29.28	0.61	9.22	8.84	200.22	20.85	0.92	1.42	84.78	80.10
T_5 (KNO_3 2%)	28.77	0.63	9.26	8.99	207.76	20.24	0.95	1.45	83.33	79.55
T_6 (KNO_3 3%)	28.46	0.66	9.34	9.05	212.88	20.08	0.99	1.50	82.05	78.92
T_7 (PBZ 500ppm)	26.12	0.56	8.99	8.79	190.82	20.85	1.48	1.70	85.16	74.53
T_8 (PBZ 1000ppm)	25.41	0.58	8.92	8.70	185.89	20.36	1.53	1.76	83.66	73.72
T_9 (PBZ 1500ppm)	24.72	0.62	8.86	8.61	181.08	19.89	1.59	1.84	82.66	72.66
T_{10} (Sorbitol 1.5%)	26.00	0.79	9.05	8.82	194.17	22.01	1.20	1.58	93.72	77.55
T_{11} (Sorbitol 2.0%)	25.52	0.81	9.02	8.82	193.18	21.48	1.25	1.64	93.11	76.89
T_{12} (Sorbitol 2.5%)	25.09	0.84	8.99	8.56	182.62	21.18	1.30	1.68	92.78	75.83
SEm±	0.264	0.007	0.094	0.097	2.412	0.700	0.015	0.019	0.910	0.495
CD (5%)	0.737	0.018	0.261	0.270	6.739	NS	0.043	0.053	2.541	1.383

significant effect on the basis of pooled analysis. The maximum per cent fruit setting (1.59%) was recorded in T_9. Whereas, T_0 resulted in lowest fruit setting (0.69%). Combined effect of cultivars and agro-chemicals had significant effect on per cent fruit setting. The treatment combination V_2T_9 (Langra + PBZ 1500 ppm) resulted in maximum per cent fruit setting (1.74%), whereas minimum (0.67%) was recorded with Dashehari + water spray.

The maximum per cent fruit retention (1.56%) was registered in V_2 (Langra), followed by (1.52%) treatment V_1 (Dashehari), while lowest (1.39%) obtained from treatment V_3. Further, in agro-chemical, maximum per cent fruit retention (1.84%) was reported in treatment T_9 and minimum (0.86%) was in the control. The maximum per cent fruit retention (2.06%) was recorded in V_2T_9 (Langra + PBZ 1500 ppm) and minimum (0.83%) in treatment V_1T_0 (Dashehari + water spray) which was statistically at par (0.86%) with V_2T_0 (Langra + water spray). The mean maximum (1.97%) per cent fruit retention was registered in V_2T_9 and minimum (0.84%) in V_1T_0 treatment combination. It might be due to PBZ initiates early flowering by mimic the effect of environmental factors on flowering and reduces the age dependency of shoots for early and profuse flowering (Srilatha *et al.,* 2014).

These results are in accordance with those of Sarkar *et al.* (2014). Srividhya *et al.* (2022) reported that Paclobutrazol could enhance the total phenolic content of terminal buds and altered the xylem to phloem ratio, which is important in restricting vegetative growth and enhancing flowering by altering assimilates partitioning and patterns of nutrient supply for new growth. KNO_3 used to stimulate off-season flowering of mango especially under tropical regions. Rapid decrease in potassium content in leaves at initial stage corresponded with the period of rapid growth of shoots. Decreasing or stability in potassium content after flowering, fruit setting and fruit growth might be due to utilization of potassium by fruits in their development (Bhalerao *et al.,* 2013).

The days to harvest from fruit setting was minimum (87.09 days) in. Dashehari and maximum (93.52 days) in Langra. Among chemical treatment, minimum days of harvest from fruit setting (82.05 days) was in T_6 (KNO_3 3%) which remained at par with T_9 and maximum (103.33 days) was reported under the control. By use of KNO_3 (3%), 21.28 days early crop (fruit setting to harvesting) obtained over the control. The first flush after fruiting was early (62.45 days) recorded in Kesar, followed by (80.97 days) and (87.81 days) in Langra and Dashehari, respectively. Srilatha *et al.* (2015) reported that the paclobutrazol accelerated the induction of flowering as indicated by increase in percentage of flowering plants, more flowers, faster rate of flower emergence, more petals and higher yield in 20 accessions of mango hybrids.

CONCLUSION

It was concluded that Langra and Dashehari are promising in the region. Paclobutrazol (1500 ppm) was found better for shoot length and diameter, tree spread, canopy volume and days of fruit setting from flower initiation and flowering.

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Management of weed diversity through organic mulching and alternative weed suppression practices on ginger (*Zingiber officinale*)

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ABSTRACT

A field experiment was conducted at the Regional Research Station (Hill Zone), Uttar Banga Krishi Viswavidyalaya, Kalimpong, Darjeeling, West Bengal, during 2019 and 2020 to study the effect of weed diversity, growth and yield of ginger (*Zingiber officinale* Rose) as influenced by organic mulching and alternative weed management practices. The randomized block design, having seven varying treatments with three replications was used. The treatments consisted of dry weed biomass mulch @ 5.0 t/ha (T_1), paddy straw mulch @ 5.0 t/ha (T_2), FYM Mulch @ 5.0 t/ha (T_3), dry leaves of *Schima wallichi*@ 5.0 t/ha (T_4), dry leaves of *Artimesia* sp. and *Eupatorium* sp. @ 5.0 t/ha (T_5), hand weeding (twice) at 45 and 90 DAS (T_6) and unweeded control (T_7). The result showed that hand weeding twice at 45 and 90 DAS (T_6) appreciably reduced the total weed population/m^2 and total dry weight of weeds than unweeded control plot (T_7) at all the stages of crop growth. The highest plant height (82.10 cm), number of leaves/clump (65.41), number of pseudostem/clump (5.17), rhizome length (7.22 cm), rhizome width (5.50 cm), number of fingers/rhizome (6.42), yield/plant (0.268 kg/plant), yield (20.33 t/ha) and weed control efficiency were recorded under the hand weeding twice at 45 and 90 DAS (T_6) compared to other treatments. The results showed that it is necessary to cover the soil surface with different mulch materials and manual weed control practices to achieve a good control of weeds along with enhanced yield attributes.

Key Words: FYM, Mulch, Dry weeds, Yield, Weeds, Weed biomass, Pseudostem

Ginger (*Zingiber officinale* Rose) is an important commercial spice crop. Weeds compete with ginger for nutrients, moisture and space, causing 35-75% yield reduction. However, environmental condition of hilly regions of Kalimpong and adjoining areas is characterized by moderate temperature and high rainfall which is highly conducive for year round emergence and growth of highly competitive perennial and annual weed species, *Cynodon* spp., *Cyprus* spp., *Digitaria* spp., *Eleusina indica, Imperata cylindrica, Commelina* spp., *Bidens pilosa, Amaranthus species, Physalis minima, Spilanthes acmella, Sida acuta, Solanum nigrum, Polygonum* and *Ageratum conyzoides* (Sah *et al*. 2017, Choudhary and Kumar 2019). In spite of diverse and highly competitive weed flora existing in ginger-growing areas, information on weed management in ginger is not available. Mulching has a positive effect on micro climate of soil (Bu *et al*. 2002) and increase the yield (Choudhary *et al*. 2013). The surface application of mulch favourably influences weed flora by suppressing their emergence and subsequent growth (Lalitha *et al*., 2001, Choudhary and Kumar 2019), and may also provide the nutrients by microbial decomposition of organic mulches (Ghosh *et al*., 2006). Therefore, the present study was carried out on handweeding and spreading of FYM, dry leaves of tree species and dry weed biomass mulch for optimum growth and yield of ginger.

