Review Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Artificial pollination in date palm: a review

Kapil Mohan Sharma, D. A. Baidiyavadra and Hiralal Chaudhary

Date Palm Research Station, Sardarkrushinagar Dantiwada Agricultural University, Mundra-Kachchh, Gujarat- 370421

ARTICLE INFO

Key Words: Date palm, Pistillate Receptivity, Pollination, Pollen storage.

doi: 10.48165/ijah.2021.3.1.1

ABSTRACT

One of the most crucial and time-consuming agronomical procedures in date cultivation is pollination, which is necessary to achieve the required yield. Fruit growth, quality, and yield are greatly impacted by date palm pollen (DPP), which is also highly influenced by pollen structure, viability, and germination capacity. In commercial farming, pollen management involves keeping pollen under refrigeration and combining it with different adjuvants to reduce the amount of pollen needed for pollination. Pollination success is further influenced by female flowers and their receptivity, therefore careful monitoring is essential to notice the timing of anthesis of the female inflorescence. Mechanized tools have made the tedious act of pollination easier, and pollination techniques have improved with time. In addition to aiding in pollination, pollen is also used as a secondary food source for a number of illnesses, including male infertility. The significance of pollen, how to utilize it and potential issues during cultivation are all covered in this article.

Introduction

Dates (*Phoenix dactylifera* L.) are among the world's oldest cultivated fruits and being dioecious, the male and female inflorescences flower on different plants. Although date palms are naturally pollinated by the wind, most commercial date palms are artificially fertilized. Because of the structure, longevity, asynchronized flowering, constant height gain, and prickly leaves of the palm, pollination is one of the most crucial yet time-consuming agronomical procedures in the cultivation of dates. Since the date palm's early domestication, which is estimated to have occurred around 4000 BCE (Zohary and Hopf, 2000), the importance of pollen and its management has been recognized. According to Zaid and de Wet (2002a), the earliest domestication of the crop occurred most likely in the Arabian Gulf region close to its center of origin, Mesopotamia (modern-day Iraq), where the crop was revered. Pollination is a prerequisite for fruit development, and different stages of fruit development are taken into account from the day of pollination. According to Sharma *et al.* (2019, 2021 & 2023) in the absence of adequate pollination, there is a significant risk of abortion or the development of parthenocarpic fruits that are of poor quality and cannot be used or sold. This article discusses the numerous optimizations made to pollination

*Corresponding author.
E-mail address: k.m.sharma456@sdau.edu.in (Kapil Mohan Sharma)
Received 05.09.2023; Accepted 08.01.2024

techniques and pollen management over time, from manual application to mechanical use.

Pollination is regarded as one of the most crucial agronomic techniques in cultivation today. Fruits that do not successfully pollinate mature into parthenocarpic fruit, which are small in size and lack desirable commercial traits (Cohen *et al*., 2016). The majority of date palms in the wild groves found in oases and along rivers grow in clusters, with wind acting as the primary means of pollination. However, in order for pollination to be successful, the male and female populations should ideally be 1:1 and closely spaced; this is not feasible for commercial cultivation but does occur in oasis ecosystems (Sharma *et al.*, 2023).The male date palm plants are typically planted in a separate area designated for them, or they are planted alongside farms or roadsides in the majority of commercial date palm orchards across the world. Pollination of approximately fifty female plants is thought to require, on average, one male plant; however, this depends on the quantity of pollen present in each spathe and the number of flowers on the plant (Zaid and de Wet, 2002b).

Fruit set and successful pollination depend greatly on the source and caliber of the pollen. Basically, you can successfully pollinate the flowers with any male date pollen. Nonetheless, it has been observed that the date palm's fruit and seed characteristics are influenced by the pollen's quality called as metaxenia (Abbas *et al*., 2014).

In an ideal environment, enough pollen can flow from the male to the female inflorescences due to the coordinated emergence of the male and female inflorescences. After the initial dusting of male strands on the female inflorescence, hand pollination in traditional methods using two to three male strands placed upside down in the female inflorescence also helps this coordinated synchronization. This method is most popular in most regions of the world (Sharma *et al.,* 2021; Baidiyavadra *et al*., 2019). Pollen management is necessary in two more situations, *viz.* (i) when male inflorescences emerge before female inflorescences, and (ii) when female inflorescences emerge before male inflorescences. In the first instance, pollen is manually collected from the male flowers either by mechanically extracting them or by drying them in the shade. In the second scenario, saved, extracted, and dried pollen from the prior season can be used to make up for the lack of pollen. The pollen is either preserved or used directly for pollination after extraction. It is necessary to pay close attention to the temperature during pollination as well as when the female spathe cracks.

Floral Biology

Flower structure

The date palm is a dioecious species, meaning it has separate male and female flowers that develop in clusters on distinct palms. These clusters of flowers emerge from the leaf axils of the previous year's growth. They can be identified by their distinct morphological characters as listed in Table 1 (adopted from Sharma *et al.*, 2023).

Pollen structure

Pollen, the fine dust-like grain material from male flowers, contains ellipsoidal, bisymmetric, or rhomboid shapes, with dimensions ranging from 17.20–21.40 μm in length and 6.97–10.30 μm in width. Other studies also reported sizes of pollen 20.38–21.94 × 16.32–16.96 μm and 18.56–18.64 × 18.51–18.55 μm (Soliman and Al-Obeed, 2013; Al-Khalifah, 2006).

Pollen viability and germination

In date palm cultivation, successful pollination and fruit set depend more on pollen viability compared to other fruit crops. Pollination success is determined by applying ample

Table 1. Characteristics of male and female flowers of the date palm

	Male Flowers	Female Flowers
Inflorescence colour	Creamy or waxy white	Yellowish white
Spathe character	Short and wide body	Narrow and long body
Inflorescence character	Broom-like inflorescences feature a higher number of strands packed closely together.	Inflorescences are comparatively fewer densely packed with strands
Flower Character	Similar to rice panicles are flowers	Flowers are globose and resemble the seeds of sorghum.
Flower structure	6 stamens, 3 petals, 3 sepals, and 3 carpels make up a flower.	3 sepals and 3 petals make up a flower.
Aroma	It has a unique, pleasant fragrance that attracts insects.	Having a mild aroma, but it doesn't attract many insects.

viable pollen, with viability assessed through tests like acetocarmine staining. The freshness of pollen significantly impacts its germination rate, varying with genotype and inflorescence emergence time. Proper storage is crucial for maintaining pollen viability. The acetocarmine stain method is commonly used to assess viability, with red staining indicating viability. Pollen germination is confirmed through a test involving incubation in a specific medium and microscopic observation of pollen tube germination (Maryam *et al*., 2017). When pollen is fresh, it is most effective and has the maximum germination rate; as it aged, it becomes less effective. The genotype and flower emergence time also affect the quality of the pollen and its capacity to germinate.

Selection of male plant

Selecting the best male pollinators for the commercial female cultivar being produced in a area based on compatibility or optimum results because the male parent's pollen directly influences characteristics like seed size, shape, and colour as well as fruit size, development rate and ripening time in the embryo and endosperm (Sharma *et al.*, 2023; Salomon-Torres*et al.*, 2021). Moreover, synchronization of flowers and amount of pollen produced also accounts for selection of male plants (Helail and El-Kholey, 2000); Rezazadeh *et al*., 2013).

Pollen extraction

The process of pollen extraction from male date palm inflorescences involves careful harvesting during the anthesis period, typically early in the morning to avoid bee interference. Harvesting a day or two before spathe cracking may be done but requires experience. The spathe cover is removed immediately after harvest to prevent moisture, which can spoil the flowers and pollen. The harvested inflorescence is then shade-dried for 3–7 days, avoiding direct sunlight or high temperatures to preserve pollen viability.

Three main pollen extraction methods are employed:

a. **Manual extraction using a sieve**: it is the traditional method where strands are separated, shade-dried, and manually strained to separate pollen from flowers.
b. **Manual extraction by beating**: it involves tying inflorescences upside down to collect flowers and pollen on a base, suitable for handling larger quantities.
c. **Mechanical extraction uses machines**: in this methods machines with a rotating barrel, screen disk, cyclone separator, and suction pump, which efficiently extracts 40% more pollen than traditional methods. This method also reduces direct pollen exposure to growers, minimizing allergy risks.

During shade drying, flower color turns dark brown, but this does not affect pollen quality or quantity. The entire process is crucial for obtaining high-quality pollen for successful pollination in date palm cultivation.

Pollen storage

According to Dennison (1992), pollen can be collected and stored at room temperature (24°C) for up to one month if the male emerges early. Date palm pollen typically lasts for two to three months before it starts to rapidly lose vitality. It is possible to pollinate the female inflorescence with recently collected pollen from the current season when itsfemale inflorescence opens after the male inflorescence (Sharma *et al.,* 2021). If female inflorescence opens early to male, pollen that has been saved from the previous season can be used to pollinate the female inflorescences provided they are stored under refrigeration. Many research hasbeen conducted on theoptimal temperatures to store pollen, with the lowest temperature producing the greatest results. Other temperatures that have been tried include room temperature, 4 °C, -20 °C, and -196 °C. However, keeping at -20°C is typically a better alternative for commercial use due to practical considerations and the unavailability of cryopreservation units. To minimize quality loss from decreased vitality, pollen can be pollinated the same day it is removed from cold storage (Karim *et al*., 2022). A few of the successful experimentation on pollen storage and germination test after period of storage has been listed in Table 2.

Methods of pollination

The period of male and female inflorescence emergence varies due to climatic or agronomicalfactors, however,all the inflorescence do not emerge at a time, thus multiple pollination activities over 3–4 sets may be required to pollinateallbunchesofapalm.Increasedpollenconsumption for pollinating a greater number of inflorescences raises production costs for farmers. Commercial farms often use pre-identified males for pollination, with an average male date palm producing 20 to 30 spathes per season, each yielding 5 to 50 g of pollen. Pollination efficiency is influenced by morning temperatures, with effective time periods reported by various studies in different countries (Slavkovia *et al.* 2016). Date palm pollination broadly occurs through natural, artificial (manual labour), and

Table 2. Length of storage of pollen in relation to different temperatures and their impact on germination

Number	Temperature	Length of storage	Pollen germination (%)	Reference
1.	24°C	Fresh	94.37	Anushma *et al*., 2018
	4°C	2 months	61.64	
	4°C	12 months	0.00	
	-20°C	12 months	73.61	
	-196°C	12 months	90.29	
2.	28°C	Fresh	96.30	Kadri *et al.,* 2021
	28°C	12 months	14.70	
	4°C	12 months	42.10	
	-30°C	12 Months	52.20	
3.	4°C	12 months	24.39	Maryam *et al.*, 2015
	-20°C	12 months	27.40	
	-80 °C	12 Months	24.64	

mechanized methods. A brief of these methods are listed below.

Natural pollination: Natural pollination, common in wild groves or oases, often relies on wind for the process. This method is effective in environments with close planting and nearly equal male and female populations, as seen in natural groves. However, it is not ideal for commercial date palm orchards.Unlike some of the dioecious crops like papaya, where male plants are strategically placed, in date palm cultivation, being a widely spaced plant, it may lead to inefficient wind pollination, impacting overall yield, and potentially resulting in parthenocarpic fruits.

Artificial pollination through manual labour: For commercial cultivation, artificial pollination is the alternative because natural pollination is not a practical method. Date palms have been artificially pollinated for millennia; this practice is not new. Several techniques are covered in the sections that follow.

Using male strands: Attaching inverted male strands to female inflorescences after dusting them with pollen is a widely used technique. If fresh male strands are utilized, this process is simple to follow and works well. But it's expensive, time-consuming, and demands skilled workers.

Using a cotton swab: This technique uses a tiny cotton ball to swab the pre-collected pollen on the female inflorescence. This can be used with pollen that has been saved from the previous season as an alternative to using male strands. It is also time-consuming and expensive, much like using male strands. Alternatively sponge strips can also be used in place of cotton.

Using liquid suspension: This technique involves manually spraying pollen on the inflorescence after mixing it with water or a water-based suspension. If the pollen is blended and sprayed fresh, it works well. For an improved fruit set, the pollen can also be combined with GA_3 at a rate of 20 mgL^{-1} + 10% sucrose (Iqbal *et al*., 2012). For mechanical pollination, a highly pressurized liquid suspension is also used.

Using a cotton cloth bag: This technique involves gathering the dried pollen in the middle of the fabric and tying it off. Because the pollen is tiny, it comes out of the bag when it is dusted on the flower, resulting in pollination. For trees that are taller, a long pole is linked with the cotton bag.

Mechanical pollination

Most commercial orchards use mechanical pollination because it is an efficient method of pollination, increases productivity, overcomes labor shortages, and lowers operating costs (Shapiro *et al.,* 2008 and Mostaan, 2012). Nevertheless, costly techniques might not be appropriate in all situations (El-Mardi *et al.,* 1995).

Mechanized pollen duster/sprayer: Tractor-mounted models with a hydraulic air cannon to blast pollen are among the mechanical varieties. They have up to 22-meter of effective height and can pollinate 350 palms in an hour. They are well-liked in highly progressive nations like the USA and Israel (AGROM, 2020).

Using a hand pollen duster: An inexpensive yet efficient method of pollination, a manual pollinator involves blowing or pumping a tube from the ground level into a bottle carrying pollen to eject pollen dust on the inflorescence; nevertheless, it is not suitable for very tall trees (Sharma *et al.*, 2023).

Motorized pollen duster: Pressurized sprayers are attached to these mechanical devices. Their effectiveness surpasses that of manual pollen dusters, and their 10-meter reach lessens the need for climbing the tree. Each day, they effectively pollinate 150–200 palm trees (Al-Wusaibai *et al.*, 2012).

Electrical pollen duster: A remote control is used to operate the telescopic pole, dispenser, and pollen tank in this model, which is identical to a manual pollen duster. The effort required by humans to climb the tree is effectively decreased (Mostaan*et al*. 2010).

Aircraft: Pollinating date palms with aircraft was one of the techniques employed in the USA in the early 1960s and 1970s, and it is still practiced in some areas of Israel. However, it is ineffective and may lead to a poor fruit set (Cohen and Glasner, 2015).

Artificial intelligence and drones: These tools are made to minimize the amount of pollen needed during pollination as well as the human labour required. Drones equipped with a camera and GPS tracker were developed as part of the One Million Date Palm Trees Project. These drones can operate up to 8 km away and are effective enough to pollinate a significant number of date palms with the least amount of pollen and labour needed (Oman Daily Observ, 2018).

Usage of pollen mixture

To achieve effective pollination, it is essential for the necessary amount of pollen to reach the pistil and form the pollen tube. However, in mechanical pollination, the demand for pollen increases due to limited control over the quantity used per spathe. In situations where pollen is already scarce, it is recommended to mix the dried pollen with a diluting substance to decrease the pollen quantity. A few of the effective dilution and their adulterant are listed in Table 3.

Table 3. Usage of different pollen mixture and methods and its effectiveness in date palm pollination

S. No.	Location	Pollination methods with Treatments	Fruit set (%)	References
1	India	Hand Dusting with Dry Pollen	52.59	Sharma *et al.*, 2021
		Hand Dusting wit Dry pollen + talc (1:9)	49.69	
		Hand Dusting with Dry pollen + talc (1:19)	47.72	
2	Pakistan	Pollen suspension with Liquid pollen (1 g/ L)	74.67	Munir, 2020
		Pollen suspension with Liquid pollen (2 g/ L)	79.67	
		Pollen suspension with Liquid pollen (3 g/ L)	84.5	
		Pollen suspension with Liquid pollen (4 g/ L)	86	
3	Jordan	Hand Dusting with Dry pollen	100	Abu-Zahraand Shatnawi, 2019
		Pollen suspension with Liquid pollen (1g/ L)	72.5	
		Pollen suspension with Liquid pollen (2 g/ L)	81	
		Pollen suspension with Liquid pollen (3 g/L)	81	
		Pollen suspension with Liquid pollen (4 g/L)	91.5	
4	Saudi Arabia	Natural pollination with by wind	26.03	Munir, 2019
		Strands placement hand with 5 strands/ bunch	68.67	
		Hand Dusting with Dry pollen + wheat flour (1:9 ratio)	82.07	
		Pollen Suspension with Liquid pollen (3 g/ L)	85.71	
5	Mexico	Hand Dusting brush with Dry pollen + wheat flour (1:1 ratio)	31.74	Salomon-Torres *et al.*, 2017
6	Saudi Arabia	Strands placement with 2-3 strands/ bunch	69.1	Ben Abdallah *et al.*, 2014
		Strips of sponge with Dry pollen + wheat flour (1:4 ratio)	67.03	
7	Egypt	Hand Dusting with 2 g pollen + 3 g filler material	54.7	Hafez *et al.*, 2013
		Hand Dusting with 1 g Milagro + 4 g filler material	59.20	

Bunch care after pollination

After pollination, success is typically confirmed after 20-30 days. Managing the post-pollination bunch is crucial and depends on the local climate. In areas with mist, rain, or potential low temperatures during flowering or pollination, covering the recently pollinated inflorescence with a paper bag is advisable to maintain a suitable temperature and prevent pollen wash-off (Zaid and de Wet, 2002b). However, extended covering may lead to issues such as fruit etiolation, partial fruit drop, and potential damage from fungus inside the bag (Sharma *et al.*, 2023).

Despite these concerns, covered fruits tend to have less bruising, enhancing their market value. Around a month after pollination, when the fruits reach pea size, thinning is performed to reduce the fruit load and achieve larger ripe fruits, which command higher market value. Thinning methods include removing a third of stands from the inner circle for better aeration, removing a third of strands by length to reduce fruit load and increase size, or manually performing alternative thinning, a labour-intensive practice popular in high-value cultivars like 'Medjool' and 'Barhee'.

Conclusion

Artificial pollination is an indispensable component of date palm cultivation, offering growers the ability to maximize yields, control fruit quality, and overcome the challenges posed by natural pollination methods. This meticulous and resource-intensive process is a key factor in the success of commercial date palm orchards worldwide.

References

Abbas, M.F., Abdul-Wahid, A.H. and Abass, K.I. 2014. Metaxenic effect in date palm (*Phoenix dactylifera* L.) fruit in relation to level of endogenous auxins. *AAB Bioflux* 6(1): 40-44.

Abu-Zahra, T.R. and Shatnawi, M.A. 2019. New pollination technique in date palm (*Phoenix dactylifera* L.) cv. "*Barhee*" and "*Medjool*" under Jordan Valley conditions. Am-Euras. *Journal of Agriculture and Environmental Sciences,* 19: 37–42.

AGROM. 2020. Development, Design and Manufacture of Agricultural and Industrial Machines. Retrieved.

Al-Khalifah, N.S. 2006. Metaxenia: Influence of pollen on the maternal tissue of fruits of two cultivars of date palm (*Phoenix dactylifera* L.). *Bangladesh Journal of Botany,* 35: 151-161.

Al-Wusaibai, N.A., Ben Abdallah, A., Al-Husainai, M.S., Al-Salman, H. and Elballaj, M. 2012. A comparative study between mechanical and manual pollination in two premier Saudi Arabian date palm cultivars. *Indian Journal of Science and Technology,* 5: 2487-2490.

Anushma, P.L., Vincent, L., Rajasekharan, P.E. and Ganeshan. S. 2018. Pollen storage studies in date palm (*Phoenix dactylifera* L.). *International Journal of Chemical Studies,* 6(5): 2640-2642.

Baidiyavadra, D.A., Muralidharan, C.M. and Sharma, K.M. 2019. Fresh date production in *Kachchh* (India): Challenges and future prospects. *Medicinal Plants,* 11(3): 218-227.

Ben Abdallah, A., Al-Wusaibai, N. A. and Al-Fehaid, Y. 2014. Assessing the efficacy of sponge and traditional methods of pollination in date palm. *Journal of Agricultural Science and Technology,* 4: 267-271.

Cohen, Y. and Glasner, B. 2015. Date palm status and perspective in Israel. (in) Al-Khayri, J. M., Jain, S. M., Johnson, D. V. (ed) *Date palm Genetic Resources and Utilization: Asia and Europe, Volume 2*, 1st ed., Springer: New York, NY, USA, pp. 265-298.

Cohen, Y., Slavkovic, F., Birger, D., Greenberg, A., Sadowsky, A., Ish-Shalom, M., Benita, M., Ticuchinski, T., Avnat, Y. and Kamenetsky, R. 2016. Fertilization and fruit setting in date palm: biological and technological challenges. *Acta Horticulturae,* 1130: 351–358. https://doi.org/10.17660/ActaHortic.2016.1130.53.

Dennison, J. O. 1992. Xenia includes metaxenia. *Hortscience,* 27(7): 722-728.

El-Mardi, M.O., Labiad, S.N., Consolacion, E. and Addelbasitm, K.M. 1995. Effect of pollination methods and pollen dilution on some chemical constituents of Fard dates at different stages of fruit development. *Emirates Journal of Agricultural Sciences,* 7: 1–19. https://doi.org/10.9755/ejfa.v7i1.5351.

Hafez, O.M., Saleh, M.A., Mostafa, E., El-Shamma, M. and Maksoud, M. 2013. Improving pollination efficiency, yield and fruit quality of two date palm cultivars using growth activator. *International Journal of Agricultural Research,* 9: 29–37.

Helail, B.M. and El-Kholey, L.A. 2000. Effect of pollen grain sources on palm fruiting and date quality of *Hallawy* and *Khadrawy* date palms. *Annals of Agriculture Science,* 38(1): 479-494.

Iqbal, M., Niamatullah, M. and Munir, M. 2012. Effect of various dactylifera males pollinizer on pomological traits and economical yield index of cv's *Shakri*, *Zahidi* and *Dhakki* date palm (*Phoenix dactylifera* L.). *Journal of Animal and Plant Science,* 22: 376-383.

Kadri, K., Elsafy, M., Makhlouf, S. and Awad, M.A. 2021. Effect of pollination time, the hour of daytime pollen storage temperature and duration on pollen viability, germinability and fruit set of date palm (*Phoenix dactylifera* L.) cv. "*Deglet Nour*". *Saudi Journal of Biological Sciences*, 29(2): 1085-1091.

Karim, K., Awad, M. A., Manar, A., Monia, J., Karim, A. and Mohammed, E. 2022. Effect of flowering stage and storage conditions on pollen quality of six male date palm genotypes. *Saudi Journal of Biological Sciences*, 29(4): 2564-2572. https://doi.org/10.1016/j.sjbs.2021.12.038

Maryam, M., Jaskani, J. and Naqvi, S.A. 2017. Storage and viability assessment of date palm pollen. (in) Al-Khayri, J. M., Jain, S. M. and Johnson, D. V. (eds.). *Date palm Biotechnology Protocols Volume II: Germplasm Conservation and Molecular Breeding*, Methods in Molecular Biology, vol. 163B. Springer Science + Business Media LLC. pp 1-13.