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MATERIAL AND METHODS

The experiment was conducted at Regional Research Station (Hill Zone), Uttar Banga Krishi Viswavidyalaya, Kalimpong, West Bengal, during 2019 and 2020. The randomized block design, having seven varying treatments with three replication was used. The treatments consisted of dry weed biomass mulch @ 5.0 t/ha (T_1), paddy straw mulch @ 5.0 t/ha (T_2), FYM Mulch @ 5.0 t/ha (T_3), dry leaves of *Schima wallichi* @ 5.0 t/ha (T_4), dry leaves of *Artimesia* sp. and *Eupatorium* sp. @ 5.0 t/ha (T_5), hand weeding (twice) at 45 and 90 DAS (T_6) and unweeded control (T_7). Weed flora in experimental field was identified and their sequence of appearance, emergence profile and special characteristic feature were also noted by regular survey on weeds throughout the growing period. The effect of organic mulching and alternative weed management practices over weeds of ginger were analyzed taking consideration of total weed populations, total dry weight of weeds, weed control efficiency and yield components and yield.

Weed suppression efficiency was calculated from following formula and it is expressed in %.

$$\text{WSE} = \frac{\text{Weed dry weight in control plot (unweeded)- weed dry weight in treated plot}}{\text{Weed dry weight in control plot (unweeded)}} \times 100$$

Weed Index (WI) is a measure of efficacy of particular treatment compared with weed free treatment and is expressed as percentage of yield potential under weed free.

$$\text{Weed index} = \frac{X - Y}{X} \times 100$$

where, X - Yield from weed free and Y - Yield of a particular treatment

RESULT AND DISCUSSION

The plant height was significantly different among all the treatments during both the years. However, plant height indicated significant variation over the control treatment. The hand weeding twice at 45 and 90 days after sowing resulted in higher plant height (82.92, 81.27 and 82.10 cm). This might be due to removal of all the weeds by hand which helps to develop suitable environment for root growth and improve micro environment for their growth. It was lowest under without mulch and handweeding (68.81, 67.23 and 68.02 cm) (T_7). Weed management practices by mulching, FYM and dry leaves of *Schima wallichi* and *Eupatorium* mulch significantly influenced plant height of ginger than other mulching materials. The highest plant height was noted under FYM mulch (80.23, 79.88 cm and 80.06) (T_3), followed by dry leaves of *Schima wallichi* and *Eupatorium* (78.69, 77.88 and 78.29 cm) (T_4).

Highest number of pseudostems was noted under hand weeding twice at (45 and 90 DAS) (5.16, 5.18 and 5.17) (T_6). The increase in number of pseudostem might be owing to less crop weed competition for nutrients, space, light and moisture. Weed management practices by different mulch materials, FYM mulch (5.01, 4.96 and 4.99) (T_3) produced more number of pseudostem, followed by dry leaves of *Schima wallichi* and *Eupatorium* (4.88, 4.82 and 4.85) (T_4) than other treatments. This might be due to spreading of FYM as mulch materials not only reduced the weed growth but also supply macro and nutrients to plants. The lowest number of pseudo-stem was recorded under the control treatment (4.45, 4.42 and 4.44) (T_7).

The hand weeding twice at 45 and 90 days after recorded maximum number of leaves/clump (65.95, 64.86 and 65.41) (T_6). The increase in number of leaves/clump might be due to increase in growth of crop. However, different weed management by FYM mulch produced more number of leaves/clump (63.73, 62.89 and 63.31) (T_3), followed by dry leaves of *Schima wallichi* and *Eupatorium* (61.45, 60.64 and 61.05) (T_4) and lowest was recorded under treatment without weeding and mulch (53.82, 52.95 and 53.38) (T_7).

The weed management practices by manual hand weeding resulted in maximum rhizome length (7.31, 7.15 and 7.22 cm), rhizome width (5.51, 5.48 and 5.50 cm) and number of fingers/rhizome (6.56, 6.28 and 6.42) (T_6) compared to other treatment. This might be due to manual hand weeding not only removal of weeds but also loosening and pulverised soil which ultimately enhances the rhizome length, width and number of finger per rhizome. However, weed management practices by FYM mulch recorded highest rhizome length (7.01, 6.82 and 6.91 cm), rhizome width (5.30, 5.24 and 5.27 cm) and number of fingers/rhizome (6.23, 6.02 and 6.12) (T_3), followed by dry leaves of *Schima wallichi* and *Eupatorium* (rhizome length 6.71, 6.50 and 6.61 cm, rhizome width 5.09, 5.03 and 5.06 cm and number of finger/rhizome 5.92, 5.63 and 5.78) (T_4). The increase in rhizome length, width and number of fingers/rhizome might be due to uniform germination, moisture conservation in soil, available nutrients and less crop weed competition than other treatments. The lowest rhizome length (4.96, 4.81 and 4.89 cm), width (4.01, 3.99 and 4.00 cm) and number of fingers/rhizome (4.60, 4.48 and 4.54) were noted under control (without hand weeding and mulch) (T_7).

The highest yield (269, 266 and 268 g/plant) (20.56, 20.09 and 20.33 t/ha) was noted under handing weeding twice (T_6). The increase in yield might be

Table 1: Effect of weed management on yield, weed control efficiency and weed index

Treatment	Yield/ plant (g)		Yield tonnes/ha		Weed control efficiency (%) 45 days after sowing		90 days after sowing		Weed index	
	YI	YII	YI	YII	YI	YII	YI	YII	YI	YII
TI	241	237	15.54	15.11	46.82	45.37	45.62	45.85	24.42	24.77
T2	235	230	15.11	14.97	45.90	43.24	43.12	42.70	26.51	25.47
T3	258	255	18.30	18.04	68.09	62.99	60.80	60.61	10.99	10.20
T4	251	249	17.05	16.59	56.79	54.03	50.35	50.95	17.09	17.41
T5	246	242	16.08	15.94	53.12	50.61	47.15	47.65	21.81	20.66
T6	269	266	20.56	20.09	87.47	75.76	64.70	65.08	00.00	00.00
T7	225	220	11.03	10.92	-	-	-	-	46.35	45.63
SEm±	**0.019**	**0.024**	**0.244**	**0.212**	-	-	-	-	-	-
CD (P=0.05)	**N.S.**	**N.S.**	**0.760**	**0.662**	-	-	-	-	-	-

YI=2019 and YII=2020

due to better weed control. The use of FYM as a mulch materials significantly increased the yield (258, 255 and 257 g/plant) (18.30, 18.04 and 18.17 t/ha) (T_3), followed by dry leaves of *Schima wallichi* and *Eupatorium* (251, 249 and 250 g/plant) (17.05, 16.59 and 16.82 t/ha) (Table 1).

Hand weeding twice at 45 (89.16 and 84.26%) and 90 DAS (64.70 and 65.08%) (Table 1). The highest weed control efficiency was noted under treatment received FYM mulch @ 5.0 t/ha (68.09 and 62.99%) at 45 DAS and 90 DAS (60.80 and 60.61%) (T_3) and dry leaves of *Schima wallichi* and *Eupatorium* (56.79 and 54.03%) at 45 DAS and at 90 DAS (50.35 and 50.95%) (T_4) (Table 1). The highest weed index was noticed under control (46.35, 45.63 and 45.99) (without mulch and hand weeding) (T_7) (Table 1). This might be due to higher infestation of different species of weed in under unweeded control. However, lowest weed infestation under hand weeding twice (45 DAS and at 90 DAS).

There was highest number of weeds species in unweeded control (T_7). This might be due to higher infestation by broad leaved (*Bidens pilosa, Amaranthus species, Physalis minima, Sida acuta, Solanum nigrum, Polygonum, Rumex nepalensis, Ageratum conyzoides*), grasses (*Cynodon dactylon, Digitaria* spp., *Eleusina indica, Imperata cylindrica*) and sedges (*Cyprus* spp.).

Thus it may be concluded that manual weed control practices and soil surface cover with different mulch materials is significant to achieve a good control of weeds along with enhanced yield of ginger.

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Standardization of dehydration techniques for vegetable cluster bean (*Cyamopsis tetragonoloba*)

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ABSTRACT

An experiment was conducted to standardized dehydration techniques for clusterbean (*Cyamopsis tetragonoloba* L.) pods at ICAR-CIAH, Bikaner, during 2020-21. The pods were blanched for different durations (3, 4, 5, 6 and 7 minutes) in boiling water to standardize blanching process. Five minutes blanching in boiling water followed by immediate dipping in cold water was found optimum for getting quality dehydrated product. Blanching treatment significantly enhanced the drying (5.67) and rehydration rate (4.65) and augmented rehydration capacity of dried pods. The dehydration recovery was 21.24% of fresh pods. The dried samples stored with HDPE pouches had low moisture content and high rehydration capacity than the samples stored with LDPE pouches. Thus, it is recommended that blanching is an essential process for quality pods. The HDPE pouches were found suitable packaging material for storage stability of dried pods.

Key Words: Dehydration, Blanching, LDPE, HDPE, Pods, Drying, Rehydration

Clusterbean (*Cyamopsis tetragonoloba* L.) is a rich source of soluble fiber content and minerals. Edible portion is a rich source od nutrition (Krishnakumar *et al*., 2016). The tender green pods which are used extensively for vegetable culinary both as green and dried pods (Samadia, 2012). Dried vegetables have great potential to use throughout the year (Samadia, 2016). Arid and semi arid region of India blessed with abundant and inexhaustible alternative energy source (Singh *et al*., 2019). However, quality of dehydrated vegetable like colour, texture and rehydration capacity are very much essential for commercialization of products. Blanching, chemical dipping and osmotic procedure are applied to fruits and vegetables. So far blanching treatment and dehydration procedure have not been standardized for clusterbean. Therefore, study was undertaken to standardize dehydration procedure, packaging and storage of dried clusterbean pods.

MATERIALS AND METHODS

Fresh green pods (10-12 days after setting) of clusterbean 'Thar Bhadavi' were harvested in morning hours from Vegetable Experimental Farm of ICAR-Central Institute for Arid Horticulture, Bikaner. Immediately after harvesting pods were brought to post-harvest laboratory, sorting, grading and washing were carried out and uniform-sized pods were utilized. Two experiments consisting of standardization of blanching treatment and storage and packaging of dried beans were done.

A known quantity (350 g) of green pods was taken in a muslin cloth and dipped in boiling (95 °C) water for 3, 4, 5, 6 and 7 minutes for blanching treatment. Thereafter pods were dipped immediately in cold water (26 °C) for 5 minutes to prevent overcooking. Then pods were removed from the cold water and kept for drying in perforated SS trays at room temperature. One lot of pods was dried without blanching and treated as the control.

The drying ratio was calculated by the following formula:

$$\text{Drying ratio} = \frac{\text{Weight of fresh material before drying}}{\text{Weight of dried material}}$$

Twelve beakers (six each for blanched and unbalanced samples) of each 500 ml capacity were taken and 300 ml of boiling water and 20 g of dried sample were poured into each beaker and kept for 60 minutes for rehydration. Weight of rehydrated

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samples was measured at 10 minutes interval for 60 minutes period. Surface moisture from rehydrated samples was removed properly by applying tissue paper before measuring weight. The rehydration ratio was calculated by following formula:

$$\text{Rehydration ratio} = \frac{\text{Weight of rehydrated materia}}{\text{Weight of dried material}}$$

Drying kinetics was determined by measuring sample weight by digital balance at regular interval and plotting graph of weight loss against time. Same way rehydration kinetics was determined by plotting curve of weight gain against time period during rehydration process (Ismail *et al.*, 2016).

Dried samples were packed in different packaging materials: LDPE (low density polyethylene) and HDPE (high density polyethylene) pouches. Packed samples were stored at ambient temperature up to 4 months for storage. The physicochemical analysis of stored products was carried out at an interval of 30 days during storage. Moisture content of pods during storage was determined using a hot air oven for uncrushed materials.

The Data were collected in triplicate, the mean values with standard deviations were reported. Significant mean difference at 95% confidence level (α =0.05) was identified through use of WASP 2.0 software developed by ICAR-Central Coastal Agricultural Research Institute, Goa.

RESULTS AND DISCUSSION

There was significant difference in drying ratio in blanched and unblanched samples. Maximum drying ratio was observed in samples blanched for 7 minutes duration while minimum drying ratio was noticed in the control (unblanched) (Fig. 1). However, difference in drying ratio was non-significant among all blanched samples. High-drying ratio in blanched samples may be due to softening of tissues due to heat treatment which facilitate easy removal of moisture from the product. Similar observations were also reported by Shete *et al*. (2015) in green peas; Rajeshwari *et al*. (2013) and Manzoor*et al*. (2019).

Blanching process showed significant effect on rehydration ratio of dried pods. Significant difference was observed in rehydration ratio of blanched and unblanched samples. Maximum rehydration ratio (4.65) was calculated in samples blanched for 5 minutes duration, followed by 4 minutes duration (4.15) and minimum value of rehydration ratio (3.15) was noticed in unblanched samples (Fig. 1). Blanching duration also showed significant effect on rehydration ratio. Samples blanched for 3 and 4 minutes period had significantly lower value of rehydration ratio compared to samples blanched for 5, 6 and 7 minutes. However, non-significant difference was observed among samples blanched for 5, 6 and 7 minutes. Higher RR in blanched samples may be attributed to cellular and structural disruption caused during blanching which might have contributed to the increase in RR of pods. Similar results were also observed by Al-Amin *et al*. (2015). Blanching of green pods for five minutes was found ideal for retaining colour, texture and sufficient reconstitution capacity in dried product.