Maryam, M., Jaskani, J., Fatima, B., Haidaer, M. S., Naqvi, S. A., Ahmad, R. and Khan, I. A. 2015. Evaluation of pollen viability in date palm cultivars under different storage temperatures. *Pakistan Journal of Botany,* 47(1): 377-381.

Mostaan, A. 2012. Mechanization in Date palm pollination. (in) Manickavasagan, A., Essa, M. M. and Sukumar, E. (eds.) *Dates: Production, Processing, Food and Medicinal Values, 1st ed.*, CRC Press: London, UK, 129-140.

Mostaan, A., Marashi, S. and Ahmadizadeh, S. 2010. Development of a new date palm pollinator. *Acta Horticulturae,* 882: 315-320.

Munir, M. 2019. Influence of liquid pollination technique on fruit yield and physico-chemical characteristics of date palm cultivars *Khadrawy* and *Zahidi*. *Journal of Biodiversity and Environmental Sciences,* 15: 41–49.

Munir, M. 2020. A comparative study of pollination methods effect on the changes in fruit yield and quality of date palm cultivar *Khalas*. *Asian Journal of Agriculture and Biology,* 8: 147–157.

Oman Daily Observer. 2018. Technology to be used for pollinating date palms. Retrieved.

Rezazadeh, R., Hassanzadeh, H., Hosseini, Y., Karami, Y. and Williams, R.R 2013. Influence of pollen source on fruit production of date palm (*Phoenix dactylifera* L.) cv. *Barhi* in humid coastal regions of southern Iran. *Scientia Horticulturae,* 160: 182-188.

Salomon-Torres, R., Ortiz-Uribe, N., Villa-Angulo, R., Villa-Angulo, C., Norzagaray-Plasencia, S. and Garcia-Verdugo, C.D. 2017. Effect of pollinizers on production and fruit characteristics of date palm (*Phoenix dactylifera* L.) cultivar *Medjool* in Mexico. *Turkish Journal of Agriculture and Forestry*, 41: 338-347.

Shapiro, A., Korkidi, E., Rotenberg, A., Furst, G., Namdar, H., Sapir, B., Mishkin, M., Ben-Shahar, O. and Edan, Y. 2008. A robotic prototype for spraying and pollinating date palm trees. (in) Proceeding of the ASME 2008 9th Biennial Conference on Engineering Systems Design and Analysis, Haifa, Israel, 7-9 July 2008; ASME International: Haifa, Israel, 431-436.

Sharma, K.M., Muralidharan, C.M., Baidiyavadra, D.A. and Panchal, C.N. 2019. Effect of different time of pollination in date palm (*Phoenix dactylifera* L.) cv. *Barhee*. *Environment and Ecology,* 37(4B): 1568-1570.

Sharma, K.M., Muralidharan, C.M., Baidiyavadra, D.A., Bardhan, K. and Panchal, C.N. 2021. Evaluation of potentiality of different adjuvants for date palm pollination and fruit set. *Sugar Tech.,* 23(1): 139-145.

Sharma, K.M., Kumar, M., Muralidharan, C.M. and Salomon-Torres, R. 2023. Date Palm Pollination Management. (in) Al-Khayri, J.M., Jain, S.M., Johnson, D.V., Krueger, R.R. (eds.). Date Palm. CAB International. pp 209-240.

Slavkovia, F., Greenberg, A., Sadowsky, A., Zemach, H., Ish-Shalom, M., Kamentsky, R. and Cohen, Y. 2016. Effects of applying variable temperature conditions around inflorescences on fertilization and fruit set in date palms. *Scientia Horticulturae,* 202: 83-90.

Soliman, S.S. and Al-Obeed, R.S. 2013. Investigations on the pollen morphology of some date palm male (*Phoenix dactylifera* L.) in Saudi Arabia. *Australian Journal of Crop Science,* 7(9): 1355-1360.

Zaid, A. and de Wet, P.F. 2002a. Origin, geographical distribution and nutritional values of date palm. (in) Zaid, A. and Arias-Jimenez, E. J. (eds.) *Date palm Cultivation, FAO Plant Protection Paper 156 Rev.1*. FAO of United Nations, Rome.

Zaid, A. and de Wet, P.F. 2002b. Pollination and bunch Management. (in) Zaid, A. and Arias-Jimenez, E.J. (eds.) *Date palm Cultivation, FAO Plant Protection Paper 156 Rev.1*. FAO of United Nations, Rome.

Zohary, D. and Hopf. M. 2000. *Domestication of Plants in the Old World: The origin and spread of cultivated plants in West Asia, Europe and Nile Valley,* 3rd Ed., 316. Oxford: Oxford University Press.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Impact of systematic improvement in jamun (*Syzygium cuminii* Skeels) cultivars on yield and quality of fruits

D. S. Mishra[1], A. K. Singh[1] and Jagadish Rane[2]

[1]ICAR-Central Horticultural Experiment Station, Vejalpur-389340, Panchmahal, Gujarat
[2]ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner-334006, Rajasthan

ARTICLE INFO

Key Words: Fruit yield, Farmers, Genetic, Yield.

doi: 10.48165/ijah.2021.3.1.2

ABSTRACT

Jamun (*Syzygium cumini*) is a promising fruit crop for cultivation in central Gujarat due to its high adaptability to diverse environmental conditions and appreciable fruit yield. The genetic diversity and climate factors can influence tree growth, yield and quality attributes of jamun. This study aimed to assess the effects of genotype and year effect on the performance of four cultivars of jamun under rainfed conditions in central Gujarat (India). Experiments were carried out during 2020–2021 and 2021–2022. The experimental design was a randomized block design with three replications. Results revealed that the tree growth, fruit yield and fruit quality parameters were significantly affected by genotype while the year had a significant effect on plant growth characters only. In general, CISHJ-37 recorded the higher tree height, spread and stem girth over the years in comparison to other cultivars. However, fruit weight and pulp content were found stable over the years as not significantly affected by the year's effect. Goma Priyanka and CISHJ-37 recorded the higher fruit and pulp weight while higher pulp (%) was recorded in CISHJ-42 during both the years. However, Goma Priyanka recorded significantly higher yield/tree during both the years followed by CISHJ-37 while least was observed in CISHJ-42. Similarly, higher TSS and acidity were recorded in Goma Priyanka and CISHJ-37 compared to Konkan Bahadoli. The "genotype" factor significantly affected fruit yield and quality attributes. The results indicate that, under rainfed conditions, high yielding improved cultivars like Goma Priyanka and CISHJ-37 can be profitable in central Gujarat.

Introduction

Jamun (*Syzygium cumini* Skeels; Myrtaceae) is highly adapted to diverse environmental conditions and widely distributed in India up to an altitude of 1600 m. The presences of anthocyanins, fibers and ellagitannins in the pulp of jamun fruits play an important role in reducing the oxidative stress in human being (Mishra *et al*., 2020). Jamun

*Corresponding author.
E-mail address: dsmhort@gmail.com (D. S. Mishra)
Received 05.11.2023; Accepted 08.01.2024

berries contain carbohydrates, iron, sugars, minerals, protein and the pharmacologically active phytochemicals like flavonoids, terpenes, and anthocyanins (Mishra *et al*., 2020 Singh *et al*., 2019). The powdered seeds have also reputation of being useful in the treatment of diabetes. These seeds are claimed to contain alkaloids such as jambosine, and glycoside jambolin or antimellin, which halts the diastatic conversion of starch into sugar and seed extract had lowered blood pressure (Singh *et al*., 2018). The ripe jamun fruits are consumed fresh and can also be processed into many value added products like jam, jellies, squash, cider, nectar, wine, vinegar, RTS, *etc.* (Mishra, 2018). Because of its hardy nature and various uses, it has great potential for commercial exploitation in wastelands and dry-land horticulture (Singh *et al*., 2019). As a result, it is gaining popularity among farmers all over the country particularly in rain-fed areas (Singh *et al*., 2018a). Several old nondescript varieties are under cultivation throughout the country, therefore, evaluation and recommendation with regard to high performing cultivars in terms of yield and quality was felt essential. This study aimed to assess the effects of genotype and year's effect on the productive performance of four cultivars of jamun under rainfed conditions in central Gujarat located in the western part of India.

Materials and Methods

In the present investigation, three newly developed gentotypes *viz*., Goma Priyanka from CHES, Godhra and CISHJ-37, CISHJ-42 from CISH, Lucknow were compared with Konkan Bahadoli, which is current popular cultivar for growth, yield and fruit quality attributes at the ICAR-CAH, Bikaner regional station CHES, Godhra (22.41^{0}N latitude, 73.33^{0}E longitude and altitude 115 m). These cultivars were planted earlier during July, 2013 with a spacing of 5 m x 5 m in randomized block design with five replications. These nine-year-old plants were chosen to record time to flowering and fruiting as well as fruit yield and quality attributes. Three uniform trees of each genotype/cultivar was selected for recording observations on growth in terms of plant height (cm), stem girth (cm) and plant spread (cm). The yield (kg/tree) was obtained by the weighing the fruits harvested at ripening stage. Fruit weight and fruit size were recorded as per standard procedures with the help of an electronic balance and vernier caliper respectively. The total soluble solids (TSS) were determined using an Erma Hand Refractometer (0-32°Brix). The titratable acidity (%) was determined by method of AOAC (1980). The data were subjected to statistical analysis as per the method by using open source R software. The Duncan Multiple Range Test was carried out at 95% confidence level for testing the significant differences among the genotypes and across the years.

Results and Discussion

Conventionally the canopy spread, plant height and stem girth are considered for assessing the growth of tree species (*Syzygium cumini*) while yield attributes including fruit yield per plant, weight of each fruit, pulp weight and it's percent in whole fruit are commonly recorded to assess the response of jamun to any of the treatment. The TSS and acidity are the key quality parameters often used for judging the quality of fruit. Hence, in this study these parameters were considered to assess the effect of the year, genotype and year x genotype interaction.

Growth attributes

As evident from the data presented in Fig. 1 (i-iv), the year had a significant effect on tree height, stem girth and canopy spread both in east-west and north-south direction. These parameters together indicated that the growth in the year 2022 was significantly better than the same during 2021. The effect of genotype on the growth of plants was also evident from significant difference among the cultivars of jamun irrespective of year of evaluation. The cultivars exhibited high variability for tree growth characters, during the two years evaluation, CISHJ-37 recorded the highest tree height and stem girth compared to other cultivars. However, higher tree spread in both the directions were recorded in CISHJ-37, which was closely followed by Goma Priyanka. Genetic makeup of the plants and variations in climatic conditions could be the possible reason for the wide variation with respect to growth and plant spread. Goma Priyanka is a medium tall growing cultivar, therefore reported to be useful for high density planting (Singh *et al*., 2018a.). The results of present findings are in agreement with Kaur and Bal (2015) in jamun, Mishra *et al.* (2019) in guava and Mishra *et al.* (2020) in pomegranate. G x E interaction effect was significant for all the growth parameters assessed in this study. While growth attributes such as plant height and stem girth of CISH J-37 were found to be relatively stable, these attributes of Goma Priyanka and Konkan Bardoli were different more in the second year relative to the first year indicating that there was significant growth over the years in these cultivars. The spread of canopy was maintained in Konkan Bahadoli over the years as the canopy spread was relatively less compared to other cultivars.

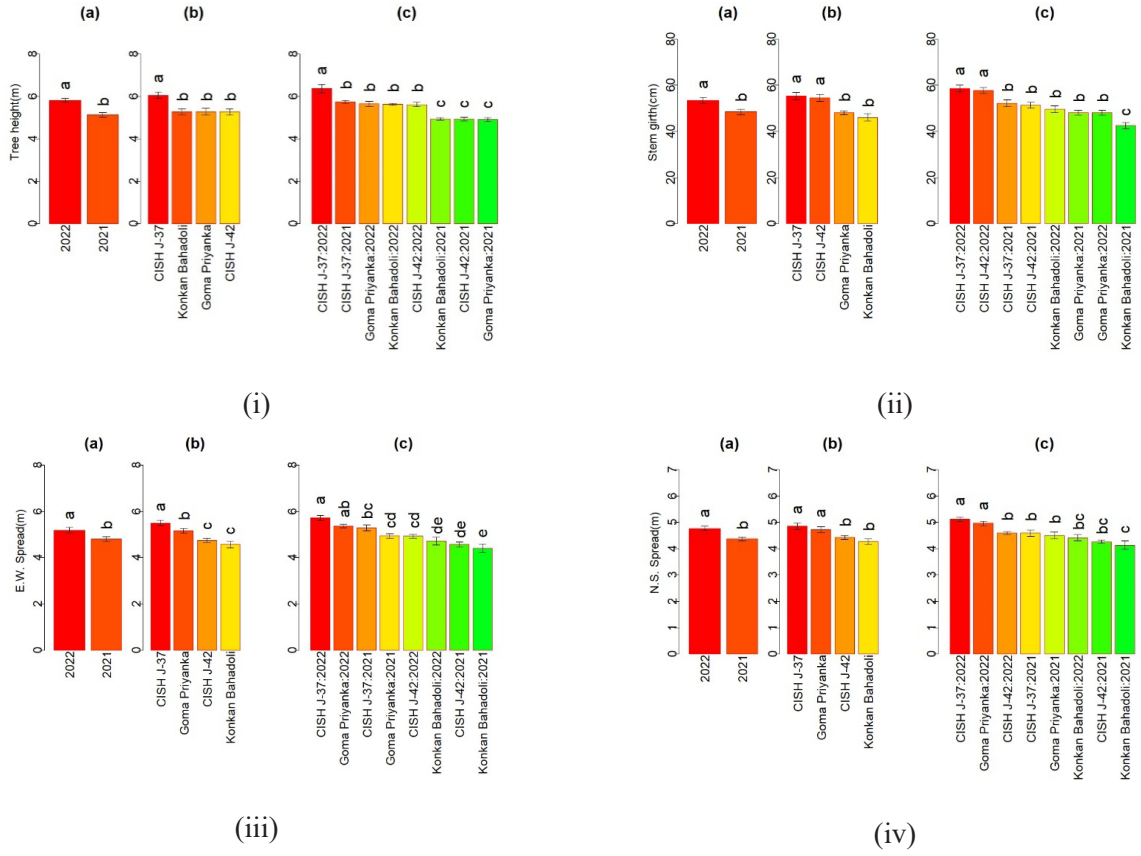

Fig. 1: Effect of year (a), genotype (b)and E X G (c) interactions on tree height (i), stem girth (ii) and spread(E-W) (iii) and spread (N-S) (iv)of jamun cultivars

Yield attributes

Fruit yield per plant as well as fruit weight were found to be stable over the years during the evaluation (Fig. 2). However, higher fruit yield/plant and pulp weight were recorded in Goma Priyanka followed by CISHJ-37compared to other two cultivars during both the years. The diversity in these characters were attributed to highly heterozygous and diverse genetic background of parents (Kaur and Bal, 2015 and Singh *et al*., 2019a). Similar trend was observed with respect to fruit weight except that Gom Priyanka and CISH-37 were at par for this attribute across the year. Pulp is considered as an important attribute for value added products and hence the cultivars chosen in this study were evaluated for pulp weight per fruit as well as pulp % in the fruit. This trait was found to be stable over the years while Goma Priyanka and CISH J-37 were found to have higher pulp weight relative to other cultivars. The proportion of pulp in the seed expressed as pulp (%) was also remained unaffected by the year of testing, however, CISH J-42 found to be superior (>92% pulp) to other cultivars during both the years. Goma Priyanka had more than 85% pulp in the fruit which was higher than that was found in the Konkan Bahadoli (80%).Variations in fruit and pulp weight were earlier reported by Kaur and Bal (2015) and Singh *et al.* (2019) in jamun and Singh *et al.* (2019b) in phalsa.

Biochemical properties

There was a significant difference among the cultivars with regard to chemical quality attributes of jamun (Fig. 3). In general, both TSS content and acidity of fruit were stable across the two years. Improved varieties of Jamun developed at CHES, Godhra and CISH, Lucknow had significantly higher TSS and acidity relative to Konkan Bahadoli. Year and variety interaction was also significant indicating that TSS and acidity of at least some cultivars such as Konkan Bahadoli were vulnerable to significant change. However, both the TSS and the acidity were stable across the years in improved varieties. These findings are in accordance with the findings of Singh *et al.* (2019a) in jamun and Mishra *et al.* (2022) in guava. The highest TSS was recorded in Goma Priyanka followed by CISHJ-37 while the minimum TSS was observed in Konkan Bahadoli during both the years. CISHJ-37 recorded the maximum acidity (0.44 %) while the lowest acidity (0.39%) was recorded in Konkan Bahdoli (Singh *et al*., 2019).

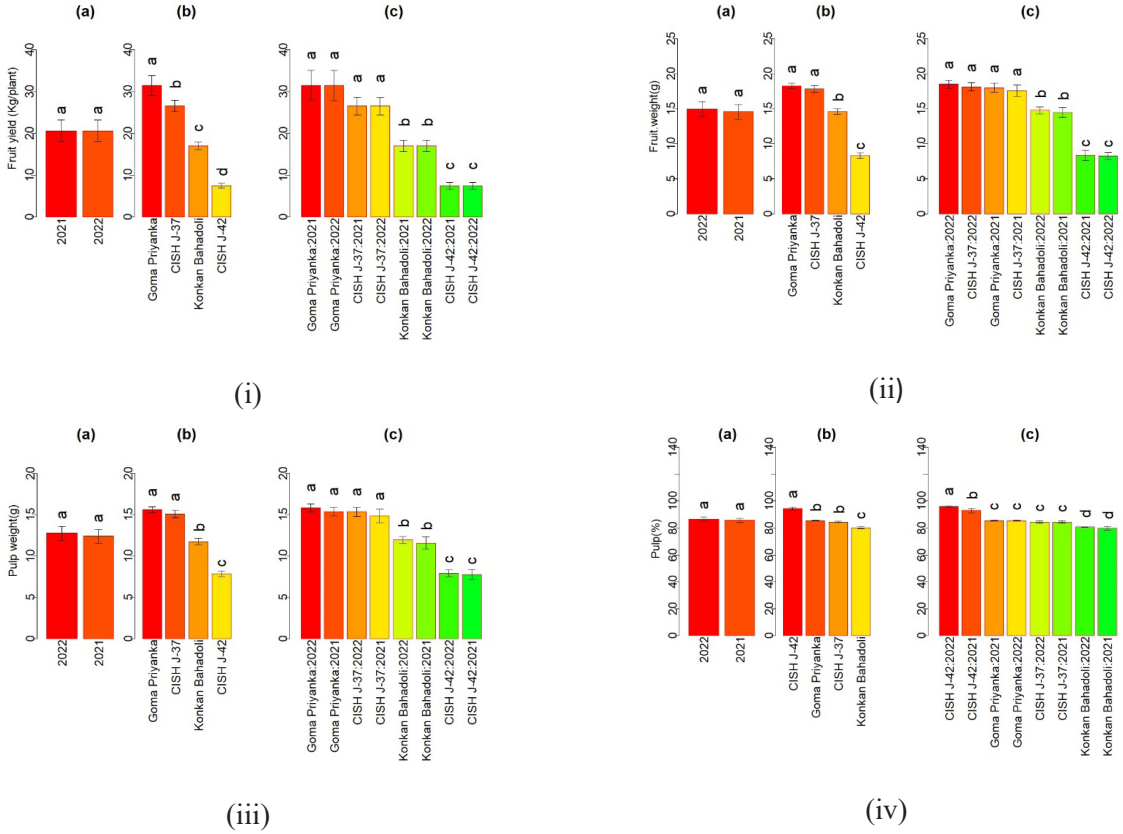

Fig. 2: Effect of year (a), genotype(b) and E x G interaction (c) on fruit yield (i), fruit weight (ii), pulp weight (iii) and pulp percentage (iv) of jamun cultivars

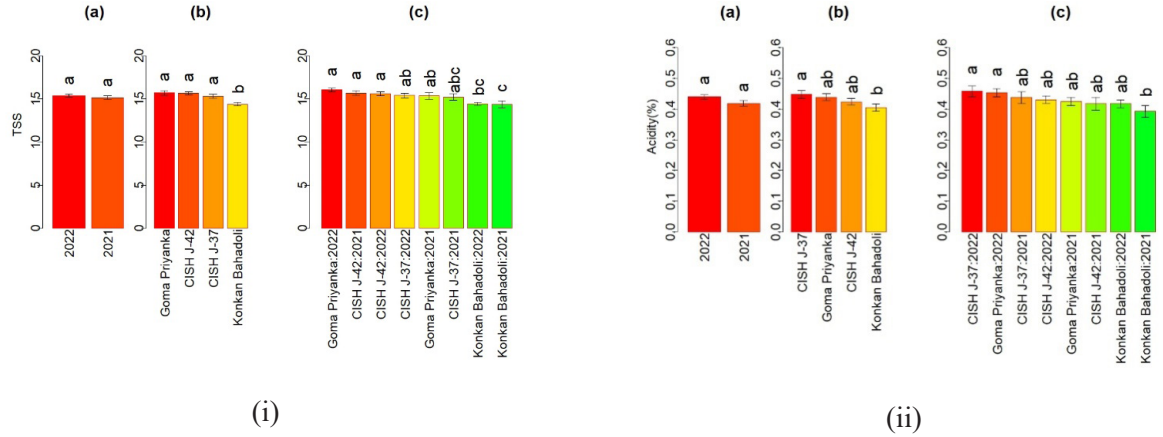

Fig. 3: Effect of year (a), genotype (b) and G x E interactions (c) on TSS (i) and acidity (ii) of jamun cultivars

Conclusion

Systematic evaluation of 4 different cultivars of jamun over two years at CHES, Godhra which represents a typically semi-arid environment of central Gujarat revealed that cultivars *viz*., Goma Priyanka and CISHJ-37 promise to provide more number of high quality fruits. This could be attributed to the relatively better adaptability to the local environments and genetic makeup of these two varieties. Hence, these genotypes are recommended for cultivation in semi-arid ecosystems of Central Gujarat.

Acknowledgements

We thank ICAR-CIAH, Bikaner, Rajasthan and AICRP-AZF for providing the necessary facilities to complete this study. Technical help provided by Mr. K.V. Parmar, is highly appreciated.

References

AOAC. 1980. Official Methods of Analysis of Association of Official Agricultural Chemists, Association of Official Agricultural Chemists, Benjamin Franklin Station, Washington, DC, USA.

Mishra, D.S., Singh, A., Kumar, R., Singh, S., Singh, A.K. and Swamy, G.S.K. 2014. Jamun. In: *Tropical and Sub Tropical Fruit Crops: Crop Improvement and Varietal Wealth*, Part. II (Ed) Ghosh, S.N. Jaya Publishing House, Delhi, pp. 375-387.

Mishra, D.S. 2018. Enhancing income through value-addition. *Indian Horticulture*, 63(5):107-109.

Mishra, D.S., Berwal, M.K., Singh A., Singh, A.K., Appa Rao, V.V., Yadav, V. and Sharma, B.D. 2022. Phenotypic diversity for fruit quality traits and bioactive compounds in red-fleshed guava: Insights from multivariate analyses and machine learning algorithms. *South African Journal of Botany,* 149:591-603.

Mishra, D.S., Singh, S., Singh, A.K., Yadav, V. and Saroj, P.L. 2019. Evaluation of guava (*Psidium guajava* L.) germplasm under semi-arid environment of central Gujarat. *Indian Journal of Arid Horticulture*, 1(1):53-55.

Mishra, D.S., Singh S., Appa Rao, V.V. and Yadav, V. 2020. Pre-harvest chemical sprays for enhancing shelf life and fruit quality of jamun. *Indian Journal of Arid Horticulture*, 2(2):30-33.

Mishra, D.S., Singh S. and Saroj, P.L. 2020. Evaluation of pomegranate varieties under semi-arid environment of central Gujarat. *Indian Journal of Arid Horticulture*, 2(2):67-69.

Singh, S., Singh, A.K., Mishra, D.S. and Appa Rao, V.V. 2018a. High density planting in jamun doubles the farmers' income. *Indian Horticulture*, 63(3):14-16.

Singh, S., Singh, A.K., Mishra, D.S., Saroj, P.L. and Appa Rao, V.V. 2018. Jamun for health and wealth. *Indian Horticulture*, 63(5):33-36.

Singh, S., Singh, A.K., Saroj, P.L. and Mishra, D.S. 2019. Research status for technological development of jamun (*Syzygium cuminii*) in India: A review. *Indian J. Hort.*, 89(12):1991-1998.

Singh, S., Singh, A.K., Saroj, P.L., Appa Rao, V.V. and Mishra, D.S. 2019a. Genetic divergence in jamun under semi-arid ecosystem of western India. *Indian Journal Horticulture*, 76(2):206-211.

Singh, S., Singh, A.K., Mishra, D.S. and Appa Rao, V.V. 2019b. Genetic diversity in phalsa (Grewia subinaequalis DC) under semi-arid ecosystem of western India. *Indian Journal of Arid Horticulture*, 1(1):56-59.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Thar Mahima: an improved cultivar of muskmelon identified for arid region

B.R. Choudhary, S.K. Maheshwari, S.M. Haldhar*, Chet Ram and Dhurendra Singh

ICAR-Central Institute for Arid Horticulture, Bikaner - 334 006
*Assoc. Prof., Deptt. of Ento., COA, Iroisemba, CAU, Imphal, Manipur - 795 004

ARTICLE INFO

Key Words: Muskmelon, arid region, TSS, yield.

doi: 10.48165/ijah.2021.3.1.3

ABSTRACT

The 'Thar Mahima' cultivar of muskmelon along with nine genotypes including checks was evaluated at ICAR-CIAH, Bikaner for 3 consecutive summer years (2016, 2017 and 2018) replicated thrice. The experiments were conducted following the recommended package of practices for muskmelon cultivation. From the results, it is evident that 'Thar Mahima' cultivar showed promising performance with respect to first fruit picking (75-80 DAS), high TSS (11.58-11.80%), fruits weighing 780-900 g with 2.8-3.2 cm thick flesh having salmon orange colour, 0.30-0.48 cm thick rind and small seed cavity (2.8-3.2 cm). It produced 4-5 fruits per plant which were round and attractive with netted surface having sutures.

Introduction

Muskmelon (*Cucumis melo* L.) is one of the most important cucurbits throughout the world which is consumed as 'Dessert fruit'. It is an annual and summer season annual crop with climbing, creeping or trailing vines. The fruits of muskmelon are many-seeded called 'pepo'. India being the centre of diversity, many landraces of muskmelon are grown in Rajasthan, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Maharashtra and Andhra Pradesh. A wide range of variation for genetic improvement of muskmelon is present in India (Pandey *et al.*, 2005 and Choudhary *et al.*, 2012). The persistence of large variability in muskmelon ensures better chances to select new genotypes for specific traits. Thus, evaluation of the variability is prerequisite in any crop improvement programme. Cultivars of muskmelon having orange colored flesh, netted rind, high TSS and more shelf life are preferred by the Indian consumers. In this article, we report the identification of 'Thar Mahima', a cultivar with better performance in arid region as compared to other prevalent varieties. While developing this improved cultivar, the selection indices described by Lal and Singh (1997), Choudhary *et al.* (2015) and Haldhar *et al.* (2015) were followed in the selection of superior plants.

*Corresponding author.
E-mail address: choudharybr71@gmail.com (B.R. Choudhary)
Received 15.01.2024; Accepted 16.03.2024

Origin

'Thar Mahima' originated from an open pollinated landrace (AHMM/BR-47) collected in 2013 from Garda, District - Baran of Rajasthan. The collected germplasm was evaluated, maintained and characterized over the years starting from 2014 at ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan, India situated at 28°N latitude, 73°18' E longitude at an altitude of 234.84 m above sea level. The soil of experimental field was loamy sand with a pH of 8.7, EC 0.20 dS/m and organic carbon 0.07%. The breeding objective of the investigation comprised to develop early and quality yielding variety of muskmelon adapted to hot arid conditions. The collected material was raised and homogenized through repeated inbreeding for 6 cycles exercising single plant selection based on earliness, fruit weight, salmon orange flesh colour, high TSS, small size seed cavity, more flesh thickness, rind with netting and high marketable fruit yield. While developing

The purified material was evaluated for three consecutive years (2016, 2017 and 2018) during summer season and based on the data the Thar Mahima cultivar has been identified by the IVIC in 2022. It is recommended for cultivation in arid and semi-arid region of the country under open field and tunnel cultivation. The seed has also been deposited to National Bureau of Plant Genetic Resources (NBPGR), New Delhi under the accession no. IC-0624305.

Description

The plants of 'Thar Mahima' have short vine (1.6-2.0 m) with profuse branching and characterized by deep lobing of leaves. Plants are andromonoecious in sex expression. Fruits are round with netting on rind surface (Fig. 1). The rind colour is attractive at marketable stage. The fruit flesh color is salmon orange at edible maturity. The fruit weight ranges between 780 to 900 g and become ready for first harvest in 75-80 days after seed sowing. Total soluble solid (TSS) content is 11.58-11.80% which is higher compared to other commercial cultivars. The salient characteristics of 'Thar Mahima' are presented in Table 1.

Table 1. Salient characteristics of 'Thar Mahima' cultivar

S. No.	Character		Description
1.	Sex form	:	Andromonoecious
2.	Fruit shape	:	Round with fruit diameter of 10.3-11.0 cm
3.	Days to first fruit picking from sowing	:	75-80 days
4.	Flesh thickness	:	2.8-3.2 cm
5.	Width of seed cavity	:	4.27-5.58 cm
6.	Total soluble solids (TSS)	:	11.58-11.80%
7.	Fruit weight	:	780-900 g
8.	Number of marketable fruits/ plant	:	4-5
9.	Flesh colour	:	Salmon orange
10.	Rind traits	:	0.30-0.48 cm thick, netted with sutures and attractive
11.	Leaf traits	:	Characterized by deep lobing of leaves

Performance

The 'Thar Mahima' cultivar along with nine genotypes including checks was evaluated at ICAR-CIAH, Bikaner for 3 consecutive summer years (2016, 2017 and 2018) replicated thrice. The experiments were conducted following the recommended package of practices for muskmelon cultivation. From the results, it is evident that 'Thar Mahima' cultivar showed promising performance with respect to first fruit picking (75-80 DAS), high TSS (11.58-11.80%), fruits weighing 780-900 g with 2.8-3.2 cm thick flesh having salmon orange colour, 0.30-0.48 cm thick rind and small seed cavity (2.8-3.2 cm). It produced 4-5 fruits per plant which were round and attractive with netted surface having sutures. The year wise ancillary characteristics are presented in Table 2, Table 3 and Table 4.

'Thar Mahima' cultivar produced an average marketable fruit yield of 193.7 q/ ha in on-station trials conducted during three consecutive summer years from 2018 to 2020. Recorded the increase in marketable fruit yield of 'Thar Mahima' over rest of the genotypes and checks. The increase in marketable fruit yield was registered 21.90% and 16.27% higher over checks *viz*., RM-50 and Pusa Madhuras, respectively (Table 5).

Also evaluated the 12 genotypes of muskmelon including 'Thar Mahima' cultivar against Fusarium wilt under field conditions during two consecutive years' *viz*., summer season of 2016 and 2017. The results confirmed that the 'Thar Mahima' cultivar showed moderately resistant reactions against Fusarium wilt with PDI of 16.67 and 14.29 during 2016 and 2017, respectively (Table 6 and Table 7).

Table 2. Performance of 'Thar Mahima' cultivar at ICAR-CIAH, Bikaner during summer season of 2016

Genotypes	First fruit picking (DAS)	Fruit weight (kg)	Fruit diameter (cm)	Flesh thickness (cm)	Rind thickness (cm)	Width of seed cavity (cm)	TSS (%)	No. of marketable fruit/ plant	Flesh colour
AHMM/BR-41	78.7	0.72	10.78	2.18	0.26	6.32	10.30	3.20	Salmon orange
AHMM/BR-42	80.0	0.88	10.80	2.04	0.24	7.06	9.22	3.40	Salmon orange
Thar Mahima	75.0	0.78	10.54	2.90	0.30	5.58	11.58	4.00	Salmon orange
AHMM/BR-49	81.3	0.70	10.16	2.20	0.22	6.54	10.48	3.20	Salmon orange
AHMM/BR-51	86.7	0.75	10.68	2.14	0.24	6.46	11.16	3.40	Greenish white
AHMM/BR-52	76.3	0.55	7.16	2.02	0.14	6.58	11.32	3.00	Greenish white
AHMM/BR-53	76.7	0.69	8.66	2.00	0.24	6.84	11.06	3.40	Whitish green
RM-50 (C)	87.0	0.75	10.06	2.20	0.22	5.63	11.10	3.20	Greenish white
Pusa Madhuras (C)	84.3	0.80	11.70	2.30	0.28	7.20	11.20	3.40	Salmon orange
CD at 5%	1.23	0.12	0.54	0.60	0.03	0.71	1.05	0.52	
CV (%)	10.32	7.51	8.73	7.32	8.04	10.22	6.80	9.71	

Table 3. Performance of 'Thar Mahima' cultivar at ICAR-CIAH, Bikaner during summer season of 2017

Genotypes	First fruit picking (DAS)	Fruit weight (kg)	Fruit diameter (cm)	Flesh thickness (cm)	Rind thickness (cm)	TSS (%)	Flesh colour
AHMM/BR-41	82.3	0.70	10.20	4.2	0.28	9.52	Salmon orange
AHMM/BR-42	90.7	0.85	13.52	3.4	0.26	11.16	Salmon orange
Thar Mahima	77.0	0.83	10.32	3.2	0.34	11.80	Salmon orange
AHMM/BR-49	88.3	0.76	10.26	1.9	0.23	10.36	Salmon orange
AHMM/BR-51	92.0	0.80	11.02	2.8	0.26	11.64	Greenish white
AHMM/BR-52	83.7	0.78	10.80	2.4	0.18	9.82	Greenish white
AHMM/BR-53	80.0	0.60	8.64	2.8	0.26	10.74	Whitish green
RM-50 (C)	90.7	0.80	10.10	2.1	0.22	11.07	Light green
Pusa Madhuras (C)	86.3	0.82	11.90	2.5	0.32	11.30	Salmon orange
CD at 5%	2.65	0.10	0.60	0.46	0.04	0.82	
CV (%)	9.30	7.16	9.08	8.91	7.00	7.60	

Table 4. Performance of 'Thar Mahima' cultivar at ICAR-CIAH, Bikaner during summer season of 2018

Genotypes	Fruit weight (kg)	Fruit diameter (cm)	Flesh thickness (cm)	Rind thickness (cm)	TSS (%)	No. of marketable fruits/ plant	Flesh colour	Rind traits
AHMM-BR-41	0.61	10.26	2.03	0.30	11.07	3.27	Salmon orange	10 sutures
AHMM/BR-42	0.97	12.30	2.16	0.39	10.90	2.33	Salmon orange	Netted with sutures
Thar Mahima	0.90	11.00	2.78	0.48	11.76	4.40	Salmon orange	Netted with sutures
AHMM/BR-49	0.90	10.91	2.46	0.35	11.00	2.83	Salmon orange	10 sutures
AHMM/BR-51	0.71	10.63	2.18	0.29	10.19	3.20	Greenish white	10 sutures
AHMM/BR-52	1.01	10.65	2.60	0.37	10.71	2.40	Greenish white	10 sutures

AHMM/BR-53	0.93	11.03	2.53	0.33	11.11	3.00	Whitish green	-
RM-50 (C)	0.78	9.10	2.02	0.25	11.00	3.20	Greenish white	Netted with sutures
Pusa Madhuras (C)	0.80	11.00	2.41	0.30	11.40	3.40	Salmon orange	10 sutures
CD at 5%	0.14	1.00	0.42	0.05	1.19	0.54		
CV (%)	9.65	9.93	10.31	9.62	6.47	9.70		

Table 5. Fruit yield of 'Thar Mahima' cultivar and Check (C) at ICAR-CIAH, Bikaner during summer season (2018-2020)

Entries	Marketable fruit yield (q/ ha)			
	2018	2019	2020	Average
Thar Mahima	180.6	205.8	194.7	193.7
RM-50 (C)	148.2	172.0	156.5	158.9
Pusa Madhuras (C)	170.3	161.4	168.0	166.6
	Average % increase over RM-50 (C)			21.90
	Average % increase over Pusa Madhuras (C)			16.27

Table 6. Screening of muskmelon genotypes against *Fusarium* wilt under field conditions during summer season of 2016

S. No.	Genotypes	PDI*	Disease Reaction
1.	AHMM/BR-1	19.33 (26.04)	Moderately Resistant
2.	AHMM/BR-38	22.67 (28.09)	Moderately Susceptible
3.	AHMM/BR-44	14.67 (22.47)	Moderately Resistant
4.	AHMM/BR-46	19.36 (25.91)	Moderately Resistant
5.	Thar Mahima	16.67 (23.97)	Moderately Resistant
6.	AHMM/BR-48	28.06 (31.95)	Moderately Susceptible
7.	AHMM/BR-49	20.09 (26.52)	Moderately Susceptible
8.	AHMM/BR-53	16.14 (23.59)	Moderately Resistant
9.	AHMM/BR-54	30.64 (33.57)	Susceptible
10.	MHY-3	18.65 (25.56)	Moderately Resistant
11.	RM-43	25.31 (30.12)	Moderately Susceptible
12.	RM-50	29.33 (32.76)	Moderately Susceptible
	CD at 5%	4.58	
	CV (%)	9.76	

* Values in parenthesis are angular transformed value

Table 7. Screening of muskmelon genotypes against *Fusarium* wilt under field conditions during summer season of 2017

S. No.	Genotypes	PDI*	Disease Reaction
1.	AHMM/BR-1	18.35 (25.26)	Moderately Resistant
2.	AHMM/BR-38	24.74 (29.70)	Moderately Susceptible
3.	AHMM/BR-44	15.62 (23.16)	Moderately Resistant
4.	AHMM/BR-46	17.78 (24.44)	Moderately Resistant
5.	Thar Mahima	14.29 (22.14)	Moderately Resistant
6.	AHMM/BR-48	26.67 (30.95)	Moderately Susceptible
7.	AHMM/BR-49	21.48 (27.46)	Moderately Susceptible
8.	AHMM/BR-53	19.23 (25.84)	Moderately Resistant
9.	AHMM/BR-54	35.82 (36.72)	Susceptible

10.	MHY-3	16.12 (23.47)	Moderately Resistant
11.	RM-43	28.34 (32.11)	Moderately Susceptible
12.	RM-50	29.98 (33.11)	Moderately Susceptible
	CD at 5%	6.88	
	CV (%)	14.48	

* Values in parenthesis are angular transformed value

DNA fingerprinting

The DNA fingerprinting of Thar Mahima along with 6 known varieties (RM-50, Durgapura Madhu, Hara Madhu, Kashi Madhu, Pusa Madhuras and MHY-3) as comparative control was done using 15 CAAT-box Derived Polymorphism (CBDP) markers. Four CBDP markers namely CBDP2, CBDP4, CBDP7 and CBDP12 were able to produce Thar Mahima specific bands and could be able to differentiate the Thar Mahima cultivar to related comparative control. The Thar Mahima varietal-specific allele distribution along with size is given in Table 9.

Table 9. Thar Mahima specific DNA fingerprints, their distribution and size

S. No.	CBDP marker	Approximate size of Thar Mahima varietal-specific alleles (bp)	No. of specific alleles
1.	CBDP2	760	1
2.	CBDP4	1100	1
3.	CBDP7	550 and 800	2
4.	CBDP12	450	1

Conclusion

'Thar Mahima' cultivar showed promising results under hot arid conditions of western Rajasthan. It possess quality attributes as per consumer preference *viz*., TSS (11.58-11.80%), flesh colour (salmon orange), small seed cavity (2.8-3.2 cm). thick rind (0.30-0.48 cm) and attractive fruits (round and netted surface with sutures). Therefore, based on performance and other overall attributes it is recommended for commercial cultivation.

Acknowledgements

Authors are thankful to the Director, ICAR-CIAH, Bikaner and ICAR, New Delhi for providing necessary facilities, guidance and support during this study.

References

Choudhary, B.R., Kumar, S. and Sharma, S.K. 2012. Genetic variability and inter-trait association in muskmelon (*Cucumis melo* L.) under arid conditions. *Crop Improvement Special Issue:* 473-474.

Choudhary, B.R., Pandey, S., Rao., E.S. and Sharma, S.K. 2015. DUS characterization of muskmelon (*Cucumis melo* L.) varieties. *Indian Journal of Agricultural Sciences*, 85 (12): 1597-1601.

Haldhar, S.M., Choudhary, B.R. and Bhargava, R. 2015. Antixenotic resistance traits of muskmelon (*Cucumis melo* L.) against fruit fly (*Bactrocera cucurbitae* (Coquillett) in arid region of India. *Indian Journal of Applied Entomology*, 29(2): 81-87.

Lal, T. and Singh, S. 1997. Genetic variability and selection indices in melon (*Cucumis melo* L.). *Vegetable Science*, 24(2): 111-1.17.

Pandey, S., Rai, M. and Singh, B. 2005. Genetic variability and character association in muskmelon (*Cucumis melo* L.). *Indian Journal of Plant Genetic Resources*, 18(2): 212-216.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Standardization of pit size and organic filling mixture for raising tissue cultured date palm in hot arid region of western Rajasthan

B.D. Sharma*, R.K. Meena**, R. Bhargava* and Sheetal Rawat**

*RNB Global University, Sri Ganganagar Road, Bikaner, Rajasthan 334601
**ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner

ARTICLE INFO

Key Words: Date palm, FYM, pits, filling mixture.

doi: 10.48165/ijah.2021.3.1.4

ABSTRACT

The study aims to provide comprehensive guidelines for optimizing pit size and the composition of filling mixtures, thereby fostering the growth, root development and overall health of tissue cultured Barhee date palm cultivars. The experiment was undertaken in 2019- 2021 at the ICAR-Central Institute for Arid Horticulture research farm located in Bikaner, Rajasthan, India. Fully hardened tissue-cultured saplings of the Barhee cultivar of date palm were planted with a spacing of 5 x 5 m in the month of July. Different planting pit sizes (1.0 m x 1.0 m x 1.0 m, 0.75 m x 0.75 m x 0.75 m, and 0.50 m x 0.50 m x 0.50 m) and filling mixtures of field soil, clay and FYM (1.0: 1.0:1.0, 2.0:0.5:0.5, 0.5:2.0:0.5 and 0.5:0.5:2.0) were used as treatment combinations for evaluating the growth of plants. The results indicated that tissue-cultured plants of the Barhee cultivar raised in a pit size of 1 m^3 with a filling mixture of field soil, clay, and FYM in the ratio of 0.5:0.5:2.0 performed better.

Introduction

The date palm (*Phoenix dactylifera* L.) is a member of the Arecaceae (Palmae) family and stands as one of the earliest cultivated fruit plants in human history. According to archaeological findings, Iraq is recognized as the source of origin date palm (Johnson *et al.* 2013). In India, the cultivation of date palms is primarily concentrated in the western parts of Rajasthan, the Rann of Kutch and the semi-arid regions of Gujarat and Punjab area which also known for its harsh, hot and arid climatic conditions (Bhansali, 2009). Rajasthan occupies almost 60% of the total of these regions. However, this region is known for its unforgiving environment characterized by harsh climatic conditions, arid soil with high salinity, extremely low rainfall, extreme temperature fluctuations and poor soil fertility.

Tissue culture has revolutionized date palm cultivation by providing disease-free and genetically consistent plantlets, offering a promising solution to strengthen date palm production in this region. Among the various imported tissue-cultured date palms, the Barhee cultivar has emerged as a prominent choice. Nevertheless, the success of tissue-cultured Barhee date palms in Western

*Corresponding author.
E-mail address: rkmeena8119@yahoo.com (R. K. Meena)
Received 20.11.2023; Accepted 22.02.2024

Rajasthan hinges on several critical factors such as the size of the planting pit and the composition of the filling mixture which determine root and shoot development and hence productivity of crop.

The size of the planting pit directly influences root development through prolonged moisture retention and increased access to plant nutrients, while the composition of the filling mixture significantly impacts soil structure, aeration and moisture-holding capacity (Mauki and Kilonzo, 2022).