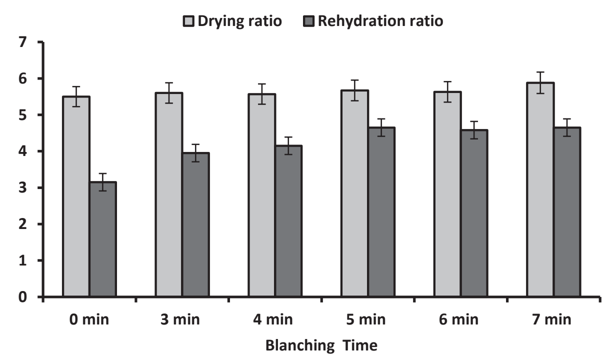


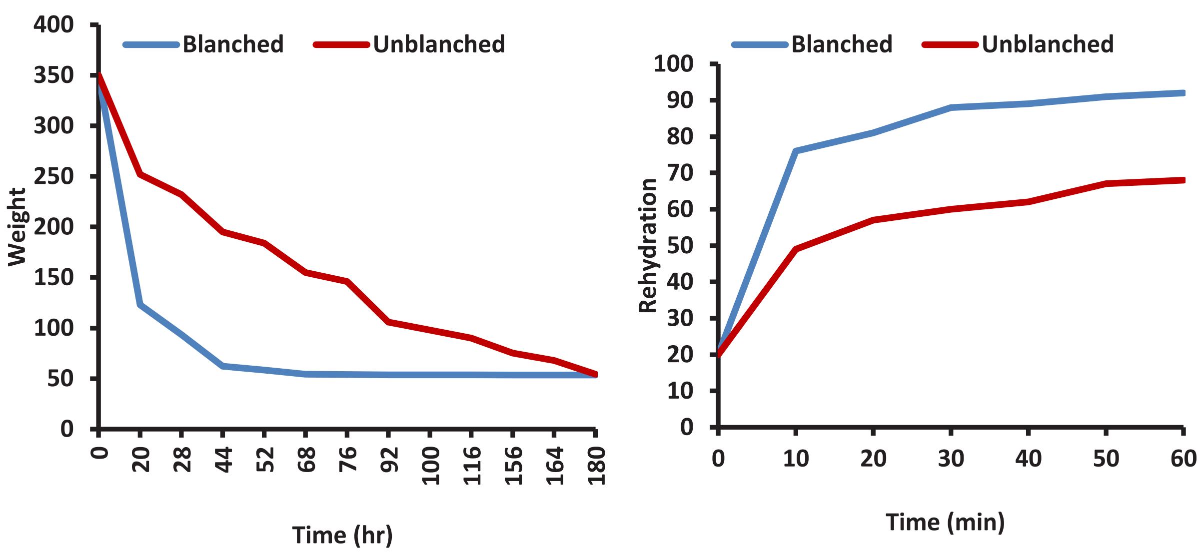
Fig. 1: Effect of blanching time on drying and rehydration ratio of clusterbean pods

The initial weight of cluster bean pods used in drying experiment was 350 g for both blanched and unblanched. The weight of blanched samples rapidly reduced with passing of time as compared to unblanched samples. Initial 20 hr of drying, 65% weight loss was observed in blanched samples, while in unblanched pods 28% loss in weight was noticed. Drying was achieved in 44 hr period in blanched samples, while unblanched pods took 180 hr for drying to acceptable moisture level. This phenomenon can be explained that in addition to the enzyme inactivation blanching resulted in tissue softening, subsequently resulting in faster moisture removal by enhancing moisture transfer from inside the samples to surface. Thus, higher heat absorption by blanched samples resulted in higher product temperature and relatively faster rate and consequently shorter drying time. Our findings are corroborated with these of Manzoor *et al*. (2019).

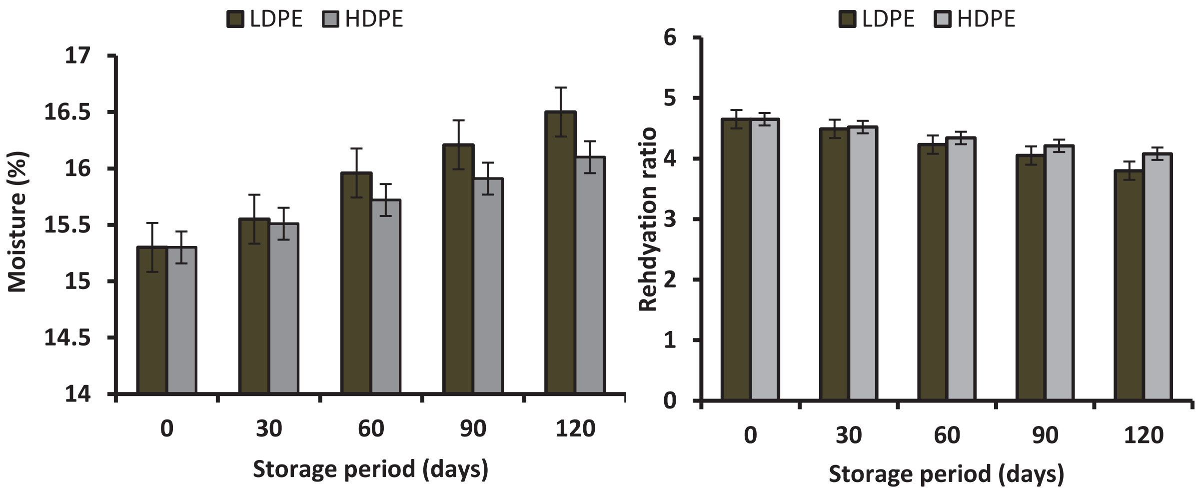
The amount and rate of water absorbed determine the sensorial properties and the preparation time required by the consumer (Ulloa *et al*., 2013). Rapid water uptake was observed both in blanched and unblanched samples during initial 10 minutes of rehydration. However, in blanched samples rehydration rate was significantly high as compared to unblanched pods (Fig. 2a and b). In later stages rehydration rate was declined and followed flat pattern in both the samples. The total weight gain at the end of rehydration process was significantly high in blanched pods (4.6 times) as compared to unblanched (3.4 times). The rapid rehydration rate in initial period was because of high water activity gradient between the sample and surrounding media (water) and as time passes, this difference reduced with consequent lower rate of rehydration. The decline in rehydration rates at later stages is related to the lower water absorption presumably because of the filling of water in free capillaries and intercellular spaces present in tissues of dehydrated pods. Similar rehydration patterns for a variety of legumes have been reported previously (Ulloa *et al*., 2013).

As the days of storage progressed, moisture content of all dried pods samples packed in LDPE and HDPE increased significantly ($p \leq 0.05$) (Fig 3a and b). This increase in moisture content might be due to hygroscopic nature of dried pods that absorb the atmospheric moisture during storage. Seevaratnam *et al*. (2012) also reported similar behaviour during storage of green leafy vegetables and Krishnakumar *et al*. (2016) during storage of dried cluster beans. With regard to packaging materials, a significant difference was found between HDPE and LDPE, rate of increase in moisture was significantly low in samples packed in HDPE as compared to LDPE during storage. At the end of storage period moisture (%) was high in dried pods stored in LDPE (16.5%) and significantly less in HDPE stored pods (16.1%) This effect might be attributed to less permeability of HDPE film to water vapor compared to LDPE. Singh *et al*. (2018) were also reported similar results during storage of dry dates at room temperature.

The RR showed significantly ($p \leq 0.05$) decreasing trend with increase in storage period. Initial 30 days of storage had non-significant difference in RR of dried pods stored in LDPE and HDPE pouches. However, during later period significant reduction in RR was observed in pods stored in LDPE pouches. At the end of storage period, RR of HDPE storage pods was 4.08, while in LDPE it was 3.80. The HDPE film showed higher values of RR than LDPE which might be due to less absorption of moisture in HDPE during storage (Pavani and Aduri, 2018) and (Manzoor *et al*. 2019).



Figs (2a and 2b). Drying kinetics and rehydration kinetics of blanched and unblanched pods



Figs 3a and b. Changes in moisture (%) and rehydration ratio during storage of dried pods

CONCLUSION

Thus, it is concluded that five minutes blanching in boiling water is optimum for getting quality dried pods. The HDPE pouches were found superior over LDPE pouches for 120 days storage at room temperature.