Pitting size and filling mixtures has been one of the most important aspects of tree planting programs that are crucial for tree survival (Jo and Park, 2017). Lack of information about appropriate pits size and filling mixture have been reported as major constraints in raising tissue cultured date palm particularly in regions featured by unreliable rainfall and low soil productivity (Ndegwa *et al.*, 2017). Different pitting size and filling mixture are important in improving root-soil contact, improves soil aeration and water infiltration (Allan, 1998). Therefore, this study aimed at size of planting pit and filling mixtures for the successful tree sapling establishment in arid regions of Rajasthan. Thus, this study aspires to offer practical recommendations for date palm growers in Western Rajasthan, enabling them to refine their practices and optimize the cultivation of Barhee date palms in this demanding environment.

Materials and Methods

The experiment was conducted during 2019-2021 at ICAR-Central Institute for Arid Horticulture, Bikaner (The experimental site was situated on 28°N latitude, 73°18'E longitude and at an altitude of 234.84 m above sea level) Rajasthan, India. The soil of the experimental site was sandy, desertic, poor in fertility and water-holding capacity. The soil nutrient content was examined at three different depths (30-90 cm depth) and samples were analysed and recorded. The average rainfall of this region was about 230 mm/annum. May-June was the hottest month (mean maximum temperature 42.9°C and mean minimum temperature 29.6°C) and December-January was the coldest month of the year (mean maximum temperature 23.7°C and mean minimum temperature 8.9°C). Occasional frost was also experienced during January and February.

This site was chosen due to its suitability for stimulating the arid conditions prevalent in the region. The detailed soil properties are given in Table 1. The treatment consisted of three pit sizes and four filling mixtures (Table 2). The experiments were laid out in a factorial randomized block design with three replications. Fully hardened tissue-cultured saplings of the Barhee cultivar of date palm, each possessing 2-3 leaves, were planted with the spacing of 5 x 5 m.

Table 1. Physico-chemical properties of experimental site

S.No.	Characteristics	Mean value	Reference
1.	Particle size analysis		Bouyoucos, 1962
	Sand (%)	89.50	
	Silt (%)	06.50	
	Clay (%)	04.00	
	Textural class	Loamy sand	
2.	Bulk density (Mg/m^{-3})	1.60	Black, 1965
3.	Particle density (Mg/m^{-3})	2.65	Black, 1965
4.	Water holding capacity (%)	5.60	Black, 1965
5.	Infiltration rate mm hr^{-1})	24	Johnson, 1963
6.	pH (1:2)	8.5	Jackson, 1979
7.	Electrical conductivity (dSm^{-1}) (1:2)	1.10	Jackson, 1979
8.	Organic carbon (g kg^{-1})	0.09	Walkley and Black ,1934
9.	Available nitrogen (kg ha^{-1})	130	Subbiah and Asija, 1956
10.	Available phosphorus (kg ha^{-1})	15	Olsen *et al.*, 1954
11.	Available potassium (kg ha^{-1})	164	Jackson, 1973
10.	DTPA extractable iron (mg kg^{-1})	29.60	Lindsay and Norvell, 1978
11.	DTPA extractable zinc (mg kg^{-1})	0.35	Lindsay and Norvell, 1978
12.	DTPA extractable copper (mg kg^{-1})	2.60	Lindsay and Norvell, 1978
13.	DTPA extractable manganese (mg kg^{-1})	13.54	Lindsay and Norvell, 1978

Table 2. Experiment details

Pit sizes (P)	1.00 m x 1.00 m x 1.00 m	P1
	0.75 m x 0.75 m x 0.75 m	P2
	0.50 m x 0.50 m x 0.50 m	P3
Filling mixtures (M)	1.0 : 1.0 : 1.0 (Field soil: Clay: FYM)	M1
	2.0 : 0.5 : 0.5 (Field soil: Clay: FYM)	M2
	0.5 : 2.0 : 0.5 (Field soil: Clay: FYM)	M3
	0.5 : 0.5 : 2.0 (Field soil: Clay: FYM)	M4

Data collection

Vegetative parameters

Parameters like plant height, number of leaves and plant spread were recorded after 12 and 24 months after planting. The plant growth parameters like height, plant spread was recorded with the help of steel tape and the number of leaves by manual counting method.

Leaf nutrient status

For date palm middle part of the physiologically mature leaves was taken for analysis of N, P, K, zinc and iron determination. One gram oven-dried grounded sample was taken in a digestion tube to which 1m mL of diacid mixture (nitric acid: perchloric acid = 5:2) zinc and iron analysis and 10 mL were added and triacid mixture (nitric acid: perchloric acid: sulphuric acid = 9: 4: 1) for P and K analysis were added. The contents were kept overnight for pre-digestion. The tubes were loaded into the digester and then heated the digestion chamber. The temperature was raised to 200 degrees centigrade for 2-3 hours till the solution turned colorless with cessation of emission of white dense fumes from the digesting samples. The tubes were kept for cooling down. The digested material was then filtered and volume made up to 100 mL with distilled water and stored for further estimation. The determination of total N and P content were carried out by using the modified micro Kjeldahl method and vanadomolybdate yellow color method, respectively. The zinc and iron were determined by using atomic absorption spectrophotometer. Petiole samples were prepared with a laboratory homogenizer using about 0.5 g of fresh material. 80% acetone was used as an extraction solvent. The total chlorophyll content (a + b) was analytically determined using a spectrophotometer, measuring absorbance at wavelengths of 662 nm and 644 nm. The chlorophyll content was then calculated using the formula provided by Witham *et al.* (1971).

Statistical Analysis

Data obtained on various characters were analyzed statistically according to the factorial randomized block design as suggested by Gomez and Gomez (1984). The critical difference (CD) was calculated to understand the significance or non-significance of difference between treatment means at 5% level of significance.

Results and Discussion

Vegetative parameters

Results revealed that the plant vegetative growth was significantly affected by the different treatments. After 12 and 24 months of planting the highest plant height, number of leaves i.e., 118.00 cm and 169.15 cm, (7.38 and 11.40) were observed in plants under the pit size of $1m^3$, respectively. Whereas, the highest plant height (120.45 and 160.20 cm), number of leaves (7.33 and 10.57) were recorded under filling mixture M4 (Table 3). The interaction effect between pit sizes and filling mixtures resulted in significant differences in plant growth. Specifically, the combination of pit size P1 and filling mixture M4 produced the highest plant height, with measurements of 130.85 cm and 185.60 cm, respectively. Additionally, this combination led to the highest number of leaves, with counts of 8 and 13.5. (Table 3 and 4). Furthermore, data presented in Table 5 reveals that plants growing under filling mixture M4 produced maximum plant spread (93.3 x 91.7 and 170.0 x 171.7) after 12 and 24 months after the planting, respectively. The maximum plant spread (95.0 x 96.0 and 178.8 x 181.2) was found in plants under the pit size P1 after 12 and 14 months after planting, respectively. The interaction effect between pit size and filling mixture was significant, with the maximum plant spread observed in the combination of pit size P1 and filling mixture M4. The findings of this study align with previous research conducted by Pahlaet *al.* (2013) and Amanullah *et al.* (2013). Their research indicated that the performance of planted seedlings,

specifically in terms of height, is positively affected by an increased application of manure. Vincent and Davies (2003) further elucidated/that larger planting pit sizes were associated with several advantages for seedlings. These advantages include a reduction in soil compaction within the rooting zone, enhanced water infiltration, and increased water availability during the critical early stages of establishment, all of which collectively influence tree growth positively. These results are consistent with earlier studies conducted by Ghafoor and Gopan (1988), Abdel-Hameed and Ragab (2004), Mohamed and Gobara (2004), Mansour *et al.* (2004) and Diab (2006) documented favorable effects on vegetative growth and leaf nutrient composition when different date palm cultivars received annual applications of organic fertilizers.

Among the different filling mixtures, M4 provided more FYM to the plant. FYM provides a slow-release source of nutrients, including nitrogen, phosphorus and potassium, which are crucial for plant growth (Tang *et al.*, 2007 and Yang *et al.*, 2004). Moreover, FYM enhances the physical properties of soil. It improves soil structure, increases water-holding capacity and promotes better aeration. This improved soil environment is conducive to root development, which is a fundamental component of vegetative growth. A healthy and well-developed root system can efficiently absorb water and nutrients from the soil, providing the necessary support for above-ground vegetative growth.

Leaf nutrient content

The maximum values of the leaf nitrogen (1.69 and 1.70%) and phosphorous content (0.28 and 0.28%) of the leaf were obtained on the palm that growing under P1 and filling mixture M4, respectively. The interaction effect between two factors was found to be significant and the highest leaf nitrogen and phosphorous content was found maximum under P1M4 *i.e.* 1.80 and 0.30% respectively (Table 6). Moreover, the highest potassium content was exhibited by plants grown under the pit size P1 (2.08%) and filling mixture M1 and M2 (2.02%) compared to the other treatments. The pit size and the composition of filling

Table 3. Effect of pit sizes and filling mixtures on the plant height (cm) of tissue cultured date palm cv. Barhee

Pit size	After 12 of planting					After 24 months of planting				
	M1	M2	M3	M4	Mean	M1	M2	M3	M4	Mean
P1	125.25	105.40	110.50	130.85	118.00	175.50	155.00	160.50	185.60	169.15
P2	110.00	105.00	115.00	120.50	112.63	150.50	135.40	140.50	155.00	145.35
P3	100.80	90.00	95.00	110.00	98.95	135.50	125.30	132.20	140.00	133.25
	112.01	100.13	106.83	120.45		153.83	138.57	144.40	160.20	

SEm±	Pit size	1.235	SEm±	Pit size	2.114
	Filling mixture	2.546		Filling mixture	3.213
	Pit size x Filling mixture	1.980		Pit size x Filling mixture	2.876
LSD (0.05)	Pit size	2.964	LSD (0.05)	Pit size	5.074
	Filling mixture	6.110		Filling mixture	7.895
	Pit size x Filling mixture	4.951		Pit size x Filling mixture	6.902

Table 4. Effect of pit sizes and filling mixtures on the number of leaves of tissue cultured date palm cv. Barhee

Pit size	After 12 of planting					After 24 months of planting				
	M1	M2	M3	M4	Mean	M1	M2	M3	M4	Mean
P1	7.5	7.0	7.0	8.0	7.38	12.6	10.0	9.5	13.5	11.40
P2	6.6	6.2	6.8	7.0	6.65	9.8	7.8	7.5	10.2	8.28
P3	6.5	6.0	6.0	7.0	6.38	8.2	7.8	7.5	8.0	7.88
	6.87	6.40	6.60	7.33		10.20	8.53	8.17	10.57	

SEm±	Pit size	0.465	SEm±	Pit size	0.362
	Filling mixture	0.785		Filling mixture	0.386
	Pit size x Filling mixture	0.643		Pit size x Filling mixture	0.354
LSD (0.05)	Pit size	NS	LSD (0.05)	Pit size	0.969
	Filling mixture	NS		Filling mixture	0.947
	Pit size x Filling mixture	NS		Pit size x Filling mixture	0.885

Table 5. Effect of pit sizes and filling mixtures on the plant spread (cm) of tissue cultured date palm cv. Barhee

Filling mixture	Pit size							
	After 12 month				After 24 months			
	P1	P2	P3	Mean	P1	P2	P3	Mean
M1	95 x 100	90 x 90	80 x 82	88.3x 90.7	190 x 185	155 x 150	140 x 145	160.7 x 160.0
M2	90 x 94	85 x 85	80 x 78	85.0 x 85.7	160 x 165	135 x 140	135 x 130	143.3 x 145.0
M3	95 x 90	85 x 82	75 x 75	85.0 x 83.3	165 x 170	135 x 125	135 x 130	145.0 x 141.7
M4	100 x 100	95 x 90	85 x 85	93.3 x 91.7	200 x 205	165 x 160	145 x 150	170.0 x 171.7
Mean	95.0 x 96.0	88.8 x 86.0	85 x 85		178.8 x 181.2	147.5 x 143.8	138.8x 138.8	
SEm±	Pit size	2.210 x 1.976			SEm±	Pit size	3.243 x 2.975	
	Filling mixture	1.768 x 1.675				Filling mixture	2.753 x 2.435	
	Pit size x Filling mixture	1.892 x 1.647				Pit size x Filling mixture	2.895 x 2.657	
LSD (0.05)	Pit size	5.145 x 4.472			LSD (0.05)	Pit size	7.132 x 6.342	
	Filling mixture	4.243 x 4.103				Filling mixture	6.242 x 6.132	
	Pit size x Filling mixture	4.540 x 4.117				Pit size x Filling mixture	6.580 x 6.139	

Table 6. Effect of pit sizes and filling mixtures on the nitrogen and phosphorus in leaves of tissue cultured date palm cv. Banshee

Pit size	Nitrogen (%)					Phosphorus (%)				
	M1	M2	M3	M4	Mean	M1	M2	M3	M4	Mean
P1	1.75	1.60	1.60	1.80	1.69	0.29	0.27	0.27	0.30	0.28
P2	1.68	1.60	1.61	1.68	1.64	0.27	0.26	0.25	0.28	0.27
P3	1.60	1.58	1.60	1.62	1.60	0.26	0.26	0.26	0.27	0.26
	1.68	1.60	1.60	1.70		0.27	0.26	0.26	0.28	
SEm±	Pit size	0.021				SEm±	Pit size	0.036		
	Filling mixture	0.031					Filling mixture	0.045		
	Pit size x Filling mixture	0.026					Pit size x Filling mixture	0.040		
LSD (0.05)	Pit size	0.051				LSD (0.05)	Pit size	0.090		
	Filling mixture	0.078					Filling mixture	0.110		
	Pit size x Filling mixture	0.064					Pit size x Filling mixture	0.885		

Table 7. Effect of pit sizes and filling mixtures on the potassium, zinc, and status in leaves of tissue cultured date palm cv. Barhee

Pit size	Potassium (%)					Zinc (ppm)				
	M1	M2	M3	M4	Mean	M1	M2	M3	M4	Mean
P1	2.10	2.05	2.05	2.10	2.08	78.25	75.40	75.00	80.00	77.16
P2	1.98	1.98	1.95	1.98	1.97	76.65	75.00	75.35	76.50	75.87
P3	1.98	1.98	1.97	1.98	1.98	75.00	75.00	75.25	76.00	75.31
	2.02	2.00	1.99	2.02		76.63	75.13	75.20	77.50	
SEm±	Pit size	0.026				SEm±	Pit size	0.362		
	Filling mixture	0.037					Filling mixture	0.386		
	Pit size x Filling mixture	0.031					Pit size x Filling mixture	0.354		
LSD (0.05)	Pit size	0.071				LSD (0.05)	Pit size	0.969		
	Filling mixture	0.088					Filling mixture	0.947		
	Pit size x Filling mixture	0.074					Pit size x Filling mixture	0.885		

mixtures showed significant interaction and the highest potassium content was found under P1M4 (2.10%) and P1M1 (2.10%). However, the zinc content was maximum (77.16 and 77.50 ppm) in plants grown under the pit size P1 and filling mixture M4, respectively. The interaction between these factors was found to be significant and the highest zinc content was observed in response to P1M4 (80.00 ppm) (Table 7).

Table 8. Effect of pit sizes and filling mixtures on the iron and total chlorophyll content in leaves of tissue cultured date palm cv. Barhee

Pit size	Total chlorophyll (mg g^{-1} FW)					Iron (ppm)				
	M1	M2	M3	M4	Mean	M1	M2	M3	M4	Mean
P1	2.30	2.05	2.05	2.50	2.23	172.00	166.00	167.00	179.00	170.25
P2	2.15	2.00	1.95	2.25	2.09	166.50	165.00	165.00	167.25	165.94
P3	1.98	1.98	1.95	2.02	1.98	155.00	155.25	155.70	158.00	155.99
	2.14	2.01	1.98	2.26		164.50	162.08	162.56	168.08	
SEm±	Pit size			0.046		SEm±	Pit size			0.682
	Filling mixture			0.067			Filling mixture			0.836
	Pit size x Filling mixture			0.063			Pit size x Filling mixture			0.644
LSD (0.05)	Pit size			0.115		LSD (0.05)	Pit size			1.637
	Filling mixture			0.164			Filling mixture			2.090
	Pit size x Filling mixture			0.154			Pit size x Filling mixture			1.610

Data in Table 8 reveal that the leaf chlorophyll content was significantly affected by both the factors and maximum chlorophyll content (2.23 and 2.26 mg g^{-1} FW) was exhibited by the plants grown under the pit size P1 and filling mix M4, respectively. The interaction effect of two factors was found to be significant and maximum chlorophyll content (2.50 mg g^{-1} FW) was found under P1M4. The highest leaf iron content (170.25 and 168.08 ppm) was recorded with pit size P1 and filling mixture M4, respectively, the interaction of pit size and the filling mixture was significant for leaf iron content and the highest leaf iron content was recorded in response to P1M4 (179.00 ppm) followed by P1M1 (172.00 ppm). The results are in agreement with the findings of Mauki and Kilonzo (2022) who proposed larger pit size especially in dryland regions for the survival of various plant species.

A larger pit size offers a more root growth has and enhance opportunities to access a broader spectrum of nutrients in the soil. The extensive root network, nurtured by a larger pit, increases the capacity of plant to absorb nutrients, potentially leading to higher leaf nutrient content. This is particularly advantageous when aiming for a rich nutrient profile in plant leaves. Furthermore, larger pits can store more moisture, ensuring that the plant has consistent access to water. Adequate moisture availability is pivotal for efficient nutrient uptake through the roots. FYM is a reservoir of vital nutrients, such as nitrogen, phosphorus, potassium and micronutrients. When integrated into the soil, it significantly enriches the nutrient pool available to plants (Kaurch *et al.*, 2005). As plants draw these essential elements through their roots, the enhanced nutrient availability can result in elevated nutrient content within the leaves. The influence of FYM extends to improved nutrient retention and enhanced soil structure. By promoting favorable conditions for nutrient storage and release through enhanced soil structure and microbial activity, FYM facilitates efficient nutrient uptake by plant roots (Acharya *et al.*, 1988). This, in turn, results in greater nutrient content in plant leaves. The influence of FYM also extends to the enhancement of photosynthesis. Improved nutrient availability, soil structure and moisture retention collectively bolster the photosynthetic capacity of plants (Bhriguvanshi *et al.*, 1988). Consequently it leads to increased nutrient assimilation and storage in the leaves, resulting in higher leaf nutrient content.

Conclusion

The results we obtained suggest that the Barhee cultivar tissue-cultured plants can perform better when cultivated in pits measuring 1 m^3 and filled with a mixture comprising 0.5 parts of field soil, 0.5 parts of clay and 2.0 parts of FYM. This study supports the idea that optimizing pit size and the composition of the filling mixture can have a beneficial impact on the establishment of date palm trees.

Acknowledgments

We are grateful to the Govt. of Rajasthan for providing the tissue culture planting material and ICAR-CIAH for the necessary facilities to conduct research.

References

Abdel-Hameed, M.A. and Ragab, M.A. 2004. Response of Sewy date palm to application of some organic fertilizers. Abstract of the Second Inter. Conf. on Date Palm. Fac. Agric., El-Arish Suez Canal Univ., Egypt.

Acharya, C.L., Bishnoi, S.K. and Yaduvanshi, H.S. 1988. Effect of long-term application of fertilizers, organic and inorganic amendments under continuous cropping on soil physical

and chemical properties of Alfisol. *Indian Journal of Agricultural Science*, 58:509-516.

Allan, R. 1998. A report on pit size treatments and how these impact on tree growth and survival. In: ICFR Bulletin Series No. 04/98. Institute for Commercial Forestry Research, Pietermaritzburg. ICARDA Annual Report, 2015. Towards dynamic drylands.

Amanullah, M.M., Rashid, A., Aziz, A., Hussain, N. and Islam, Z. 2013. Effect of various levels of N in combination with FYM on the growth and establishment of date palm (Dhakki) cultivar. In *Series B: Biological Sciences*, p. 65.

Bhansali, R.R. 2009. Date palm cultivation in the changing scenario of Indian arid zones: challenges and prospects. Desert plants: biology and biotechnology, 31:423-59.

Bhriguavanshi, S.R.1988. Long-term effect of high doses of farm yard manure on soil properties and crop yield. *Journal of the Indian Society of Soil Science*, 36:787-790.

Black, C.A. 1965. Methods of Soil Analysis. Part 2, Chemical and Microbiological properties. Agron. Mono. No.9. (American Society of Agronomy, Madison, WI, USA).

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analyses of soils. *Agron. J.*54:464-465.

Diab, Y.M. 2006. Effect of some cultural practices on yield and fruit quality of *Phoenix dactylifera* L. cv. Sewy under New Valley conditions. M.Sc. Thesis, Fac. Agric. Assiut Univ., Egypt.

Ghafoor, A. and Gopang, A.D.1988. Date palm culture in Pakistan. *Progressive Farming*, 8(1):8-13.

Gomez, K.A. and Gomez, A.A.1984. Statistical procedures for agricultural research, 2nd Edn., John Wiley and Sons, Singapore, p.98.

Jackson, M.L.1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Jackson, M.L.1979. Soil Chemical Analysis-Advanced Course. Second Edition, University of Wisconsin, Madison, USA.

Jo, H.K., Park, H.M. 2017. Effects of pit plantings on tree growth in semi-arid environments. *For. Sci. Technol.*, 13(2):66–70.

Johnson, A.I., 1963. A field method for measurement of infiltration. Geological Survey, Federal Center, Denver Co, p, 27.

Johnson, D.V., Al-Khayri, J.M. and Jain S.M. 2013. Seedling date palms (*Phoenix dactylifera* L.) as genetic resources. *Emirates Journal of Food and Agriculture*, 25(11):809-830.

Kaurch, K., Kapoor, K. and Gupta A. 2005. Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. *J. Plant Nutr. Soil Sci.*, 168:117-122.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Proceedings of Soil Science Society of America*, 42:421 - 428.

Mansour, A.E.M., Ahmed, F.F. and Ahmed, F.F. 2004. Effect of bio- and organic sources of N as a partial substitute for mineral fertilizer on fruiting of Sewy date palms. The Second International Conference on Date Palm, Fac. Agric., ElArish, Suez Canal Univ.

Mauki, D. and Kilonzo, M. 2022. Planting pit size determines successful tree seedling establishment in arid and semi-arid regions of Tanzania. *Environmental and Sustainability Indicators*, 15:100197.

Mohamed, G.A. and Gobara, A.A. 2004. Response of Sewy date palms grown under New Valley conditions to organic, bio and mineral fertilization. Minia *J. of Agric. Res. & Develop.*, 24(3):397-414.

Ndegwa, G., Iiyama, M., Anhuf, D., Nehren, U. and Schlüter, S. 2017. Tree establishment and management on farms in the drylands: evaluation of different systems adopted by small-scale farmers in Mutomo District, Kenya. *Agrofor. Syst.*, 91(6):1043-1055.