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Formulation, storability and quality assessment of blended nectar of guava (*Psidium guajava*) and papaya (*Carica papaya*) pulp

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ABSTRACT

The experiment was conducted at School of Agriculture, ITM University, Gwalior, to standardize the blended nectar of guava (*Psidium guajava* L.) and papaya (*Carica papaya* L.) pulp during 2021-2022. Blended drinks were good alternative for development of new products to provide taste, nutrition as well as medicinal properties. Due to high amount of ascorbic acid and fibre, guava acts as an anti-oxidant, whereas papaya is highly rich in carotenoides and riboflavin. The Total Soluble Solids, acidity, reducing sugars and total sugars increased, whereas pH, ascorbic acid, non-reducing sugar and organoleptic score decreased with advancement in storage period in PET bottles. Nectar prepared with 20 % fruit pulp comprising 80 % guava and 20 % papaya with 13 % TSS, 0.3 % acidity and 70 ppm SO_2 (T_6) was found more acceptable (8.20) than other blend formulations. The nectar was organoleptically acceptable up to 4 months of storage at ambient temperature (18.3-27.9^{0}C) into PET bottles. Thus, guava and papaya can be utilized for valuable nectar beverage making which can be beneficial for consumers in terms of taste, colour, flavour and therapeutic properties.

Key Words: Nectar, Blended nectar, PET bottles, Storage, Organoleptic quality.

Guava (*Psidium guajava* L.) is a rich source of vitamin C and fair source of calcium, phosphorous and roughage, hence it is ideal fruit for nutritional security. It is also good source of pectin and therefore, it is useful for preparation of jam, jelly and nectar (Bairwa *et al.* 2020). Guava is considered as one of the exquisite, nutritionally valuable and remunerative fruit crop (Singh *et al.* 2013). It contains appreciable quantities of antioxidants like polyphenols and ascorbic acid. Similarly, papaya (*Carica papaya* L.) is a good source of natural sugars and vitamin C but is low in calories and has great medicinal value. It is highly used for making processed products, candy, toffee, jam, jelly and beverages such as RTS, squash and syrup. Keeping in view, an experiment was done to standardize appropriate combination of guava-papaya blends for preparation of nectar and also to assess the changes in chemical constituents and overall acceptability of beverage blends during storage.

MATERIALS AND METHODS

Guava and papaya (local variety) fruits were purchased and their pulp were used for nectar preparation. The treatments were: T_1, 20 % blend comprising 100 % guava pulp + 0 % papaya juice and adjusted to 15% TSS, 0.30% acidity and 70 ppm SO_2; T_2, 20 % blend comprising 0 % guava pulp + 100 % papaya juice and adjusted to 15% TSS, 0.30% acidity and 70 ppm SO_2; T_3, 20 % blend comprising 50 % guava pulp + 50 % papaya juice and adjusted to 15% TSS, 0.30% acidity and 70 ppm SO_2; T_4, 20 % blend comprising 60 % guava pulp + 40 % papaya juice and adjusted to 15% TSS, 0.30% acidity and 70 ppm SO_2; T_5, 20 % blend comprising 70 % guava pulp + 30 % papaya juice and adjusted to 15% TSS, 0.30% acidity and 70 ppm SO_2; T_6, 20 % blend comprising 80 % guava pulp + 20 % papaya juice and adjusted to 15% TSS, 0.30% acidity and 70 ppm SO_2 and T_7, 20 % blend comprising 90 % guava pulp + 10 % papaya juice and adjusted to 15% TSS, 0.30% acidity and 70 ppm SO_2.

Nectar comprising 20% blend, 15% TSS, 0.30% acidity and 70ppm SO_2 were prepared by different treatments for each blend combination. This nectar was organoleptically evaluated on 9-point Hedonic scale to find out the best combination of blend.

Finally, 5 liters of nectar was prepared with best combination of blend, and filled into 200 ml sealed

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PET bottles of capacity leaving 1.6 cm head space and put for storage studies under ambient condition. During storage observation on changes in TSS, acidity, pH, vitamin-C, reducing sugars, non-reducing sugar, total sugars and organoleptic quality were recorded at monthly interval. Observations were recorded for changes in TSS, acidity, pH and vitamin-C (Rangana, 2010), sugars and organoleptic quality at monthly intervals during 4 months of storage period.

Total soluble solids was measured by using ERMA company made hand refractometer at ambient temperature and corrected at 20°C using reference table, whereas acidity was determined by titrating known quantity of sample against 0.1 N sodium hydroxide solution using phenolphthalein as an indicator and expressed in per cent anhydrous citric acid. The pH was estimated by digital pH meter at room temperature, while vitamin C content was estimated by preparing sample in 3 per scent metaphosphoric acid solution and titrating against 2, 6 dichlorophenol indophenols dye solution till the appearance of light pink colour. The reducing, non-reducing and total sugars were analyzed by using Fehling's solution A and B and methylene blue as an indicator. A panel of 9 semi trained judges including male and female evaluated nectar for its colour, flavour, taste, appearance and overall acceptability on 9-point Hedonic scale.

The experiments were conducted in 3 replications. The statistical analysis of data was done by computer software as per Panse and Sukhatne (1985).

RESULTS AND DISCUSSION

Fresh guava pulp used in nectar making contained 10.33 ^{0}B Total Soluble Solids, 0.48 per cent acidity, 4.02 pH, 212 mg/100g vitamin C, 6.32 per cent reducing sugars, 3.38 per cent non-reducing sugar and 9.70 per cent total sugars. Kumari (2016) reported similar findungs in gauva. Papaya pulp contained 12.55 ^{0}B Total Soluble Solids, 0.25 per cent acidity, 4.70 pH, 55.08 mg/100g vitamin-C, 8.64 per cent reducing sugars, 2.10 per cent non-reducing sugar and 10.74 per cent total sugars. Balaswamy *et al.* (2013) reported the similar reading.

A quality blended nectar with 20 per cent blend comprising 80 per cent guava pulp and 20 per cent papaya pulp with 15 percent sugar, 0.30 per cent acidity and 70 ppm SO_2 (T_6) was organoleptically found best for preparation of blend nectar**.** Similarly, Salvi *et al.* (2015) reported that the nectar containing 75 % guava pulp and 25 % papaya pulp has secured maximum organoleptic score.

The Total Soluble Solids of nectar increased gradually after one month of storage from 15.00 to 15.44 per cent. This change might be due to the conversion of polysaccharides into simple sugars (Table 1). Similarly increasing trend in TSS during storage was noticed in guava nectar supplemented with Aloe vera gel **(**Abed *et al.,* 2014), rangpur lime based RTS (Deen and Harendra, 2022) and paniol (*Flacourtia jangomos*) jam and jelly (Baruah *et al.* 2019) which are in agreement of present observations.

The acidity of nectar increased gradually during storage period. Total acidity increased from 0.30 per cent at initial day to 0.45 per cent at final day of storage.

The increasing trend in acidity during storage was observed by Rohila *et al.* (2017) on bael-guava nectar and Baruah *et al.* (2019) in paniol (*Flacourtia jangomos*) jam and jelly. The pH content continuously decreased from the first day 3.95 to 3.58 throughout the storage period. This decrease in pH content might be due to degradation of carbohydrates present in mixed fruit juices by the action of microorganisms. Similarly decreasing trend in pH during storage was observed by Priyanka *et al.* (2015) in jamun based RTS. vitamin C content was continuously decreased from the first day (13.36 mg/100ml) to the end of storage (13.09 mg/100ml) throughout the storage period. This decrease in vitamin C content might be due to oxidation of ascorbic acid into dehydro-ascorbic acid in the presence of oxygen.