Olsen, S.R., Cole, C.S., Wantable, F.S. and Dean, C.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate USDA, Washington, D.C. Circular. 18: 939.

Subbaiah, B.V. and Asija, G.L.1956. A rapid procedure for the estimation of available nitrogen in soil. *Curr. Sci.*, 25:259-60.

Tang, Y., Zhang, H., Schroder, J.L., Payton, M.E. and Zhou, D. 2007. Animal manure reduces aluminum toxicity in an acid soil. *Soil Sci. Soc. Am. J.*, 71(6):1699-1707.

Withan, F.H., Blaydes, D.F. and Devlin, R.M. 1971. Experiments in Plant Physiology. pp 55–58. Van Nostrand Reinhold Co., New York.

Walkley, A., and Black, I.A. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, 37(1):29-38.

Yang, C., Yang, L., Yang, Y. and Ouyang, Z. 2004. Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. *Agricultural Water Management*, 70(1):67-81.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Standardization of juice concentration for preparation of phalsa nectar and changes during storage

Mukesh Kumar*, Amarjeet Nibhoria, Pooja** and Manoj Buswal

CCS Haryana Agricultural University, Regional Research Station, Bawal-123501 (Rewari), Haryana, India
**CCS Haryana Agricultural University, College of Agriculture, Bawal-123501 (Rewari), Haryana, India

ARTICLE INFO

Key Words: Titratable acidity, ascorbic acid, nectar, phalsa, storage, TSS.

doi: 10.48165/ijah.2021.3.1.5

ABSTRACT

The experiment on preparation of phalsa nectar was conducted at Regional Research Station, Bawal. The ripe fruit of phalsa were harvested, sorted and blended with 0.5 litre water per kilogram fruit. It was heated to 70°C and filtered to extract juice. The required amount of juice, sugar and citric acid were added to fix the concentration of juice (20.0, 22.5 and 25.0 %), TSS (15°B) and titratable acidity (0.3%). After preparation of nectar, it was pasteurized and stored for 90 days to study the changes during storage. The TSS of the nectar increased up to 30 days of storage later on it decreased significantly. Titratable acidity and ascorbic acid content in nectar decreased with increase in storage period. However, sensory rating increased up to 60 days of storage and thereafter it was at par with 60 days of storage. Ascorbic acid content increased with increase in juice concentrations in nectar. Ascorbic acid content in all the concentrations of juice decreased with the increase in storage period. However, sensory rating decreased at 25% juice concentrations in the nectar. Overall, the phalsa nectar was rated as "moderately liked" or better by consumers and remained acceptable for up to 90 days of storage.

Introduction

Phalsa (*Grewia subinaequalis* DC.) is an important fruit crop, originated in India and Southern Asia, belongs to the family Tiliaceae. It is one of the few hardy tropical fruit crops because its cultivation needs least inputs and care; and yields delicious fruit of edible quality. Phalsa is a subtropical, drought tolerant and hardy fruit plant that can be grown in a wide range of climatic conditions throughout the country except for high altitude regions. It is comparatively less attacked by diseases and pests. In North India, the plants are deciduous and normally shed leaves during winter season; however, in warm regions it remains evergreen. Good amount of sunlight is required for fruit ripening and development of appropriate colour, which ultimately leads to the good eating quality of phalsa. Optimum growth is observed at a temperature ranging from 3°C to 45°C and it can tolerate light frost also.

*Corresponding author.
E-mail address: sabharwalmk@hau.ac.in (Mukesh Kumar)
Received 20.03.2024; Accepted 22.05.2024

The fruits are delicious, sour to sweet, with a mild pleasant flavor and ripe fruit contain 50-60 per cent juice, 10-11 per cent sugars and 2.0-2.5 per cent acids and good source of vitamin A and C. Fruits are low in calories and fat, while high in vitamins, minerals and fibers. This is also a fair source of phosphorus 24.2 mg/100 g (Yadav, 1999) and iron 140.8 mg/100 g fresh fruit weight (Khan *et al.*, 2006). Ripened fruit become soft and tender. Fruits are consumed during summer for cooling effect to stomach. Due to its perishable nature the phalsa fruit can be stored hardly 24 to 48 hr. Therefore, these fruits are to be consumed fresh or processed in soft drinks *viz.*, squash, juice, syrup, *etc.*, but the recopies for preparation of phalsa products is not yet standardized. The availability of fruit is also for a limited period if processed their taste can be enjoyed for a longer period by the consumers. Processing of fruit also reduce/ minimize the post-harvest losses as well as reduces fruit glut in the market, growers can also get better returns and consumer get value added products (Kumar *et al.*, 2015).

Materials and Methods

The experiment was conducted in the Horticulture Laboratory, Regional Research Station, Bawal. The ripened fruit, attained deep purple colour were procured from experimental orchard CCS HAU, Regional Research Station, Bawal. Healthy and equally ripened phalsa fruit were crushed to prepare juice by adding 0.5 litre water per kilogram of ripe fruit. Fruits were blended and heated up to 70°C, thereafter stained for juice. Phalsa nectar was prepared with different concentrations of juice *viz.*, 20.0, 22.5 and 25.0 per cent. The total soluble solids (TSS) and titratable acidity were fixed to 15° Brix and 0.3 percent, respectively and adjusted with the help of sugar and citric acid.

The nectar was filled in glass bottle of 300 ml capacity and these were pasteurized after botting with air tight seal. The nectar bottles were stored for three months at ambient temperature and analyzed for changes in TSS, titratable acidity, ascorbic acids content and sensory rating at monthly intervals. TSS was measured with the help of ERMA made hand refractometer (0- 32°B). Titratable acidity was estimated by using phenolphthalein indicator and titrated against N/10 NaOH (A.O.A.C., 2000). Ascorbic acid content was also estimated using the method explain in A.O.A.C. (2000). Sensory rating was estimated by jury of 10 members on nine hedonic scale bases.

The marking was done on the basis of colour, appearance, aroma, texture, taste and overall acceptability. The average of the sensory score on 9 hedonic scale was considered as, liked extremely (9), liked very much (8), liked moderately (7), liked slightly (6), neither liked nor disliked (5), disliked slightly (4), disliked moderately (3), Disliked very much (2) and disliked extremely (1). The sensory evaluation was judged by 10 jury members of different age group.

Statistical analysis: The statistical method described by Panse and Sukhatme (1985) was used for analyses of data and it was calculated with the help of '*Opstat*' software available on website (*www.hau.ac.in*) CCS HAU, Hisar. The comparative performance of the data was judged with the help of critical difference at 5 per cent level of significance (Fisher, 1958) in a completely randomized block design.

Results and Discussion

Total soluble solids (TSS): The nectar prepared with 20.0, 22.5 and 25.0 % concentration of juice, 15°B TSS and 0.3 % titratable acidity. It was stored at ambient temperature for three months (90 days). The changes in physico-chemical and sensory rating were analyzed at monthly interval. Initially the TSS was fixed to 15°B and it increased significantly during storage upto 30 days of storage thereafter it started declining but remained higher than initial value. Increase in the TSS during the storage of guava RTS was also observed by Nagpal (2002). Initial increase in TSS may be due to breakdown of left-over complex sugars or polysaccharides (starch, cellulose and pectic substances) into soluble/ simple sugars (Kumar *et al.*, 2009). However, it started declining after 30 days of storage may be due to losses of sugars during browning process. TSS of nectar in different concentrations of juice was not affected significantly. The interaction of juice concentration with storage period was also observed non-significant.

Titratable acidity: The titratable acidity during the storage of the nectar was decreased significantly as compared to initial level. Titratable acidity after 60 days after storage was observed at par with 30 and 90 days after storage, however it decreased significantly at 90 days of storage as compared to 30 days after storage. The concentration of titratable acidity in nectar decreased during storage may be due to utilization of acids during chemical reactions (Millard reaction) taking place between organic acids and sugars to form brown pigments (Kannan and Thirumaran, 2002; Kumar *et al.*, 2009). It may also be due the chemical interaction with organic constituents of the fruit and reversal glycolytic pathway. The value of titratable acidity was not differed significantly in different concentrations of juice. The titratable acidity in interaction of storage period with juice concentration was also observed non-significant.

Ascorbic acid: Ascorbic acid content in the nectar of phalsa increased with increase in the concentration of juice

Increase in ascorbic acid content in higher concentration of juice might be due to higher amount of juice used for preparation of nectar and the juice was the source of the ascorbic acid in the nectar. Decrease in ascorbic acid content during storage might be due to thermal oxidation during processing, oxidation into dehydro-ascorbic acid or furfural or hydroxyl methyl furfural at room temperature (Aruna *et al.*, 1997). It decreased with increase in storage duration from 0 to 90 days of the storage. Decrease in ascorbic acid content and titratable acidity were also observed during storage of phalsa RTS (Kumar *et al.*, 2020). Ascorbic acid content was also increased in all the storage period with increase in the amount of juice used.

Sensory evaluation: Initial sensory rating of the phalsa nectar was at par with the rating at 30 and 90 days after storage, but it increased to maximum level at 60 days after storage but remained above moderately liked range. It was acceptable upto 90 days after storage; however, it was slightly more acceptable at 60 days after storage, which was at par with acceptability at 30 and 90 days after storage. Sensory rating of the nectar decreased with increase in the concentration of the juice from 20.0 to 25.0 %, however the sensory rating of nectar having 22.5 % juice was at par with the nectar of 20 % juice concentration.

On the overall basis, the nectar prepared with 22.5 % juice content was acceptable, however nectar prepared with 25 % concentration of juice was slightly less acceptable as compared to lower concentration juice. Nectar prepared from different concentrations of juice and observed for change in sensory rating during storage upto 90 days and found above liked moderately (>7.0) sensory rating because the jury were not habitual to consume (taste of tongue) phalsa nectar and it has less flavour as a genetic character of the fruit. Jury members had never tested phalsa nectar earlier to this hedonic evaluation test.

Table 1. Effect of different juice concentrations on TSS (°B) during storage of phalsa nectar

Juice concentrations (%)	Days after storage				Mean
	0	30	60	90	
20.0	15.00	15.30	15.21	15.01	15.13
22.5	15.00	15.37	15.23	15.03	15.16
25.0	15.00	15.40	15.26	15.07	15.18
Mean	15.00	15.36	15.23	15.04	

CD (p=0.05)

Factors	Juice concentrations	Storage	Storage x Juice concentrations
CD (p=0.05)	NS	0.06	NS
SE(m)	0.02	0.02	0.04

Table 2. Effect of different juice concentrations on titratable acidity (%) during storage of phalsa nectar

Juice concentrations (%)	Days after storage				Mean
	0	30	60	90	
20.0	0.300	0.282	0.279	0.276	0.284
22.5	0.300	0.280	0.276	0.273	0.282
25.0	0.300	0.279	0.273	0.270	0.281
Mean	0.300	0.280	0.276	0.273	

CD (p=0.05)

Factors	Juice concentrations	Storage	Storage x Juice concentrations
CD (p=0.05)	NS	0.005	NS
SE(m)	0.001	0.002	0.003

Table 3. Effect of different juice concentrations on ascorbic acid content (mg/100 ml juice) during storage of phalsa nectar

Juice concentrations (%)	Days after storage				Mean
	0	30	60	90	
20.0	5.92	5.44	4.64	3.50	4.88
22.5	6.56	5.92	5.12	3.84	5.36
25.0	7.20	6.24	5.28	4.16	5.72
Mean	6.56	5.87	5.01	3.83	

CD (p=0.05)

Factors	Juice concentrations	Storage	Storage x Juice concentrations
CD (p=0.05)	0.05	0.06	0.11
SE(m)	0.02	0.02	0.04

Table 4. Effect of different juice concentrations on sensory rating (on nine hedonic scale basis) during storage of nectar

Juice concentrations (%)	Days after storage				Mean
	0	30	60	90	
20.0	7.2	7.3	7.5	7.3	7.3
22.5	7.0	7.2	7.4	7.2	7.2
25.0	6.9	7.0	7.1	7.0	7.0
Mean	7.0	7.2	7.3	7.2	
CD (p=0.05)					

Factors	Juice concentrations	Storage	Storage x Juice concentrations
CD (p=0.05)	0.1	0.1	NS
SE(m)	0.03	0.03	0.06

Conclusion

Phalsa is highly perishable fruit, which can be stored only upto 48 hours mainly because of ambient temperature that peaks up to 40°C at the time of fruit harvest during the month of June. The post-harvest interventions, attempted to address this constraint through the present study, revealed preference for the nectar prepared by using phalsa juice. Thus, the study provides scientific leads regarding value addition that can reduce the post-harvest losses and can promise to increase the income of the farmers.

Acknowledgements

Authors are highly thankful to the University authority, CCS HAU, Hisar and AICRP of AZF, Bikaner for providing support and financial assistance during experiment and maintenance of phalsa germplasm.

References

A.O.A.C. 2000. Official methods of analytical chemist, International, 17 Edn. Washington D.C.

Aruna, K., Vimala, V., Giridher, N. and Rao, D.G. 1997. Studies on preparation and storage of nectar prepared from papaya. *Beverage and Food World*, 24: 29-32.

Fisher, R.A. 1958. The Genetical Theory of Natural Selection, 2nd edn. Dover Publications, New York.

Kannan, S. and Thirumaran, S. 2002. Studies on the syruping and drying method of ber (*Ziziphus mauritiana* Lamk.) candy. *Beverage and Food World*, 29: 39-40.

Khan, A.S., Hussain, A. and Khan, F. 2006. Nutritional importance of micronutrients in some edible wild and unconventional fruits. *Journal of the Chemical Society of Pakistan*, 28: 576–582.

Kumar, M., Godara, R.K., Singh, D. and Pathak, D.V. 2015. Effect of different preservatives on the storage of ber pulp. *International Journal of Farm Science*, 5(4): 222-228.

Kumar M., Singh D., Godara R.K., Singh S., Sandooja J.K. and Mehla C.P. 2009. Studies on the suitability of dried *ber* fruits for preparation of RTS beverage. *Haryana Journal of Horticultural Sciences*, 38 (3&4): 216-219.

Kumar, M., Yadav, B.S. and Yadav, V.P.S. 2020. Effect of pulp concentration on physicochemical and organoleptic changes in RTS and juice during storage. *Indian Research Journal of Extension Education*, 20 (1): 48-50.

Nagpal, G. 2002. Evaluation of guava hybrids for ready to serve beverages. M.Sc. thesis submitted to CCS HAU, Hisar

Panse, V.G. and Sukhatme, P.V. 1985. Statistical methods for agricultural workers. 4th ed. ICAR, New Delhi.

Yadav, A.K. 1999. Phalsa: A potential new small fruit for Georgia. In: Janick, J (Ed.), Perspectives on New Crops and New uses. ASHS: 348-352.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Investigating the biochemical makeup of various bael (*Aegle marmelos* Correa.) cultivars under semi-arid condition of Madhya Pradesh

Suraj Kumar[1], Rahul Dongre[2] and Bharti Choudhary[3]

[1]M.Sc. (Fruit Science) Scholar Department of Horticulture, JNKVV, Jabalpur (MP)
[2]Scientist (Horticulture) AICRP on Arid Zone Fruits, Department of Horticulture, JNKVV, Jabalpur (MP)
[3]Technical Officer (Horticulture) AICRP on Arid Zone Fruits, Department of Horticulture, JNKVV, Jabalpur (MP)

ARTICLE INFO

Key Words: Bael, *Aegle marmelos*, Cultivar, Biochemical and Semi arid.

doi: 10.48165/ijah.2021.3.1.6

ABSTRACT

The present study was carried out to investigate the biochemical properties of various Bael (*Aegle marmelos* Correa.) cultivars under Semi Arid Condition of Madhya Pradesh during 2021-22. The experiment has seven cultivars of the bael *i.e.* Goma Yashi, NB-5, NB-7, NB-9, NB-17, CISH-1 and CISH-2 to assess the biochemical properties of fruits and to indentify the superior. The study analyzed with Randomized Block Design. The results revealed that the different varieties of bael exhibited considerable variation for biochemical attributes. Significantly highest total soluble solid (39.22°Brix) and lowest acidity (0.30%) was recorded in the cultivar Goma Yashi. Significantly higher reducing sugar (4.95%) and total sugar (20.03%) was recorded in the cultivar NB-9 while non-reducing sugar (15.66%) was relatively higher in the cultivar CISH-1.

Introduction

Bael (*Aegle marmelos* Correa) is one of the important under-utilized medicinal and indigenous fruit crop of India. It belongs to family Rutaceae. Locally, it is known by different names in different languages *viz.*, Bael fruit, Indian Bael, holy fruit, golden apple, Elephant apple, Bengal quince, Indian quince, stone apple in English; Baelputri, Bela, Siri-phal, Kooralam in Hindi. Each and every part of this tree *i.e.* fruit, seed, trunk, bark, leaf, and root are important ingredients of several Ayurvedic prescriptions (Jauhari and Singh, 1971). Bael has been used in traditional medicine for its numerous health benefits. The fruit, leaves, roots, and bark of the tree are all utilized for medicinal purposes. Bael is known for its digestive properties and is used to treat various digestive disorders such as diarrhea, dysentery, and indigestion (Dongre and Choudhary, 2023). It is also believed to have antimicrobial, antifungal, and anti-inflammatory properties. Bael fruit is also used in the preparation of jams, jellies, chutneys, and

*Corresponding author.
E-mail address: dongre.jnau@gmail.com (R.A. Kaushi)
Received 10.12.2023; Accepted 12.02.2024

desserts. The fresh fruit is not consumed freely because of eating difficulties due to its hard shell, mucilaginous texture, numerous seeds, and fibers. Seeds are flattened oblong, about 1 cm long, bearing woolly hairs and each enclosed in a sac of adhesive, transparent mucilage.

The percentage content of some of the minerals *viz.* phosphorus, potassium, calcium, magnesium and iron is 0.137, 0.746, 0.188, 0.127 and 0.007%, respectively. It is also rich in riboflavin, vitamin A, carbohydrates, *etc.* (Gopalan *et al.*, 1985). Various chemical constituents viz, alkaloids, coumarin and steroids have been isolated and identified from different parts of the bael tree. Marmelocin is probably the therapeutically active factor of bael fruit and is known as the panaceae of the stomach ailments. The aroma component of bael fruits was studied by Totikoma *et al.* (1982). As an estimate, about 0.084 lakh ha area under plantation of improved variety of bael in country with about 0.81 lakh tonnes of production. Madhya Pradesh, kymore plateau and Satpura hills region have a wide distribution of bael cultivars, particularly in dry, undulating, forest, and tribal areas, providing enormous scope and potential for cultivation of this fruit tree. The total area and production of Bael in Madhya Pradesh are 250 ha and 0.02 lakh tonnes respectively (Anonymous, 2021). Therefore, the prime objective of present investigation was to find out a cultivar of better biochemical attributes which is qualitatively superior to other cultivars growing under semi arid condition of Madhya Pradesh.

Materials and Methods

The present investigation was carried out during 2021-22 at Department of Horticulture, College of Agriculture, JNKVV, Jabalpur (23.10° N latitude, 79.58° E longitude and 411.73 meters above sea level), located in the Kymore plateau agro-climatic area of Madhya Pradesh. This region has a semi-arid and subtropical climate. Summers are hot, while winters are moderately cool. The annual rainfall ranges from 1100 to 1400 mm, with an average of 1191 mm from June to September. About 99% rainfall is received during June to September and the rest during October and January. Winter occurs during November- February with occasional frost. The soil of the experimental site has clay loam texture with average fertility. It is tenaciously sticky when wet and hard when dry. Seven bael cultivar selected *viz.*, Goma Yashi, NB-5, NB-7, NB-9, NB-17, CISH-1 and CISH-2 were planted at spacing of 8 x 8 m. Properly ripened, healthy and uniform size fruits were harvested and selected for the biochemical characterization. The flesh was carefully extracted for estimation of total sugar solids (TSS) with the help of digital refractometer. Acidity was determined by titrating the juice against N/10 NaOH and was expressed as per cent citric acid. Total sugars were analyzed as per method given by Lane and Eynon (1943) and the non- reducing sugar content was computed by subtracting reducing sugars from total sugars and value was expressed in percentage. The data was statistically analysed under the method of Randomized Block Design by OPSTAT software.

Result and Discussion

The biochemical characteristics of fruit play a crucial role for tree improvement purpose as well as processing industries. Quality of any fruit can be assessed by the important biochemical traits. The data on biochemical characteristics of ripened bael fruits are presented in Table-1 and Figures (1-5) with respect to TSS, acidity %, total sugar (%), reducing sugar (%) and non reducing sugar (%). The mean performance of the genotypes revealed a wide range of variability for all traits under study.

Total soluble solid was significantly high in Goma Yashi (39.22°Brix) followed by NB-5 (37.88°Brix) and NB-9 (37.60°Brix) at ripe stage. However, the lowest 31.77°Brix T.S.S. was noted in cultivar CISH-2. Significantly lowest acidity (0.03%) was noted in cultivar Goma Yashi followed by NB-5 (0.31%) and NB–9 (0.133%). However, the highest acidity (0.41%) was recorded in the cultivar CISH-2. Total sugar was found maximum in NB-9 (20.03%) followed by Goma Yashi (19.37%) and NB-5 (18.41%), whereas the same was recorded the minimum in NB-7 (17.09%). Reducing sugar was estimated the highest in NB-9 (4.95%) followed by NB-5 (4.86%) and NB-17 (4.65%) whereas the lowest in NB-7 (3.46%). The significantly maximum non-reducing sugar (15.66%) was recorded in the cultivar CISH-1 followed by NB-9 (15.08%) and Goma Yashi (15.06%). While, the minimum non-reducing sugar (12.63%) was noted in cultivar NB-17. Variations in the biochemical parameters of the cultivar might be due to the root distribution pattern of individual cultivar, adaptability to varied agro-climatic conditions, availability of nutrient to individual cultivar and genetic makeup of the cultivar. The findings are in agreement with findings of Ram and Singh (2003), Verma and Gehlot (2007), Mitra *et al.* (2010), Kuldeep *et al.* (2023) and Pale *et al.* (2019.

Table 1. Biochemical composition of fruits of bael cultivars under semi-arid ccondition of Madhya Pradesh.