The loss of vitamin C in nectar of different fruits-based beverages during storage at ambient temperature was also reported by Selvi *et al.* (2018) and Baruah *et al.* (2019). The reducing sugars and total sugars of blended nectar, increased gradually and it was increased from 6.44 per cent to 6.85 per cent and 9.46 per cent to 9.65 percent, respectively. These finding were supported by Singh and Singh (2014); Rohila *et al.* (2017) and Baruah *et al.* (2019). The non-reducing sugar of blended nectar, decreased continuously throughout the entire period of storage and it was decreased from 3.02 to 2.80 %. This finding was supported by Deen and Harendra (2022) in rangpur lime based RTS. Organoleptic score of blended RTS decreased gradually with the storage period at room temperature (18.3-27.9^{0}C). The acceptability of nectar was maintained up to four months. The score was significantly decreased

Biochemical assessment and organoleptic changes of nectar during storage period into PET bottles

Storage period (months)	TSS (0Brix)	Acidity (%)	pH	Vitamin-C (mg/100ml)	Reducing sugars (%)	Non-reducing sugar (%)	Total sugars (%)	Organoleptic	
								Score	Rating
0	15.00	0.30	3.95	13.36	6.44	3.02	9.46	8.20	LVM
1	15.04	0.30	3.90	13.35	6.49	3.00	9.49	8.00	LVM
2	15.11	0.33	3.83	13.30	6.58	2.95	9.53	7.75	LM
3	15.25	0.38	3.72	13.22	6.70	2.88	9.58	7.42	LM
4	15.44	0.45	3.58	13.09	6.85	2.80	9.65	7.12	LM
SE.m±	0.04	0.01	0.02	0.03	0.02	0.02	0.03	0.03	
CD (1%)	0.17	0.06	0.08	0.12	0.07	0.09	0.13	0.15	
CD (5%)	0.12	0.04	0.06	0.08	0.05	0.06	0.09	0.10	
CV	0.43	6.60	0.88	0.34	0.42	1.20	0.54	0.78	

LVM, Like very much; LM, Like moderately

from 8.20 at first day to 7.12 at final day of storageinto PET bottles. Reduction in organoleptic quality is also reported in guava-papaya blended fruit bar (Avhad *et al.*, 2019).

CONCLUSION

It may be concluded that nectar prepared from 20 % blend pulp comprising 80 % guava pulp and 20 % papaya pulp containing 20 % TSS, 0.30 % acidity and 70 ppm SO_2 (T_6) was found best during organoleptic evaluation. The TSS, acidity, reducing sugars, total sugars increased, whereas pH, vitamin C, non-reducing sugar and organoleptic quality decreased during storage into PET bottles. The nectar can be stored up to 4 months at ambient storage (18.3-27.9^{0}C) with acceptable quality into PET bottles.

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Short Communication

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Effect of biofertilizers and growing media on growth of air-layers of pomegranate (*Punica granatum*)

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Pomegranate (*Punica granatum* L.) is propagated through sexual and asexual means. Air-layering is most common and practical method of propagation. However, it is limited by variable success of air-layering. It is typically performed during rainy season, i.e. July and August, resulting in more successful rooting. There are different media like soil, sand, vermiculite, FYM, vermicompost, *etc* play an important role in the success of rooting or cutting. Biofertilizers enhance soil biological properties, phosphate solubility, and crop yield (Yosefi *et al*., 2011). Some bacteria supply plants with growth-promoting substances and play a significant role in phosphate solubilization (Abou-Aly *et al*., 2006). Looking the role of biofertilizers and growing media in growth of air-layers of pomegranate, and experiment was conducted.

The experiment was conducted at College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Mehsana, Gujarat, during July 2021. The air-layering was performed on five years old pomegranate plants. The layers were detached from mother plants after 50-55 days from the date of operation when the adventitious roots were clearly visible. The randomized complete block design with factorial concept was used. There were ten treatment combinations having different biofertilizer and growing media, *viz*. T_1: Bio NPK consortium + soil + sand (1:1, v/v), T_2: Bio NPK consortium + soil + FYM (1:1, v/v), T_3: Bio NPK consortium + soil + vermicompost (1:1, v/v), T_4: Bio NPK consortium + soil + sand + FYM (1:1:1, v/v/v), T_5: Bio NPK consortium + soil + FYM + vermicompost (1:1:1, v/v/v), T_6: phosphate solubilizing bacteria (PSB) + soil + sand (1:1, v/v), T_7: phosphate solubilizing bacteria (PSB) + soil + FYM (1:1, v/v), T_8: phosphate solubilizing bacteria (PSB) + soil + vermicompost (1:1, v/v), T_9: phosphate solubilizing bacteria (PSB) + soil + sand + FYM (1:1:1, v/v/v) and T_{10}: phosphate solubilizing bacteria (PSB) + soil + FYM + vermicompost (1:1:1, v/v/v).

The mixtures of various growing media were filled in plastic polybags (10′ × 8′). Before planting, half of the bags were filled with mixtures, while other half were filled after placing air-layers in middle portion and compressed from the side for complete mixture contact and watered immediately using a watering cane. Each treatment was replicated three times with twenty air layers per replication, for a total of sixty air layers per treatment that are grown for seventy-five days. A sufficient number of air layers of uniform size were developed on mother plants.

During second week of October, rooted air layers were separated from mother plants and transplanted into polybags containing various growing media and biofertilizers. Need-based inter-culturing, hoeing and plant-protection measures were adopted for raising air-layers. Observations on number of new shoots, length of new shoot, length of layer, number of leaves and stem diameter were recorded at 60 and 75 DAP. Fresh and dry weight of shoot were recorded at 75 DAP. They were statistically analyzed.

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The maximum number of new shoots (4.47 and 4.63), length of new shoot (12.60 cm and 13.15 cm), length of layer (48.37 cm and 50.29 cm), number of leaves (106.08 and 116.04) and stem diameter (8.25 mm and 8.33 mm) were recorded at 60 and 75 days respectively after planting along with maximum fresh and dry weight of shoot (12.09 g and 3.01 g) at 75 days after planting were recorded in pomegranate layers planted in bio NPK consortium as compared to phosphorus solubilizing bacteria (PSB).

Rhizobacteria secretes plant growth promoting substance which is responsible for cell elongation and cell multiplication, resulting in increasing length of shoot (Sarita *et al*., 2019). Maximum numbers of leaves in layers are due to enhanced availability of nutrients and released plant growth stimulating hormones by biofertilizers (Simpi, 2016).

The maximum number of new shoots (4.97 and 5.06), length of shoot (14.02 cm and 14.64 cm), length of layer (51.46 cm and 53.26 cm), number of leaves (110.64 and 121.27) and stem diameter (8.53 mm and 8.62 mm) at 60 and 75 DAP, respectively along with maximum fresh and dry weight of shoot (13.61 g and 3.55 g) at 75 DAP were noted in pomegranate layers planted in medium G_5 consisting soil + FYM + vermicompost (1:1:1, v/v/v).

Vermicompost promoted vegetative growth due to its high micronutrient content in rooting media (Kumar *et al*., 2015). A greater number of leaves due to improved soil texture, structure, porosity, water-holding capacity, the activity of beneficial soil microfauna and flora, maintained soil temperature and improved soil health and nutrient status of media. Better nutrient availability leads to a higher production of photosynthetically active leaves in these media, increasing an increase in stem diameter (Borah *et al*., 2008).

The maximum number of new shoots (4.97 and 5.06), length of shoot (14.02 cm and 14.64 cm), length of layer (51.46 cm and 53.26 cm), number of leaves (110.64 and 121.27) and stem diameter (8.53 mm and 8.62 mm) at 60 and 75 DAP, respectively along with maximum fresh and dry weight of shoot (13.61 g and 3.55 g) at 75 DAP were noted in pomegranate layers planted in medium G_5 consisting soil + FYM + vermicompost (1:1:1, v/v/v).