Cultivars	TSS (°Brix)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)
Goma Yashi	39.22	0.30	19.37	4.31	15.06
NB-5	37.88	0.31	18.41	4.86	13.55
NB-7	32.22	0.34	17.09	3.46	13.63
NB-9	37.60	0.32	20.03	4.95	15.08
NB-17	36.44	0.33	17.28	4.65	12.63
CISH-1	32.77	0.32	19.26	3.60	15.66
CISH-2	31.77	0.41	18.28	3.57	14.71
SEm±	0.363	0.003	0.271	0.016	0.276
CD at 5%	1.00	0.009	0.834	0.048	0.849

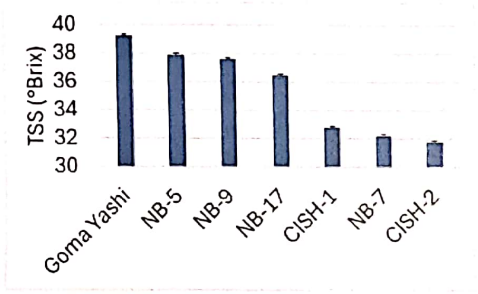

Fig. 1: T.S.S. (°Brix) of bael cultivars under semi-arid condition of MP

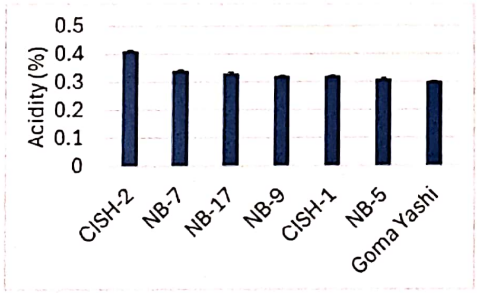

Fig. 2: Acidity (%) of bael cultivars under semi-arid condition of Madhya Pradesh

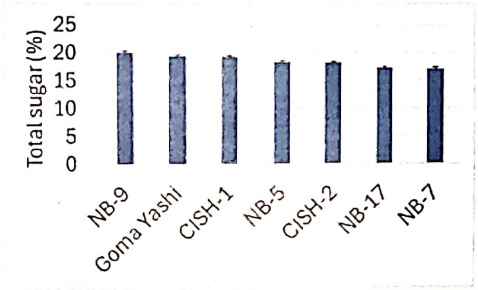

Fig. 3: Total sugar (%) of bael cultivars under semi-arid condition of Madhya Pradesh

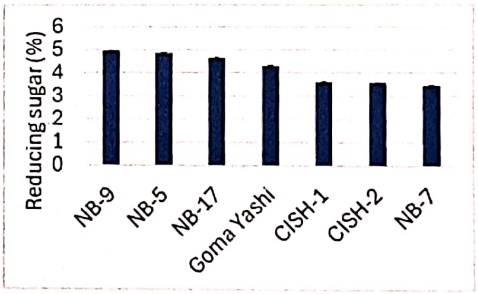

Fig. 4: Reducing sugar (%) of bael cultivars under semi-arid condition of Madhya Pradesh

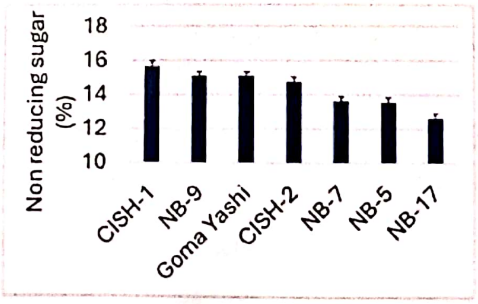

Fig. 5: Non reducing sugar (%) of bael cultivars under semi-arid condition of Madhya Pradesh

Conclusions

On the basis of findings of the present study, it is revealed that the significant variation exist within the genotypes based on biochemical characters. The best genotype having the highest T.S.S. (39.22 %) and lowest acidity (0.30%) is Goma Yashi. The maximum reducing sugar (4.95%) and total sugar (20.03%) was recorded in the cultivar NB-9

while non-reducing sugar (15.66%) was recorded in the cultivar CISH-1. On the basis of biochemical characteristics Goma Yashi cultivar may be recommended for semi-arid condition of Madhya Pradesh.

Acknowledgements

The authors are grateful and thankful to ICAR-CIAH, Bikaner for financial assistance.

References

Anonymous. 2021. Ministry of agriculture database 2021-22. *http/agricoop.nic.in.*

Dongre, R. and Choudhary, B. 2023. Study on the physico-chemical characteristics of bael germplasms collected from various location of Madhya Pradesh, India. *International Journal of Theoretical & Applied Sciences*, 15(2):11-15.

Gopalan, C.B.M., Ramashastri, B.V. and Balasubramanium, S.C. 1985. Nutritive value of Indian foods, ICMR, Hyderabad, Pp. 47.

Jauhari, O.S. and Singh, R.D. 1971. Bael-a valuable fruit. *Indian Horti*culture, 16:9-10.

Kuldeep, D.K., Binod, K., Singh, Kuldeep Gadpal, Dongre R., Kalatippi, A.S. and Bhooriya, M.S. 2019. Biochemical studies in different cultivars of guava under eastern Uttar Pradesh condition. *International Journal of Current Microbiology and Applied Science*, 8(2):16-19.

Lane, J.H. and Eynon, L. 1943. Determination of reducing sugar by Fehling's solution with methylene blue as indicator. *Journal of the Society of Chemical Industry*, 42:32

Mitra, S.K., Maity, C.S., Mani, D. and Ghosh, B. 2010. Genetic resources of bael (*Aegle marmelos* Correa.)-a potential underutilized fruit. *Acta Horticulturae*, 864:49-51.

Pale, J.P.L., Chetri, S., Suresh, C.P., Singh, Y.S., Chaurasiya, A. and Barman, A. 2019. Morphological and Bio-chemical Characterization of Bael (*Aegle marmelos* Correa.) in West Garo Hills, Meghalaya, India. *International Journal of Current Microbiology Applied Science*, 8(10):2414-2420.

Parihar, N. and Pandey, C.S. 2019. Evaluation of bael (*Aegle marmelos* Correa.) Gene pool of kymore plateau and satpura hill region. *International Journal of Genetics*, 11(3):571-574.

Ram, D. and Singh, I.S. 2003. Physico-chemical studies on bael (*Aegle marmelos* Correa.) fruits. *Progressive Horticulture*, 35(2):199-201.

Totikoma, Y., Shimono, Y., Kobayashi, A. and Yamanishi, T. 1982. Aroma component of bael fruits (*Aegle marmelos* Correa). *Agril. Biological Chemistry*, 46(7):1873- 1877.

Verma S. and Gehlot, R. 2007. Studies on development and evaluation of ready-to-serve (RTS) drink from bael (*Aegle marmelos* Correa.). *Research on Crops*, 8(3):745-748.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Feasibility of banana (*Musa paradisiaca* L.) cultivation under Banswara district conditions of Rajasthan

R.A. Kaushik[1], A.K. Suthar[1], V. Singh[1] and D.K. Sarolia[2]

[1]Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur
[2]ICAR-Central Institute for Arid Horticulture, Bikaner

ARTICLE INFO

Key Words: Banana, Feasibility, Phenology.

doi: 10.48165/ijah.2021.3.1.7

ABSTRACT

An experiment was conducted at seven locations denoted as AF_1, AnF_1, AnF_2, LF_1, MF_1, SF_1 and IF_1 respectively to study the feasibility of banana cultivation under Banswara district conditions of Rajasthan which are very much milder than that in the desert regions in further north and north-west Rajasthan and also commensurate with the required environmental conditions for banana. For this, phenology of banana cv. Grand Naine was studied by observing the growth pattern. At harvest the vegetative parameters such as range of leaf area varied from 1.21 m^2 (IF_1) to 5.52 m^2 (AnF_1) per plant, number of functional leaves varied from 5.03 (IF_1) to 10.03 (AnF_1), pseudostem height from 131.18 cm (IF_1) to 203.37 cm (AnF_1), pseudostem girth from 39.65 cm (IF_1) to 59.38 cm (AnF_1). Likewise, yield and yield attributing characters were also observed such as peduncle length from 33.96 cm (IF_1) to 45.01 cm (AnF_1), bunch weight from 8.42 kg (IF_1) to 17.06 kg (AnF_1), number of hands per bunch from 6.56 (IF_1) to 8.76 (AnF_1), number of fruits per hand from 10.63 (IF_1) to 14.04 (AF_1), fruit length from 12.68 cm (IF_1) to 16.11 cm (AF_1), fruit diameter from 2.37 cm (IF_1) to 3.35 cm (AnF_1), fruit weight from 90.75 g (IF_1) to 118.30 g (AF_1) and estimated yield per hectare from 25.98 t (IF_1) to 52.65 t (AnF_1). The study of crop duration had shown values which varied from 292.74 (AnF_1) to 307.03 days (IF_1) for shooting, fruits attained the physiological maturity after flower emergence from 105.84 days (AnF_2) to 114.34 days (IF_1) and plants completed their life cycle in 398.63 days (AnF_2) to 421.37 days (IF_1). The parameters pertaining to quality of fruits were also studied such as TSS (°Brix), titrable acidity (%) and organoleptic rating which ranged from 11.57 (IF_1) to 14.48 (AnF_2), 0.126 (AnF_1) to 0.196 (SF_1) and 6.95 (IF_1) to 7.64 (AnF_2), respectively. The results of the experiment proved that Banswara conditions are ideally suited for banana cultivation and the yield and quality of the fruits was at par with those of other locations in the country where banana cultivation is commercially practiced.

*Corresponding author.
E-mail address: kaushikra@yahoo.co.in (R.A. Kaushik)
Received 10.12.2023; Accepted 12.02.2024

Introduction

Banana (*Musa spp*.) is the second most important fruit crop in India after mango. This crop year round availability, affordability, varietal range, tastes and nutritive makes it the favorite fruit among all classes of people. Banana are grown in about 120 countries. Total annual worldwide production of banana is estimated at 135 million tonnes. As of 2022, bananas production in India was 34.5 million tonnes that accounts for 25.51% of the world's bananas production. Other leading producers are Brazil, Eucador, China, Phillipines, Indonesia, Costa Rica, Mexico, Thailand and Colombia.

In India, banana ranks first in production and third in area among fruit crops. It accounts for 13% of the total area and 33% of the production of fruits. The major banana producing states are Andhra Pradesh, Maharashtra, Karnataka, Gujarat and Assam. Overall, while banana cultivation in India is robust, there is room for non-traditional area cultivation feasibility to meet both domestic and international demands (Priyanka *et al.,* 2018).

Diversification of horticultural crops is the need of hour to suffice the demand of consumers for their nutritional or feeding requirements and to get along with the time new places for cultivation of such crops have to be explored. The agroclimatic conditions of Banswara district are in compliance with that of banana for cultivation and so far no feasibility studies have been carried out at Banswara. Thus, keeping the above points in mind, the present investigation was planned to study the feasibility of banana cultivation under Banswara district conditions of Rajasthan.

Materials and Methods

A field experiment was conducted during the year 2011-12 under Banswara district conditions of Rajasthan. In the experiment 105 plants (15 plants from each site randomly) of cultivar Grand Naine banana, planted at seven different sites at farmers' field *viz*. Arjun, Anil, Anirudh, Laxmikant, Manohar Lal, Shamim and Ishwar denoted as AF_1, AnF_1, AnF_2, LF_1, MF_1, SF_1 and IF_1 respectively, under conditions having subtle difference in climatic and soil conditions, were selected. Several variations were observed in the plants even when a single cultivar was planted on large scale which is mainly due to soil properties leading to differences in root characteristics followed by altered rate of nutrient uptake and prevalence of different environmental conditions. These studies were done in order to study the extent of feasibility of banana cultivation under agro climatic conditions of Banswara district of Rajasthan.

In this study we measured vegetative parameters, yield and yield attributing characters, data related to crop duration and quality parameters. Vegetative parameters included leaf area (m^2), number of functional leaves, psuedostem height (cm) and psuedostem girth (cm). The yield and yield attributing characters included peduncle length, bunch weight (kg), number of hands per bunch, number of fruits per hand, fruit length (cm), fruit diameter (cm), fruit weight (g). Crop duration included days to shooting and time taken for shooting to harvesting. The quality parameters included TSS (°Brix), titrable acidity (%) and organoleptic rating. The experiment was subjected to one way analysis of variance.

Results and Discussion

Vegetative parameters

Average leaf area of banana at the time of harvest varied from 1.21 m^2 (IF_1) to 5.52 m^2 (AnF_1). Locations AnF_1 and AnF_2 were at par with each other and were highly significant over the site IF_1 (1.21 m^2). Locations, which were non-significant in growth pattern of leaf area (AnF_1, 5.52m^2 and AnF_2, 5.32 m^2) had shown a significant difference with other locations. There was no significant difference between number of functional leaves at location AnF_1 (10.03) and AnF_2 (9.48). However both gave significant results in comparison to all other sites. The minimum numbers of functional leaves born by the plants of site IF_1 (5.03), which were 99.40 % less in comparison to number of leaves born by the plants of site AnF_1. Pseudostem height increased with the time and attained a maximum value of 203.37 cm (AnF_1) at harvest, which was significantly higher in comparison to the plants of site IF_1 (131.18 cm) thus at the time of harvesting the plants at site AnF_1 attained 55.13 per cent more height in comparison to the plants at site IF_1. pseudostem girth increased gradually as the crop matures and attained maximum value of 59.38 cm at the location AnF_1 at the time of harvest, which was at par with the treatment AF_1 (59.01 cm) and AnF_2 (58.95 cm), and which recorded significantly higher growth in comparison to other locations. Among all the locations, the site SF_1 had shown the minimum mean pseudostem girth (38.87 cm). The results were in confirmation with the work of Chahil *et al.* (2010), Hidoto (2009) and Rajamanickam and Rajmohan (2010).

Yield and yield attributing characters

The maximum peduncle length (45.01 cm) was observed at the site AnF_1, whereas, minimum value (33.96 cm) was found at the location IF_1. The site AnF_1 had shown at par results with the site AF_1 and AnF_2. Bunch weight of banana varied from 8.42 kg (minimum) to 17.06 kg (maximum), which were from the sites IF_1 and AnF_1, respectively. The values of bunch weight (kg) at sites AF_1 (16.67), AnF_1 (17.06) and AnF_2 (16.89) had non significant difference among each other but found to have significant difference with the plants of location LF_1 (14.74), MF_1 (11.94), SF_1 (9.89) and IF_1 (8.42). The maximum number (8.76) of hands per bunch, were found at site AnF_1while the least (6.56) number of hands per bunch were observed at IF_1. The location AF_1 (8.08), AnF_1 (8.76), AnF_2 (8.70) and LF_1 (8.44) were at par with each other and were significantly higher in comparison to rest of the location viz. MF_1 (7.34), SF_1 (6.74) and IF_1 (6.56). The plants at the site AF_1 had shown the significantly higher values (14.04 fruits per hand) among all other locations and found to possess 32.07 % more fruits per hand in comparison to the plants of location IF_1. However the treatment AnF_1 (13.85) and AnF_2 (13.89) were at par with each other and had shown significant results in comparison to site MF_1 (12.31), SF_1 (11.64) and IF_1 (10.63). Fruit length ranged from 12.68 cm (minimum at IF_1) to 16.11 cm (maximum at AF_1). Thus, among all these values the fruits of the site AF_1 were longest in comparison to fruits of other sites and were at par with AnF_1 (15.89) and AnF_2 (15.85) location. These locations differed significantly in comparison to site MF_1 (14.86), SF_1 (14.46) and IF_1 (12.68). The location AnF_1 (3.35 cm) and AnF_2 (3.21 cm) were at par, further the site AnF_2 (3.21 cm) was at par with AF_1. The least value was shown by IF_1 (2.37 cm), which was significantly lower (41.35 % less) in comparison to AnF_1 location. A range of 91.75 g (minimum at IF_1) to 114.30 g (maximum at AF_1) in terms of fruit weight was observed. The fruits of location AF_1 (114.30 g), AnF_1 (112.58 g) and AnF_2 (111.38 g) were at par, while others possessed significantly lower fruit weight viz. IF_1 (91.75 g) and that was about 22.70 % less in comparison to AF_1 location. These results are in concurrence with the findings of Chahil *et al.* (2010), Patil *et al.* (2010) and Rajmanickam *et al.* (2008).

Crop duration

The location IF_1 took maximum (307) days from planting to shooting and the plants at site AnF_1 flowered in the least time period of 292 days after planting. Fruits were ready for harvesting after a period of about 105.84 days to 114 days. The minimum days were taken by the plants of the AnF_2 location which was at par with the plants of site AnF_1 and rest of the locations had shown significantly different time period for maturity. The plants completed their life cycle in minimum 398 days to a maximum value of 421 days shown by the plants at location AnF_2 and IF_1 respectively. The plants from the site IF_1 took about 5.7 per cent more time in comparison to the site AnF_2. These results are in confirmation with the findings of Krishnamoorthy and Kumar (2005), Nainwad *et al.* (2005), Rajamanickam and Rajmohan (2010).

Quality *parameters*

The significantly higher value of 14.48°Brix was observed at AnF_2. While AF_1 (12.87°Brix), AnF_1 (12.8°Brix), AnF_2 (14.48°Brix) and LF_1 (12.52°Brix) were at par with each other. On the other side MF_1 (11.78°Brix), SF_1 (11.86°Brix) and IF_1 (11.57°Brix) were at par with each other. The values of titrable acidity from AnF_1 (0.126 per cent) and AnF_2 (0.129 per cent) location were at par with each other. Likewise, LF_1 (0.175 per cent) and MF_1 (0.169 per cent)

Table 1. Vegetative and fruit characteristics of banana under Baswara conditions

Locations	Leaf area (m^2)	No. of functional leaves	Pseudostem height (cm)	Pseudostem girth (cm)	Peduncle length (cm)	Bunch weight (kg)	No. of hands per bunch	No of fruits per hand	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
AF_1	5.00	9.27	198.32	59.01	43.68	16.67	8.08	14.04	16.11	3.04	114.30
AnF_1	5.52	10.03	203.37	59.38	45.01	17.06	8.76	13.85	15.89	3.35	112.58
AnF_2	5.32	9.48	197.76	58.95	44.96	16.89	8.70	13.89	15.85	3.21	111.38
LF_1	5.11	9.38	195.45	53.05	42.25	14.74	8.44	12.61	15.18	2.80	108.93
MF_1	3.03	7.85	164.86	49.57	39.68	11.94	7.34	12.31	14.86	2.53	102.94
SF_1	1.96	6.47	134.37	38.87	37.83	9.89	6.74	11.64	14.46	2.42	100.78
IF_1	1.21	5.03	131.18	39.65	33.96	8.42	6.56	10.63	12.68	2.37	90.75
SEm±	0.09	0.20	2.49	0.79	0.58	0.21	0.18	0.21	0.21	0.06	1.65
CD (P=0.05)	0.25	0.58	6.98	2.23	1.63	0.59	0.52	0.59	0.59	0.17	4.64

Table 2. Crop duration and quality of banana under Baswara conditions

Locations	Days to shooting (days)	Shooting to harvesting (days)	Crop cycle (days)	TSS (°Brix)	Acidity (%)	Organoleptic rating (out of 10)
AF_1	294.40	107.27	401.67	12.87	0.134	7.32
AnF_1	292.74	106.05	398.79	12.89	0.126	7.59
AnF_2	292.79	105.84	398.63	14.48	0.129	7.64
LF_1	297.87	109.28	407.15	12.52	0.175	7.44
MF_1	298.95	108.98	407.93	11.78	0.169	7.41
SF_1	302.37	112.23	414.60	11.86	0.196	7.21
IF_1	307.03	114.34	421.37	11.57	0.184	6.95
SEm±	4.22	0.48	5.77	0.21	0.002	0.102
CD (P=0.05)	11.85	1.36	16.20	0.59	0.006	0.29

were also at par at each other. The titrable acidity was found in the range of 0.126 (AnF_1) per cent to 0.196 (SF_1) per cent. Organoleptic rating was found statistically significant. Results from the location AnF_2 (7.64) was maximum and was at par with AF_1 (7.32), AnF_2 (7.59), LF_1 (7.44) and MF_1 (7.41) and had significant difference with the locations SF_1 (7.21) and IF_1 (6.95). The results are in conformity with the findings of Abd El-Naby (2010) and Narayana and Mustaffa (2007).

Conclusion

The results of the experiment proved that Banswara conditions were ideally suited for banana cultivation and the yield and quality of the fruits was at par with those of other locations in the country where banana cultivation is commercially practiced. Among the locations Arjun (AF_1) and Anil (AnF_2) were most feasible for banana cultivation.

Acknowledgements

The planting material and other inputs provided by the state Horticulture Department, Banswara for conducting these studies are dully acknowledged.

References

Abd El-Naby, S.K.M. 2010. Effects of postharvest treatments on quality aspect of Maghrabi banana fruit. *American-Eurasian J. Agric. & Environ. Sci*., 8 (5): 582-587.

Chahil, B. S. Gill, T. K. and Singh, C. 2010. Performance of tissue cultured banana cv. Grand Naine (*Musa paradisiaca* L.) under sub-tropical climatic conditions. *Indian Journal of Ecology,* 37(2): 217-220.

Hidoto, L. 2009. Effect of sucker management on banana yield. *African Crop Science Conference Proceedings,* 9: 275-277.

Krishnamoorthy, V. and Kumar, N. 2005. Preliminary evaluation of diploid banana hybrids for yield potential, male fertility and reaction to *Radophalous similis*. *Plant Genet. Res. Newslr.,* 141: 39-43.

Narayana, C.K., Mustaffa, M.M. 2007. Influence of maturity on shelf-life and quality changes in banana during storage under ambient conditions. *Indian Journal of Horticulture,* 64 (1).

Nainwad, R., Kullkarni, N. and Kalalbundi, B. 2005. Extent of variation in growth and yield attributes of some tissue culture vs conventional sucker planted banana varieties. *Karnataka J. Agric. Sci.,* 18(1): 221-222. Patil, S., Solia, B. and Patil, B. 2010. Prediction of fruit yield of banana using stem girth and yield attributes. *Green Farming*, 1(2): 219.

Priyanka Kumari, K.M. Singh and Santosh Kumar Atre. 2018. Problems and Constraints in Banana Cultivation: A Case Study in Bhagalpur District of Bihar. *Int. J. Curr. Microbiol. App. Sci*. 7(07):1752-1759.

Rajamanickan, C., Rajmohan, K., Parthiban, S. and Venkatesan, K. 2008. Performance of triploid banana (*Musa spp*.) cultivars of Kerala. *South Indian Hort.,* 55(1-6): 119-132.

Rajamanickam, C. and Rajmohan, K. 2010. Variability studies in Palayankodan ecotypes AAB genomic group of banana (*Musa spp.*). *J. Hort. Sci.,* 5(2): 109-113.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Effect of pre-harvest spray of calcium chloride and calcium nitrate on shelf life of aonla (*Phyllanthus emblica* L.) cv. NA-7

Mukesh Kumar, Manoj Kumar and Anuradha Bishnoi

CCS Haryana Agricultural University, Regional Research Station, Bawal (Rewari)

ARTICLE INFO

Key Words: Calcium chloride, calcium nitrate, aonla, pre-harvest spray, shelf life.

doi: 10.48165/ijah.2021.3.1.8

ABSTRACT

The studies on shelf life of aonla was conducted at Research Farm and Laboratory Horticulture, Regional Research Station, Bawal. The selected plants were sprayed with calcium nitrate and calcium chloride @ 1.0 and 1.5 % at 10 and 20 days before harvest. After harvesting uniform fruit from different treatments were stored at room temperature. The fruit were analyzed for PLW, decay loss, TSS, titratable acidity and ascorbic acid during storage period. Lowest PLW and decay loss was recorded in the fruit sprayed with calcium nitrate @ 1.5% before 20 days of harvest. TSS increased up to 6th day of storage, while titratable acidity and ascorbic acid decreased continuously during storage. Highest TSS, lowest titratable acidity and maximum ascorbic acid content was recorded in fruit of calcium nitrate sprayed (1.5%) plants at 20 days of storage however, lowest B: C ratio was observed in control.

Introduction

Aonla (*Phyllanthus emblica* L syn. *Emblica officinalis* Gaertn), is gaining popularity because of its high yield, good returns, hardy nature, drought tolerance, prolific bearing and suitability for growing under marginal lands. It also has a tremendous export potential due to its medicinal, therapeutic and high nutritive value. However, fruit are highly perishable in nature and cannot be transported far off places. The quality of fruit has direct impact on marketing as well as on transportation and export potential of fruit in turns influences profit of the grower. The exogenous application of calcium partly delays the senescence process and finally improved the quality of the fruit. The soil application of calcium is unable to increase calcium content in fruit, as it is immobile in plant system. Calcium helps in the formation of calcium –pectate, increase rigidity of middle portion and cell wall of the fruit. Pre-harvest application and post-harvest dip of calcium compound minimize weight loss; reduce respiration, transpiration and rotting of mango fruit (Singh *et al.,* 1998). However, no much information are available in aonla. Therefore, present study was conducted to improve the quality of aonla fruit with pre-harvest application of calcium.

*Corresponding author.
E-mail address: sabharwalmk@hau.ac.in (Mukesh Kumar)
Received 05.03.2024; Accepted 07.05.2024

Materials and Methods

The study was conducted at Research Farm and Laboratory of Horticulture, Regional Research Station, Bawal. Fifteen-year-old forty uniformly grown healthy plants of NA-7 were selected randomly for pre-harvest spray of calcium in the form of calcium nitrate and calcium chloride in the month of August in randomize block design with four replications. These plants were sprayed thoroughly with calcium nitrate and calcium chloride @ 1.0 and 1.5 % and pure water (control) at 10 and 20 days before harvest with tractor mounted spray pump. Fruit from these plants were harvested at maturity stage in the last week of November. Undersized, oversized, diseased and damaged fruit were discarded and healthy fruit of almost same size were selected for storage study in complete randomized design with four replications. Fruit were packed in perforated polythene bags of size two kg and stored at ambient temperature. The fruit were analyzed for changes in PLW, decay loss, TSS, titratable acidity and ascorbic acid at alternate day during the storage period. Physiological loss in weight (PLW) was determined on initial weight basis and it was expressed in percentage.

PLW (%) = [(initial weight - weight at sampling date / initial weight)] x 100.

Decay loss was calculated by weighing the decayed fruit (fungal infection/ spoiled) and it was divided by initial weight and unit was expressed in percentage. Total soluble solids (TSS) of fruit juice was estimated by hand refractometer and expressed in degree brix (°B). Titratable acidity and ascorbic acid were estimated by using the method described in AOAC (2000).

Results and Discussion

Physiological loss in weight (PLW) and decay loss increased with the increase in storage period of fruit in all the treatments; however, no change in PLW and decay loss was noticed up to two and 4 days of storage, respectively. Maximum PLW and decay loss was recorded in fruit harvested from water sprayed plants (control) as compared to the fruit harvested from calcium sprayed plants up to 10 days of storage. PLW and decay loss was recorded minimum in fruit sprayed with calcium nitrate @ 1.5% before 20 days of harvest (Table 1). Physiological loss in weight of fruit might be due to evaporation, transpiration, and loss of dry matter by respiration. Calcium spray might have strengthened cell walls/ maintained fruit firmness and tissue rigidity which reduces fruit softening, respiration, ripening processes, fruit infection by decreasing the enzyme activities caused disintegration of cellular structure resulted in less weight loss and decay loss during storage (Levy and Poovaiah, 1979). These results are supported by the findings of Selvan and Bal (2005) in guava and Singh *et al.* (2008) in ber. Pre-harvest spray of calcium nitrate was better as compared to calcium chloride.

At the time of harvest, no remarkable change in TSS and titratable acidity was observed in the fruit sprayed with different solutions of calcium but TSS contents increased and titratable acidity decreased with the increase in storage period. TSS was maximum on 6th day of storage and thereafter it starts decreasing in all the treatments while titratable acidity decreased continuously in all the treatments up to last day of storage.

Among the different treatments, the highest TSS was recorded in the fruit sprayed with calcium nitrate @ 1.5% before 20 days of harvest (Table 2). During the storage, TSS might be increased due to hydrolysis of starch and other complex molecules into sugars (Wills *et al.* 1980). The higher TSS was observed in calcium nitrate sprayed (1.5%) fruit during storage as it may maintaining the lowest metabolic activity. These results are in line of the findings of Selvan and Bal (2005) in guava and Mahajan and Dhatt (2004) in pear. Titratable acidity decreased least in fruit sprayed with calcium nitrate 1.5 % at 10 and 20 days before harvest, (Table 3). Lowest titratable acidity was recorded in the control as compared different treatments. The less reduction of titratable acidity in fruit during storage may be due to delayed ripening process and slow down the respiration rate by $Ca(NO_3)_2$ spray. Similar finding were also reported by Goutam *et al.* (2010) on guava.

Ascorbic acid content during the storage of aonla was recorded higher in all the treatments as compared to control. Among the treatments, higher ascorbic acid content was recorded in the fruit sprayed with calcium nitrate in comparison to calcium chloride. However, highest ascorbic acid content was recorded in fruit up to 10 days of storage with the spray of calcium nitrate @ 1.5 percent at 20 days before harvest (Table 3). Decrease in ascorbic acid during storage may be due to oxidizing enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase (Singh *et al.* 2005). Similar finding were reported by Ahmed and Singh (2000) and Singh *et al.* (2008) in mango and ber fruit, respectively. Calcium treated fruit had minimum degradation of ascorbic acid contents (Laufmann and Sams, 1989)

The benefit-to-cost (B:C) ratio was higher with pre-harvest sprays of calcium chloride and calcium nitrate at 1.0% and 1.5% applied 10 and 20 days before harvest. Among these treatments, the highest B :C ratio was observed with a 1.5% calcium nitrate spray applied 20 days before harvest. In contrast, the lowest B:C ratio was found in the control (water spray).

Table 1. Effect of pre-harvest spray of calcium on PLW (%) and decay loss (%) of the anola cv NA 7 during storage (Pooled data 2018-19, 2019-20 & 2020-21)

Treatments	Spray (days before harvest)	Physiological loss in weight (%)					Decay loss (%)				
		Storage period (days)					Storage period (days)				
		2	4	6	8	10	2	4	6	8	10
$Ca(NO_3)_2$ @ 1.0%	10	1.2	1.5	1.9	2.2	2.7	0.0	0.0	2.5	3.1	3.9
	20	1.2	1.3	1.8	2.0	2.6	0.0	0.0	2.0	2.8	3.6
$Ca(NO_3)_2$ @ 1.5%	10	1.0	1.3	1.7	2.1	2.5	0.0	0.0	1.5	2.5	3.4
	20	1.0	1.2	1.4	1.8	2.2	0.0	0.0	1.0	2.0	2.7
CaCl2 @ 1.0%	10	1.5	1.8	2.1	2.6	3.2	0.0	0.0	3.5	4.0	4.7
	20	1.5	1.7	1.9	2.3	3.0	0.0	0.0	3.0	3.7	4.4
CaCl2 @ 1.5%	10	1.3	1.6	2.1	2.5	2.8	0.0	0.0	2.5	3.2	4.1
	20	1.3	1.6	1.9	2.2	2.7	0.0	0.0	2.0	3.1	3.9
Control	10	1.7	2.2	2.9	3.5	4.1	0.0	2.0	5.1	6.5	6.9
	20	1.8	2.3	2.8	3.4	4.0	0.0	2.0	5.2	6.6	6.8
CD (P=0.05)		NS	0.2	0.2	0.2	0.2	-	-	0.3	0.4	0.5

Table 2. Effect of pre-harvest spray of calcium on TSS (°B) of the anola cv NA 7 during storage (Pooled data 2018-19, 2019-20 & 2020-21)

Treatments	Spray interval/ storage (days)	Storage period (days)						B : C ratio
		0	2	4	6	8	10	
$Ca(NO_3)_2$ @ 1.0%	10	9.07	9.11	9.13	9.14	9.03	8.92	7.28
	20	9.09	9.15	9.18	9.20	9.12	8.98	7.17
$Ca(NO_3)_2$ @ 1.5%	10	9.11	9.18	9.20	9.22	9.13	9.05	7.89
	20	9.23	9.25	9.26	9.28	9.19	9.14	8.37
$CaCl_2$ @ 1.0%	10	8.83	9.11	9.16	9.20	9.01	8.81	6.67
	20	8.87	9.00	9.05	9.10	9.01	8.85	6.58
$CaCl_2$ @ 1.5%	10	8.92	9.10	9.13	9.14	9.01	8.86	7.28
	20	9.01	9.15	9.16	9.17	9.02	8.84	7.17
Control	10	8.81	9.29	9.35	8.25	8.51	8.20	5.67
	20	8.80	9.30	9.34	8.25	8.50	8.21	5.66
CD (P=0.05)		NS	0.05	0.05	0.04	0.05	0.08	NA

Table 3. Effect of pre-harvest spray of calcium on titratable acidity (%) and ascorbic acid (mg/100g) content in juice of the anola cv NA 7 during storage (Pooled data 2018-19, 2019-20 & 2020-21)

Treatments	Spray days before harvest	Titratable acidity (%)						Ascorbic acid (mg/100g)					
		Storage period (days)						Storage period (days)					
		0	2	4	6	8	10	0	2	4	6	8	10
$Ca(NO_3)_2$ @ 1.0%	10	2.25	2.13	2.06	2.01	1.92	1.86	517	496	482	470	462	455
	20	2.25	2.15	2.07	2.02	1.95	1.91	517	499	483	475	469	461
$Ca(NO_3)_2$ @ 1.5%	10	2.24	2.16	2.11	2.05	1.99	1.94	519	503	499	488	478	470
	20	2.24	2.18	2.13	2.08	2.03	1.97	521	510	503	494	485	477
CaCl2 @ 1.0%	10	2.24	2.11	2.01	1.91	1.86	1.80	515	495	484	465	458	447
	20	2.25	2.14	2.03	1.94	1.89	1.81	516	547	486	468	460	449
CaCl2 @ 1.5%	10	2.24	2.13	2.07	1.97	1.90	1.84	517	502	492	472	464	455
	20	2.25	2.14	2.09	2.01	1.94	1.87	517	505	497	480	470	460
Control	10	2.16	2.03	1.97	1.85	1.81	1.73	515	484	479	465	450	429
	20	2.15	2.01	1.98	1.84	1.82	1.72	515	482	480	466	451	430
CD (P=0.05)		NS	0.03	0.03	0.04	0.05	0.06	NS	2	3	5	5	6

Conclusion

The results of the experiment demonstrated that the conditions in Banswara were ideal for banana cultivation, with yield and fruit quality comparable to those at other commercially practiced banana-growing locations in the country. Among the various locations studied, Arjun (AF1) and Anil (AnF2) were found to be the most feasible for banana cultivation.

Acknowledgements

The authors are thankful to the authority of CCS HAU, Hisar and AICRP (AZF) for technical guidance and financial support in conductance of the experiment. The authors also acknowledge the persons who helped directly or indirectly in execution of the experiment.

References

AOAC. 2000. Official Methods of Analysis. 17th Edition. The Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Ahmed, M.S and Singh, S. 2000. Studies on extension of storage life of 'Amrapali' mango. *The Orissa Journal of Horticulture*, 28:73–76.

Goutam, M., Dhaliwal, H.S. and Mahajan, B.V.C. 2010. Effect of pre-harvest calcium sprays on post-harvest life of winter guava (*Psidium guajava* L.). *Journal of Food Science and Technology*, 47(5):501-506.

Laufmann, J.E. and Sams, C.E. 1989. The effect of post-harvest calcium chloride treatment on polyphenol oxidase and peroxidase activity in golden delicious apple. *Horticultural Science*, 24, 753-754.

Levy, D. and Poovaiah, B.W. 1979. Effect of calcium infiltration of senescence of apples. *Horticulture Science*, 14:466.

Mahajan, B.V.C. and Dhatt, A.S. 2004. Studies on post-harvest calcium chloride application on storage behaviour and quality of Asian pear during cold storage. *Journal of Food Agriculture and Environment*, 2(3-4):157–159.

Selvan, M.T. and Bal, J.S. 2005. Effect of different treatments on the shelf-life of 'Sardar' guava during cold storage. *Journal of Research Punjab Agricultural University*, 42:28–33.

Singh, S., Singh, A.K., Joshi, H.K., Bagle, B.G. and Dhandar, D.G. 2008. Storability of ber (*Zizyphus mauritiana* Lamk) fruit in semi arid environment. *Journal of Food Science and Technology*, 45:65–69.

Singh, B.P., Panday, G., Sarolia, D.K., Pandey, M.K. and Pathak, R.K. 2005. Shelf-life evaluation of aonla cultivars. *Indian Journal of Horticulture,* 62(2): 137-140.

Singh, S., Brahmachari, V. and Jha, K.K. 1998. Effect of calcium and polythene wrapping on storage life of mango. *Indian Journal of Horticulture*, 55 (3):218-222.

Wills, R.B.H., Bembridge, P.A. and Scott, K.J. 1980. Use of flesh firmness and other objective tests to determine consumer acceptability of 'Delicious' apples. *Australian Journal of Experimental Agriculture and Animal Husbandry*, 20:252–256.

Review Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Post-harvest management of sapota: a review

H. L. Chaudhary*[1], D. M. Dabhi[2], H. N. Leua[3] and K. M. Sharma[1]

[1]Date Palm Research Station, S. D. Agricultural University, Mundra-Kachchh, Gujarat
[2]Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat
[3]Department of Fruit Science, College of Horticulture, S. D. Agricultural University, Jagudan-Mehsana, Gujarat

ARTICLE INFO

Key Words: Edible coating, packaging, post-harvest life, quality, sapota

doi: 10.48165/ijah.2021.3.1.9

ABSTRACT

Sapota (*Manilkara achras*) is a tropical fruit tree that grows slowly and is evergreen. When fully mature, it is commonly eaten as a dessert fruit and is grown commercially in several countries, including India, Sri Lanka, the Philippines, Venezuela, and Mexico. However, because of its short shelf life and highly perishable nature, sapota has limited availability in the market. The main challenge in post-harvest management of sapota is its quick ripening, which significantly reduces its shelf life. To address this issue, various techniques and technologies have been explored, such as the use of chemicals, plant growth regulators (PGRs), packaging materials, wax coating, and irradiation. This review aims to explore post-harvest solutions that can increase the availability of sapota fruits in the market for longer periods and maintain their quality throughout storage by extending their shelf life. By improving the shelf life of sapota through pre-harvest treatment and various storage applications, this study seeks to reduce post-harvest losses, increase availability, and ensure the economic sustainability of this horticultural crop.

Introduction

Sapota (*Manilkara achras* (Mill.) Fosberg) is an evergreen fruit tree belonging to the family Sapotaceae. In India, it is popularly known as "*Chiku*" and is one of the delicious fruits of humid tropical and subtropical regions. It is a good source of digestible sugar which ranges from 12 to 18 per cent and has appreciable amounts of protein, fibre, minerals, calcium, phosphorus and iron. The major sapota-producing states in India are Karnataka, Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu. Sapota is a hardy tropical fruit crop that prefers warm but moist weather and can grow in both dry and humid areas. Under the warm (10 to 38 °C) and humid (70 % relative humidity) climate, it flowers and fruits throughout the year. The pulp of sapota is sweet and melting. Value-added products of sapota are jam, juice, squash, slices, candy, powder, nectar, milkshakes and chocolate. Kalipatti is the leading variety in Maharashtra, Gujarat and North Karnataka (Pawar *et al.*, 2011). Other important cultivars that farmers use for cultivation are Cricket ball, Gutthi, Kirthibarthi and Pala. Fruits are harvested at the full maturity stage.

*Corresponding author.
E-mail address: chaudharyhiralal007@gmail.com (H. L. Chaudhary)
Received 05.03.2024; Accepted 07.05.2024

Sapota is a climacteric fruit crop and is a very high ethylene-evolving fruit. At ambient conditions, it takes about 6 to 7 days for ripening of fruits. The storage life is minimal at ambient room temperature because of is highly perishable due to its high respiration rate and faster softening. It cannot be stored longer than 5 days due to rapid metabolic activities (Beikhosia and Rawat, 2020). If not managed correctly after harvesting, it overmature in a day or two at room temperature. After harvesting, if not handled properly, it becomes over-mature within a day or two at ambient temperature. Fermentation of the fruit pulp is of common occurrence and thus it is highly needed to manage its post-harvest shelf life. Improving fruit availability on the market for a longer period and preserving sapota fruit quality during storage through longer shelf life are discussed in this article.

Methods and technologies to enhance the post-harvest life of sapota fruits

Significant losses in sapota fruit have been reported due to poor post-harvest management practices, highlighting the need for better techniques to increase shelf life. The extension of shelf life can be achieved by reducing the rate of transpiration, respiration, and ethylene evolution, which can be accomplished through proper storage and post-harvest practices (Seema *et al*., 2021). The use of appropriate chemicals during pre- and post-harvest stages can also help protect fruits and vegetables from microbial and environmental damage, extending their availability over a longer period. Controlled and modified atmospheres can also be used to store fruits and vegetables at low temperatures, along with appropriate chemical treatments to delay senescence and inhibit microbial decay (Ramjan and Ansari, 2018). Proper post-harvest management practices, including both pre-harvest and post-harvest treatments, are crucial to increase the post-harvest life and maintain the quality of fruits (Baidya *et al*., 2020).

Storage and packaging material

Sapotas are stored in cool and dry conditions to prevent spoilage. It's important to control temperature and humidity levels to avoid excess moisture or dehydration. This slows down the ripening process and reduces the growth of pathogens. Proper ventilation is also vital to prevent the build-up of ethylene gas, which can accelerate ripening. To maintain humidity levels and prevent physical damage, it's recommended to wrap individual fruits in paper or store them in perforated plastic bags. By following these storage conditions carefully, you can significantly extend the shelf life of sapota fruits, reducing post-harvest losses and allowing for longer storage periods. Packaging is a process that reduces the respiration rate, ripening process, ethylene sensitivity, and ethylene production. It also minimizes the softening of texture. As a result of these activities, the shelf life of the product is extended. Packaging helps in extending shelf life by minimizing shrinkage, weight loss, and other quality parameters (Pratap *et al*., 2018). A few of the successful methods are listed in Table 1.

Chemicals and plant growth regulators

Chemicals can be used to improve the shelf life of sapota fruits by slowing down metabolic activities, preventing ripening, and preserving their colour and consistency. These chemicals are also effective in inhibiting the growth and spread of microorganisms, preventing shrivelling (Shivani *et al*., 2022). Plant growth regulators such as 1-MCP can be applied shortly after harvest to delay the ripening and senescence processes by inhibiting ethylene action. GA_3 is another growth regulator that can help slow down the ripening process and enhance fruit firmness, thus maintaining the structural integrity of the fruits during storage. A few of the successful methods are discussed in Table 2.

Edible coatings

Edible coatings provide a natural and eco-friendly solution to increase the shelf life of sapota fruits by tackling issues such as moisture loss, gas exchange, microbial contamination, and oxidative deterioration. If applied correctly, these coatings can significantly extend the storage life of sapota fruits while preserving their quality, freshness, and nutritional value. This protective layer helps preserve the fruit's quality, appearance, and texture over an extended period, making it more appealing to consumers and reducing food waste. Additionally, some edible coatings can be formulated with antioxidant properties, which can further contribute to delaying oxidative processes and prolonging the shelf life of sapota. A few of the practical examples are listed in Table 3.

Irradiation

Irradiation is an effective method to kill bacteria, moulds, and insects that are present on the surface and inside fruits. This methodcan also delay the natural ripening process of sapota by suppressing the activity of enzymes responsible for fruit softening and deterioration.. This prolongs the shelf life of fruits. Importantly, irradiation does not leave

any harmful residues and does not induce radioactivity. Therefore, it is a safe and reliable method for extending the shelf life of fruits. With proper irradiation treatment and handling practices, sapota can maintain its freshness and appeal for an extended duration, providing consumers with a high-quality product that has an increased shelf life compared to untreated fruits. A few of the successful methods are discussed in Table 4.