The increase in number of new shoots might be due to optimum nitrogen uptake might have reduced the C: N ratio and thereby inducing buds in earlier days (Kumar and Ponnuswami, 2013). When biofertilizers are added to the media it increases rhizosphere activity and thereby better nutrient uptake Thus, bio NPK consortium and soil + FYM + vermicompost (1:1:1, v/v/v) were found to be superior for growth parameters of pomegranate air-layers in terms of shoot with gross return under net house condition.

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Enhancing shelf-life of carrot (*Daucus carota*) by different treatments during post-harvest processing

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The study was carried out on the effect of physical, chemical and biological treatments on carrot (*Daucus carota L.*) for enhancing shelf-life during post-harvest processing at Department . of Food Process Engineering., Agricultural Engieering college & Research Institute, Tamil Nadu Agricultural University, Coimbatore. The most significant changes in post-harvest quality were weight loss, bitterness, bacterial deterioration, rooting and sprouting. Losses in carrots are due to *Sclerotinia* rot, *Botrytis* rot, Bacterial soft rot (*Erwinia sp.*) and sour rot (*Geotrichum sp.*). Among different methods, combination of chlorination and ozonization during washing followed by application of *Lactobacillus plantarum 020* at the rate of 10 ml / litre of wash water was more effective.

About 20 - 30% of the total carrot is lost due to postharvest spoilage and water loss (Shibairo *et al*. 2002). The losses in vegetables are much higher due to inadequate post-harvest handling, transportation and storage facility (Sarkar *et al*., 2020). The major constraint in its processing is postharvest losses caused due to microbial spoilage. Processed carrots have less than 48 hours of shelf-life. Therefor study was undertaken to find out post-harvest microbial management techniques.

The probiotic culture, *Lactobacillus plantarum* 020, (source: NDRI, Karnal, India) was cultured in De Man, Rogosa and Sharpe (MRS) broth for 24 h at 37^{o}C. The culture was harvested, centrifuged and prepared for further study. Harvested cells were mixed in sterile distilled water to get 10^9 CFU per ml and used for different treatments. The starter culture prepared as above was used to treat carrots at the rate of 10 ml culture per 1000 ml of wash water during post-harvest processing. Ten ml of prepared starter culture of *Lactobacillus plantarum* 020 was introduced into 1000 ml wash water to get 1% inoculum. Prepared wash water was kept at room temperature for one hour and used to treat carrots.

The treatments were: T_0, Control; T_1, Chlorination (200 ppm) + Ozonization (30 min); T_2, Chlorination (200 ppm) + *Lactobacillus plantarum* 020; T_3, Ozonization (30 min) + *Lactobacillus plantarum* 020 and T_4, chlorination (200 ppm) + ozonization (30 min) + *Lactobacillus plantarum* 020.

The population density of bacteria, fungi, actinomycetes and viability of probiotic culture was enumerated by serial dilution plate technique (Parkinson *et al*., 1971). A known quantity of whole carrot sample was transferred to peptone water to get 10^{-1} dilution. After thoroughly mixing it, one ml of this dilution was transferred to 9 ml peptone water to get 10^{-2} dilution. Likewise, sample was diluted serially with 9 ml peptone water till appropriate dilution was obtained.

Carotene content in carrot was estimated following the procedure as described by Lee (1986). The carotene content was measured on days 0, 2, 4 and 6. Measured quantity of sample was homogenized in a pestle and mortar using acetone and extracted repeatedly using acetone until the residue is colourless. This mixture is then added to a separating funnel containing petroleum ether. Five per cent sodium sulfate solution was then added to the solution. The petroleum ether extract was removed from the funnel and added to anhydrous sodium sulfate. Carotene content was estimated using spectrophotometry method, in which yellowish colour formed is measured against spectrophotometer at the wavelength of 453 nm. Total quantity of carotene content in 100 g of carrot sample is calculated using the formula:

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$$\text{Total carotene} = \frac{\text{Absorbance of sample} \times \text{Total volume} \times 100}{0.2592 \times \text{weight of the sample} \times 1000}$$

Weight loss in carrots during storage was found using an analytical balance with a precision of 1×10^{-4}g. The loss of colour during storage was estimated with a spectrophotometer (HunterLab's MiniScan EZ) which provides a 31.8 mm port size that has a 25 mm viewed area. The relative intensities of light at different wavelength along visible spectrum (400-700 nm) are then analyzed to produce numeric results, indicating the colour of the sample. The results were expressed as Hunter colour values of L*, a* and b*, where L* value denotes lightness (+) and darkness (-), a* value is used to indicate the redness (+) and greenness (-) and the b* value is used to denote the yellowness (+) and blueness (-) of sample.

The changes in hardness of carrots during storage were measured using a texture analyser (Brookfield, CT3 Texture Analyzer, India). The following specifications were loaded. The Brookfield texture analyser had load cell of 50 kg capacity, the probe was chosen TA44, an aluminium cylinder with 4 mm diameter, compression was the selected test type. The target value was fixed to 5 mm distance and no hold time was fixed. The trigger load was fixed to 10 g with a test speed 1 mm/s. These parameters once set, will automatically run the data for the remaining samples. The hardness of a carrot is measured by maximum force required to compress the sample.

The statistical analysis was carried out using AGRES software. Differences were considered to be significant at $p<0.05$. The data were subjected to analysis of variance (ANOVA) with a mean comparison performed using two factorial completely randomized design.

The carotene content was significantly affected by the storage period, storage temperature and treatments used ($p<0.05$). During storage, there was a sharp decline in the total carotene content in carrots. However, carotene content was maintained in samples treated with probiotic culture. The carotene content ranged from 5.9625 ± 0.76 to 13.35 ± 0.37 during storage. The carotene content having the presence of probiotics was found higher during storage compared to samples without probiotics. The carotene content of samples treated with T_0, T_1, T_2, T_3 and T_4 on 0th day were 13.3, 11.68, 10.12, 10.70 and 12.14 mg/100g on 0th day respectively. On storage there was a minimal degradation in total carotene content in samples. Since, untreated sample had a maximum spoilage on 6th day, carotene content of T_0 samples were not recorded. The carotene content of samples treated with T_1, T_2, T_3 and T_4 on the 6th day were 7.99, 7.02, 6.86, 7.65 mg/100g. Among treatments used, T_1 and T_4 had minimal degradation in carotene content compared with other treated samples. Abitha *et al.* (2019) studied the impact of probiotics in preserving the microbiological property and nutritional quality in carrot and found similar results.

The study showed the ability of probiotic cultures in reduced carotene content degradation during storage under room temperature among other treated samples. The degradation in carotene content of untreated sample was observed mainly due to spoilage. On the 6th day of storage, there was a maximum spoilage in untreated samples degrading the total carotene content, whereas a minimum degradation in carotene was observed in treated samples.

Several *Bacillus* sp. known as endophytes can prevent deleterious effects of pathogenic microorganisms (Popy Bora *et al.*, 2019). The probiotic strains of *L. casei, L. acidophilus, L. plantarum,* and *L. delbrueckiiare* are resistant to low pH, did not influence the lycopene content and its chemical properties (Ferdousi *et al.*, 2013).

There was a steady increase in per cent weight loss in all samples during the storage period. The percent weight loss among samples ranged between 7.9 ± 0.85 to 35.996 ± 0.65. The highest weight loss was observed in untreated samples. At the end of storage, probiotics treated samples retained the weight in samples, as probiotics cells in surface reduced microbial load causing spoilage. Among treated samples, carrots coated with *Lactobacillus plantarum* 020 maintained weight during storage at room temperature. The per cent weight loss in samples treated with T_0, T_1, T_2, T_3, T_4 were 36.99, 27.79, 23.24, 25.16 and 22% respectively. Among treated samples, T_4 and T_2 had a reduced weight loss percentage among other treated samples with 23.24 and 22 % weight loss percent.

The microorganism also maintained a good cell vitality during storage preserving its moisture. Probiotic used as an edible coating to improve the quality factor of minimally processed carrots showed a reduced effect in colour and showed a greater retention in moisture content of carrots (Shigematsu *et al.*, 2018). The use of probiotics as an edible coating demonstrated a slowdown in moisture loss from food products (Soukoulis *et al.*, 2014).

The L* value of carrots ranged from 51.26 to 54.57 during storage. The L* value indicates lightness of sample. The a* value ranged 24.09 to 32.86 during storage indicating the redness of the sample. The b* value ranged from 27.77 to 34.38 during storage indicating the yellowness of the sample. Carrots showed more changes in colour after treatments. Luminosity was significantly different in all samples compared to the control. There was an increase in lightness in all treated carrots. Similarly a decrease in intensity of redness and yellowness of the treated carrots was observed when compared to the control. On the 6th day of storage, T_4 treated samples had a minimum change in lightness L* compared to the 0th day of T_4 treated carrots. T_1 treated carrots had higher intensity in reddness (a*value) and yellowness (b*value) than other treated samples by the 6th day of storage.

Similar results were reported by (Bermúdez-Aguirre and Barbosa-Cánovas, 2013). Different treatment methods used along with the processing conditions largely affects the colour value of carrots. This change in colour may be due to various chemical and enzymatic changes that occur during various treatments.

The hardness varied according to microbial load and moisture content present on the 6^{th} day of storage. The untreated sample had an increased microbial load, softening tissues as most of the roots were spoiled. Hence, T_0 samples were excluded in hardness determination. Among the samples, T_4 samples were observed to maintain the firmness than other treated samples by the 6th day of storage. Similar results were reported on hardness test for different varieties of carrots. The hardness of carrots largely depends on the variety and stage of maturity at which carrots are harvested.

Carrots treated with chlorine, ozone and *Lactobacillus plantarum* 020 had minimum degradation in firmness than other combination treated samples. Chlorine, ozone and *Lactobacillus plantarum* 020 treated carrots required 47.697 N, deformation at hardness were on 2.08 mm distance, adhesiveness of 1.6 mJ and 5 fractures in carrots on the 6th day of storage. Carrots processed with the above treatment had a shelf-life of six days under normal room temperature, whereas shelf-life of untreated carrots was two days under normal room temperature. The finding of the study could be adopted well in real field conditions to improve carrot shelf-life.

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Effect of organic manures and micronutrients on yield of brinjal (*Solanum melongena*)

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The field experiment was conducted at Horticulture Farm, SKN College of Agriculture, Jobner (Jaipur), Rajasthan, during *kharif* season, 2018, in a randomized block design with three replication. There were altogether 48 plots each of 2.25 m × 2.40 m size. Transplanting was done on 21 July 2018 with spacing 60 cm × 45 cm. Hoeing, weeding and irrigation were provided at proper time so as to facilitate better growth and development of crop. The treatments were organic manure, *i.e.* control, FYM (40 t/ha), vermicompost (6.6 t/ha), poultry manure (6.6 t/ha) and micronutrients, i.e. control, Zn (0.5%), Fe (0.5%) and B (0.3%) foliar spray. The observation were recorded on number of branches/plant, number of leaves/plant, fruit yield/plot (kg/plot) and fruit yield (q/ha). The data on growth and yield were statistically analysed according to the method suggested by Fisher and Yates (1959).

The maximum number of branches (3.19, 9.17, 13.36 and 15.35 at 30, 60, 90 and 120 DAT) and number of leaves (13.79, 77.32, 187.78 and 219.58 at 30, 60, 90 and 120 DAT) were observed with the treatment vermicompost @ 6.6 t /ha (M_2), which was statistically at par with treatment poultry manure @ 6.6 t /ha. But 50 % flowering was non-significantly influenced by various micronutrients. The positive influence of organic manures could be because of increase in shoot length and plant vigour, application of organic manures which have helped in plant metabolic activity through the supply of important micronutrients in early growth phase, which in turn encouraged early vigorous growt. These results are in accordance with those of Mamta *et al.* (2012), Agarwal and Sharma *et al.* (2014); Samadhiya *et al.* (2015) and Barman *et al.* (2017).

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The maximum number of branches (3.24, 9.27, 13.50 and 15.49, respectively) and number of leaves (14.03, 78.41, 191.51 and 222.49, respectively) were observed with the treatment Zn @ 0.5 per cent (N_1). But 50 % flowering was non-significantly influenced by various micronutrients. This perceptible increase in growth parameter is due to active synthesis of tryptophan, in the presence of Zn which acts as precursor of IAA, which stimulates the growth of plant tissues. There is an enhancement in cell multiplication and cell elongation resulting in more plant height. Similarly results were also reported by Solanki *et al.* (2017); and Uikey *et al.* (2018).

The maximum fruit length (8.17 cm), fruit diameter (7.31 cm), number of fruits/plant (6.59), fruit weight (129.67 g), fruit yield (17.13 kg /plot) and fruit yield (317.20 q /ha) were recorded under the treatment vermicompost @ 6.6 t /ha (M_2), which was statistically at par with poultry manure @ 6.6 t /ha (M_3), while, minimum fruit length (7.06 cm), fruit diameter (6.09 cm), number of fruits/plant (5.14), fruit weight (111.08 g), fruit yield (11.52 kg /plot) and fruit yield (213.40 q /ha) were observed in treatment M_0 (control). (Table 1). These results are in accordance with Agarwal and Sharma *et al.* (2014).

Application of micronutrients significantly increased fruit length (8.30 cm), fruit diameter (7.41 cm), number of fruits/plant (6.63), fruit weight (131.05 g), fruit yield/plot (17.39 kg /plot) and fruit yield (321.99 q/ha) recorded under the treatment Zn @ 0.5 per cent (N_1), which was significantly superior than other treatments. While, minimum fruit length (7.20 cm), fruit diameter (6.19 cm), number of fruit/plant (5.23), fruit weight (113.67 g), fruit yield/plot (12.02 kg /plot) fruit yield (222.59 q /ha) were observed in treatment (N_0) control.

Table 1: Effect of organic manures and micronutrients on yield and yield attributes of brinjal

Treatment	Fruit length (cm)	Fruit diameter (cm)	Number of fruits/plant	Fruit weight (g)	Fruit yield (q/ha)
Organic manures					
M_0, control	7.06	6.09	5.14	111.08	213.40
M_1, FYM (40 t /ha)	7.58	6.56	5.89	121.55	265.87
M_2, Vermicompost @ 6.6 t /ha	8.17	7.31	6.59	129.67	317.20
M_3, Poultry Manure @ 6.6 t /ha	8.01	7.11	6.28	128.08	297.21
SEm±	0.18	0.19	0.17	2.68	7.09
CD (P= 0.05)	0.54	0.55	0.49	7.73	20.47
Micronutrients					
N_0 – control	7.20	6.19	5.23	113.67	222.59
N_1- Zn (0.5%) foliar spray	8.30	7.41	6.63	131.05	321.99
N_2- Fe (0.5%) foliar spray	7.72	6.80	6.02	124.00	277.84
N_3- B (0.3%) foliar spray	7.62	6.66	6.01	121.67	271.25
SEm±	0.18	0.19	0.17	2.68	7.09
CD (P= 0.05)	0.54	0.55	0.49	7.73	20.47

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