Table 1. Storage and packaging material to enhance post-harvest shelf life of sapota

S.No.	Materials	Details	Treatment time/ Place	Treatment Method	Results	References
1.	Modified atmosphere packaging (MAP) of polybags with gas concentration and stored temperature	25 µ LDPE bags with gas concentration 5% O_2+10% CO_2 and stored at 6°C temperature	Freshly harvested and fully matured sapota fruit stored in ambient condition	On the postharvest MAP	The shelf life of fruit could be increased up to 49 days	Antala *et al.*, 2014
2.	Polyethylene bags	100-gauge thickness having 1.2 per cent ventilations	Freshly harvested fruit stored at room temperature	Packaging treatment at room temperature	Prolonged the shelf life of sapota up to 9th day of storage compared to other packaging materials.	Awasarmal *et al.*, 2011
3.	Packaging of polybags with ventilation and storage temperature	200-gauge LDPE bags with 2.1% ventilation and 12±1°C temperature	Stored in a cold chamber and the temperature was maintained at 12±1°C and RH 85-90%	On the postharvest packaging of freshly harvested sapota fruits in polythene bags with ventilation	Recorded a maximum shelf life of 31.83 days and higher quality in terms of fruit firmness (2.1 kg/cm^2), organoleptic score (9.93), TSS (20.11°Brix), ascorbic acid (22.34 mg/100 g), titratable acidity (0.23%), reducing sugars (8.21%) and total sugars (12.31%)	Bindu *et al.*, 2012
4.	Storage condition+chemical +packaging material	8°C+$KMnO_4$ 1.5 mM in CFB box	After harvest fruit stored at Cold storage	Cold storage Temperature (8°C) with post-harvest dipping of $KMnO_4$	Prolong the shelf life	Seema *et al.*, 2020
5.	Packaging material	Corrugated fibre board (CFB) box	Skin colour of the fruits changed from light brown to dark brown (Potato like colour) and brown scale like structure on the surface of fruit	On the postharvest packaging	Reducing physiological loss in weight and fruit decay with minimum changes in chemical constituents	Seema *et al.*, 2021

Table 2. Chemical treatments to enhance post-harvest shelf life of sapota

S.No.	Chemicals/ materials	Details	Treatment time/ Place	Treatment Method	Results	References
Pre-Harvest Application						
1.	CPPU	6 ppm	Sprayed twice i.e., in the months of November and January	Foliar application	To extend shelf life	Barkule *et al.*, 2017
2.	$CaCl_2$	1 %	Three weeks before harvest	Pre-harvest spraying	Increasing fruit firmness, marketable fruits and Maximum shelf life (10 days) with minimum physiological weight loss and spoilage loss	Patel *et al.*, 2014

Post-Harvest Application						
3.	$CaCl_2$	5,000 ppm	After harvest stored at room temperature	Post-harvest 10-minute dip treatment	Improves the fruit firmness, shelf life and ripening period of the sapota up to 12 days of storage.	Tsomu and Patel, 2014
4.	$CaCl_2$ and storage conditions	10,000 ppm	Treated fruits were stored in the cold storage	Post-harvest 5-minute dip treatment	Treated with $CaCl_2$ 10,000 mg/l (23.67 days)	Patel *et al.*, 2020
5.	1-MCP and storage conditions	100 nL L^{-1} and low temperature 12.0±0.5°C	Post-harvest storage condition	Fruits fumigated with 1-MCP	Best for extending the shelf life and increasing the marketable fruits	Thakriya *et al.*, 2022
6.	2,4-D and Storage conditions	2,4-D @ 4 ppm	Fruits storage at low temperature (12°C)	Post-harvest dip treatment for 5 minutes	Exhibited the longest shelf life of 32 days	Madhavi and Srihari, 2002

Table 3. Enhancement of shelf life of sapota using edible coating

S.No.	Chemicals/ materials	Details	Treatment time/Place	Treatment Method	Results	References
1.	Soyabean starch based edible coatings	Cultivar PDKV-AMS 1001 was used for the extraction of starch	Coated sapota were stored at refrigerated condition	Refrigerated dipped treatment	Enhanced the shelf-life of sapota fruit by 2 weeks in comparison to the control	Chettri *et al.* 2023
2.	Coated with corn starch	2.5 %	Fully matured, uniform size sapota fruits	Stored at ambient storage	Extends the shelf life and also preserves the ascorbic acid and phenol content during storage	Dey *et al.*, 2014
3.	Pectin coating	3 %	Post-harvest application under cooled to room temperature storage	Post-harvest edible coating	The pectin based edible coating extended the shelf life of sapota fruits upto 11 days by delaying the changes in the physico chemical parameters such as weight loss, TSS, pH, total acidity, ascorbic acid, firmness and colour	Menezes and Athmaselvi, 2016
4.	Growth regulator and coating	GA_3 200 ppm and coating of fruits with wax 6 %	Post-harvest treatment at ambient temperature	Dipped and coated	Maximum shelf-life (9.17 days)	Patel and Patel, 2016
5.	Coating of *Aloe vera* gel with water	Ratio of 1:2 and 7 minutes dipping time	Freshly harvested fruit coated with maintaining 15±2°C temperature	Post-harvest dip treatment	Extended the storage life of sapota up to 20 days	Padmaja and John, 2014
6.	Methyl cellulose and palm oil	15 g L^{-1} and 11.25 g L^{-1}	Fruit stored at 24±1°C and 65±5% RH	Post-harvest edible coating	Increased shelf-life of 3 days at near ambient environmental storage conditions	Vishwasrao and Ananthanarayan, 2017
7.	Green grass jelly edible coating	0.4 %	Coated sapota were stored at room temperature	Post-harvest edible Coating	Extend the shelf life of sapota fruit two days longer than the control treatment.	Setiawan *et al.*, 2023

Table 4. Enhancement of shelf life of sapota using irradiation

S.No	Chemicals/ materials	Details	Treatment time/ Place	Treatment Method	Results	References
1.	Packaging material+irradiation	Packaging of 100 gauge with 0.1% performation+0.2% kGy gamma radiation	Fruit stored at 15°C for 20 days	Irradiation	Increased post-harvest life of fruits by 26 days over control 5 days	Srinu *et al*., 2015
2.	Growth regulator and irradiation	GA_3 200 ppm and 0.20 k Gy	At Post Harvest Technology lab and irradiation unit	Post-harvest treatment of PGR and Irradiation	The fruits had lower PLW (12.82%), higher firmness (2.21 kg/cm^2), lower ripening (56.50%), lower spoilage (35.50%) and enhanced the shelf life up to 12 days	Yadav *et al*., 2012

Conclusion

The quick ripening and short shelf-life of sapota can cause significant losses and hinder its economic viability and long-term market availability. However, various pre-harvest and post-harvest techniques can be used to extend its shelf life and improve its market availability. These techniques include the use of storage and packaging materials, chemicals and plant growth regulators, edible coatings, and irradiation. Although these methods may have some challenges, such as being cost-effective and scalable, further research and development efforts are necessary to optimize them for broader adoption and sustainability. It is essential to maximize the shelf life of sapota through comprehensive post-harvest management to ensure food security, reduce waste, and promote economic prosperity in the horticultural sector.

References

Antala, D.K., Satasiya, R.M., Akabari, P.D., Bhuva, J.V., Gupta, R.A. and Chauhan, P.M. 2014. Effect of modified atmosphere packaging on shelf life of sapota fruit. *International Journal of Agricultural Science and Technology*, 2(1): 32-38.

Awasarmal, A.B., Soni, S.B. and Divekar, S.P. 2011. Effect of different packaging materials on shelf life of sapota fruit. *International Journal of Processing and Post Harvest Technology*, *2*(2):125-128.

Baidya, B.K., Mahato, A., Pattnaik, R.K. and Sethy, P. 2020. A Review of physiological and biochemical changes related to ripening along with post-harvest handling and treatments of Sapota. *Journal of Pharmacognosy and Phytochemistry*, 9(4),: 2030-2035.

Barkule, S.R., Patel, B.N., Shah, N.I. and Gurjar, T.D. 2017. Effect of different chemical substances on quality and shelf-life of sapota (*Manilkara achras*) cv. Kalipatti harvested in summer season. *Trends in Biosciences*, 10(19): 3490-3492.

Beikhosia, J.K. and Rawat, V. 2020. To study the effects of different packaging materials on shelf life of sapota–a review. *International Journal of Current Microbiology and Applied Sciences.*, 9(11): 2310-2315.

Bindu, P.R., Sudha, V. and Rajasekhar, M. 2012. Influence of low temperature on shelf life and quality of sapota (*Manilkara achras* (Mill.) Fosberg) fruits packed in polybags. *Acta Horticulturae,* 1012: 873-879.

Chettri, S., Sharma, N. and Mohite, A.M. 2023. Formulation of extracted soyabean starch based edible coatings by different methods and their impact on shelf life of sapota fruit. *Journal of the Saudi Society of Agricultural Sciences,* pp. 1-7.

Dey, K., Ghosh, A., Bhowmick, N. and Ghosh, A. 2014. Physico-chemical properties of sapota (*Manilkara achras* (Mill) Forsb.) fruits coated with corn starch. *Journal of Crop and Weed*, 10(2): 43-49.

Patel, H.A., Patel, M.J., Kore, P.N. and Lokesh Yadav. 2017. Pre-harvest spray of calcium on physical parameters of sapota [*Manilkara achras* (Mill.) Forsberg] fruits cv. Kalipatti. *International Journal of Chemical Studies,* 5(6):156-158.

Madhavi, M. and Srihari, D. 2002. Effect of post-harvest application of growth regulators on low temperature storage life of sapota [*Manilkara achras* (Mill.) Fosberg] fruits cv. Pala. *Indian Journal of Horticulture*, 62(2): 187-189

Menezes, J. and Athmaselvi, K.A. 2016. Study on effect of pectin based edible coating on the shelf life of sapota fruits. *Biosciences Biotechnology Research Asia*, *13*(2):1195-1199.

Patel, P.D. and Patel, A.D. 2016. Effect of different growth regulators, chemical and wax coating on ripening of sapota fruits cv.'Kalipatti'. *Indian Journal of Applied Research,* 6(6): 120-121.

Padmaja, N. and John, D.S. 2014. Preservation of sapota (*Manilkara zapota*) by edible aloe vera gel coating to maintain its quality. *International Journal of Scientific Research*, 3:177-179.

Patel, B.D., Parekh, D.D., Jangid, R. and Thakor, A.O. 2020. Effect of different chemicals on physical parameters of sapota (*Manilkara achras* (Mill.) Fosberg) cv. Kalipatti under cold storage condition. *Journal of Pharmacognosy and Phytochemistry*, 9(5): 2374-2376.

Pawar, C.D., Patil, A.A., and Joshi, G.D. 2011. Quality of sapota wine from fruits of differential maturity. *Karnataka Journal of Agricultural Sciences*, 24(4): 501-505.

Pratap S., Singh R. and Savita. 2018. Impact of packaging material on shelf life and quality of Sapota- A Review. *Journal of Emerging Technologies and Innovative Research*, 5(12):1147-1155.

Ramjan, M.D. and Ansari, M.T. 2018. Factors affecting of fruits, vegetables and its quality. J*ournal of Medicinal Plants Research*, 6:16-18.

Seema, N.U, Jhalegar, M.J., Jagadeesh, S L., Bhuvaneshwari, G., Awati, M.G. and Ahmed, T. 2020. Effect of different storage condition on quality and shelf life of sapota (*Manilkara achras*) fruits. *International Journal of Chemical Studies*, 8(4): 2364-2372.

Seema, N.U., Jhalegar, M.J., Jagadeesh, S.L., Bhuvaneshwari, G., Await, M.G. and Ahmed, T. 2021. Effect of packaging material on shelf life and quality of sapota cv. Cricket ball. *The Pharma Innovation Journal*, 10(5):1306-1312.

Setiawan, C.K., Aini, I.Q., Widyastuti, T., Djaafar, T.F. and Prabasari, I. 2023. Green grass jelly edible coating maintains shelf life of sapota fruit (*Manilkara zapota*). *IOP Conference Series: Earth and Environmental Science*, 1172 (1): 012058

Shivani, A.M., Galande, H.R. and Syed, S.J. 2022. Effect of post-harvest application of different chemicals on quality parameters of sapota cv. Kalipatti. *The Pharma Innovation Journal*, 11(2): 10-20.

Srinu, B., Bhagwan, A. and Babu, J.D. 2015. Effect of combination of polypropylene packaging and irradiation on shelf life of sapota fruit stored at low temperature. *Environments and ecology,* 33(1):1672-1675.

Thakriya, H.R., Tandel, Y.N., Saravaiya, S.N., Ahlawat, T.R. and Viyol, S.H., 2022. Influence of 1-MCP and storage conditions on physical properties of sapota. *The Pharma Innovation Journal,*11(1): 10-15.

Tsomu, T. and Patel, H.C. 2014. Effect of post-harvest treatments of chemical and plant growth regulators on physical parameters of sapota fruit cv. Kalipatti. *Journal of Food Processing and Technology*, 5(7): 347-349.

Vishwasrao, C. and Ananthanarayan, L. 2017. Delayed post-harvest ripening-associated changes in *Manilkara zapota* L. var. Kalipatti with composite edible coating. *Journal of the Science of Food and Agriculture*, 97(2): 536-542.

Yadav, N.K.K., Bharathi N. and Goud P.V. 2012. Combined effect of growth regulators and irradiation on shelf life of sapota (*Manilkara achras* (Mill.) Forsberg) cv. Kalipatti. *Plant Archives*, 13(2):1039-1042.

Review Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Integrated nutrient management in arid zone fruit crop production - a review

J. Jayachitra and N. Richard Kennedy

Regional Research Station, Tamil Nadu Agricultural University, Aruppukottai - 626101

ARTICLE INFO

Key Words: INM, fruit yield, quality, soil fertility and crop productivity.

doi: 10.48165/ijah.2021.3.1.10

ABSTRACT

The indiscriminate use of chemical pesticides along with improper nutrient management is deleterious to the plant health, environment and human being. The quality attributes of different fruits are badly affected due to indiscriminate application of inorganic agro-chemicals which results in quality deterioration with less consumer preference and low returns to the growers. It also causes soil health deterioration and disturbs the soil microorganisms. Such practices are also common among the fruit growers. Due to these practices, the plants also become susceptible to several biotic and abiotic stresses. Therefore, it is a holistic approach based on usage of all possible sources of plant nutrients in an integrated manner is considered as alternative source to maintain soil fertility and plant nutrient supply for sustaining the desired crop productivity.

Introduction

The world population (7.87 billion) is currently growing at a rate of 1.03% per year and is expected to reach around 9.6 billion in 2050. India has 1.38 billion people accounting for 17.5% of the world population, with a meagre 2.4% of the world surface area (UN, 2021). Now a days, the greatest challenge is to provide this burgeoning population with stable, safe and nutritious quality food. In the current Global Hunger Index (GHI), India stands at position 101 of 116 countries; this presents a gloomy situation in combating malnutrition, eventually affecting the socio-economic progress (Grebmer *et al.,* 2020). The World Health Organization (WHO) has also indicated that hungriness is the most serious problem worldwide, particularly for African countries and India. Therefore, 195 nations have decided to adopt sustainable development goals (SDG) for addressing the serious malnutrition problems with a holistic approach by the year 2030 (Anonymous, 2016). Consumer awareness about the health benefits of fruits offers great thrust for their regular consumption as part of a balanced diet. Worldwide demand of nutrient-dense fruit has increased immensely in recent years not only for enhancing people's nutritional status but also for their positive effects on immune and metabolic health. This is particularly interesting considering the COVID-19 pandemic scenario. In India, major fruit crops, such as mango, banana, citrus, guava and apple, account for

*Corresponding author.
E-mail address: microjayachitra@yahoo.com (J. Jayachitra)
Received 05.01.2024; Accepted 07.03.2024

more than 72% of the total area under fruit crops, while indigenous (native) fruit crops contribute only 6.56% of the area (0.437 mha) with quite high productivity *i.e.* 11.47 tons/ ha (NHB, 2019). Climate change is inducing a rise in air temperatures, UV radiation levels and in the frequency of extreme events, such as drought or flood, which, especially in arid or semi-arid areas, can result in an intensification of the negative impact of salinity, mineral deficiency/toxicity and of diseases and insect-pest attacks on crops (Sanwal *et al.,* 2022). Consequently, climate change represents a great threat to obtaining the sustainable production of major commercial fruits (Gora *et al.,* 2019). Under such environmental conditions, the fulfilment of the consumers' choice and nutritional food security at an affordable and sustainable level is a major concern for the researchers as well as the growers. Under the given circumstances, specific growing areas may be utilized for exploiting the potential of underutilized crops producing edible fruits that meet the food and nutritional demand of local population. It is necessary to explore some biotic and abiotic resistant/ tolerant native underutilized fruit crops that could be resilient to certain climatic variations and adapt to a wide range of agro-climatic conditions. The indigenous fruit crops are not only proven to be superior in terms of wider adaptability to environmental conditions but are also known for their nutritional value (Berwal *et al*., 2019). However, a limited amount of research has been carried out for the development of production protocols and utilization of these underutilized fruit species. Moreover, the limited number of identified varieties, the low availability of quality planting materials and the inadequate availability of suitable cultural and post-harvest management practices are still major limitations challenging the systematic cultivation of these underutilized crops. The vegetation of arid areas includes a large number of edible fruit-bearing and food producing species. In the Indian arid zone, around 30 plant species are known for their different edible uses, and around 19 of them bear edible fruits and possess horticultural importance (Rathore, 2009). Many of the underutilized fruit crops can be used as fresh fruit but also for culinary and medicinal purposes providing important nutrients, and some of them also have ornamental values. Local people are aware of their medicinal and nutritional properties. Indeed, most indigenous underutilized fruit crops, such as ber, kair, aonla, lasora and phalsa are rich in minerals, antioxidants and phytonutrients compared to many commercial fruit crops. Moreover, these underutilized fruits are not very popular and are sold at very low prices in the local markets because of the lack of (a) people's awareness about their nutritive values, (b) consumption habits, (c) limited research, and (d) developmental policies by the government agencies for their potential exploitation. Considering the importance of these tree crop species in traditional medicine, their nutritional richness and wide adaptability, the Government of India, under their centrally sponsored scheme, *i.e.* Mission on Integrated Development of Horticulture (MIDH, then 'National Horticulture Mission', NHM) during 2005–2006 gave a special impetus to establish orchards of underutilized fruit species. Now days, inorganic fertilizers are one of the most expensive inputs in orchard management. Besides, continuous application of huge amount of chemical fertilizers hampers the soil health, soil productivity, environment, quality of produce and human being who consume them. In view of above facts, there is need to increase the production and productivity through Integrated Nutrient Management (INM).

What is Integrated Nutrient Management?

It involves the combined use of inorganic, organic and biological sources of essential plant nutrients to sustain optimum crop yield and also improve or maintain the physico-chemical properties of soil. It provides crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe. The principal aim of the integrated approach is to utilize all the possible sources of plant nutrition in a judicious and efficient manner.

Objectives of INM

- To reduce the dependence on chemical fertilizers.
- To reduce inputs cost by conserving locally available resources & utilize them in an efficient manner.
- To maintain productivity on sustainable basis without affecting soil health.
- To increase the fertilizer use efficiency.
- To utilize the potential benefits of green manures, leguminous crops and biofertilizers
- To prevent degradation of the environment.
- To meet the social and economic aspirations of the farmers without harming the natural resource base of the agricultural production.

Requirement of INM

It is required due to the following reasons

- The decline in productivity can be attributed to the appearance of deficiency in secondary and micronutrients.

- Consistent increasing cost of chemical fertilizers.
- Unavailability of fertilizers as per requirement.
- Environmental pollution and its ill effects on soil, animals and human being due to continuous and excessive use of chemical fertilizers.
- Continuous depletion of soil nutrients.
- Without an integrated supply and use of plant nutrients from chemical fertilizer and organic sources, better production is not possible.
- The fertilizer production in our country is less than the required amount.

Therefore, organic manures and biofertilizers have to be looked for as alternate sources to meet the nutrient requirement of fruit crops and to bridge the gaps. Such integrated approach will help to maintain soil health, productivity and improving farmer's profitability. The INM involves the following components.

i. **Organic manures:** Organic manures defined as materials which are organic in nature and derived from plant and animal origin used to improve fertility and productivity of soil. The manures contain organic matter in large proportion and plant nutrients in small quantities. They are mostly used to improve the soil productivity by correcting soil physical, chemical and biological properties. e.g. FYM, vermicompost, compost, oil cakes, green manure etc. Green decomposed material used as manure is called green manure. It is obtained in two ways by growing green manure crops or collecting green leaf (along with twigs) from plants grown in wasteland, fields, bunds and forest. Green manuring is practised in the field plants which usually belong to leguminous family and incorporate into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops. Crop residues are materials left in an agricultural field or orchard after the crop has been harvested and after mostly leaf fall stage in case of fruit crops. These residues include stalks and stubble (stems), leaves, seed pods, *etc*. These are also very valuable animal feed. Sometimes poultry manure/ droppings are mixed with other additives and used as fish or cattle feed. Management of crop residues is either through removal, burning or incorporation into soil. Burning is a minor practice in India. Crop residues are an important source of organic matter that can be returned to soil for nutrient recycling, and to improve soil physical, chemical and biological properties (Kumar and Goh, 2000).

ii. **Biofertilizers:** The products containing living cells of different types of microorganisms which have an ability to mobilise nutritionally important elements from non-usable to usable form through biological process. e.g. N-fixing bacteria (*Rhizobium, Azotobactor, Azospirillium, etc*.) phosphorus solublising bacteria (PSB), potassium solublising microorganisms (KSM), Vesicular Arbuscular Mycorrhizae (VAM), *etc*.

iii. **Chemical fertilizer:** Fertilizers are the materials which are used to fertilize (to provide one or more essential nutrients) the crops are generally termed as fertilizers but now a days; the term fertilizer is widely used for commercially manufactured inorganic fertilizers. Thus, chemical fertilizers defined as the any material (solid, liquid or gas) containing one or more nutrient elements in the form of chemical compounds of the organic or inorganic nature.

iv. **Management of problematic soils:** Problematic soils such as saline soils, alkali soils, acid soils, waterlogged soils are known to decrease the productivity of the soil. These soils should be regularly managed and reclaimed through the application of soil amendments such as gypsum for alkali soils, lime for acid soils, use of good quality water for saline soils and use of other organic and inorganic materials based on soil test results. It helps to improve soil fertility and productivity and sustain the crop yield.

v. **Irrigation water management:** Plants absorb the nutrients from the soil only in a dissolved state and sufficient moisture is therefore required for utilizing the nutrients of the soil. Management of moisture in the soil by improved and modern irrigation techniques like drip or sprinkler or basin where the rainfall is low and draining the soil where it is subjected to stagnation of water helps to increase water and nutrient availability to the crops.

Major steps in INM

- Evaluate the field for potential of crop yield.
- Determine residual nutrient availability and major yield limiting factors for each field.
- Based on soil and leaf nutrient analysis, correction of nutrient deficiency will result in higher yield.
- Evaluate availability of on-farm nutrients from plant residues, green manures, cover crops, animal manures, symbiotic N-fixation by legumes and nutrients in irrigation water.
- Estimate and prioritize supplemental nutrient requirements for each field and crop.
- Establish the most efficient nutrient application programme with respect to crop, nutrient source, time of application, placement method and quantity.

- Regularly evaluate the results of nutrient application in terms of yield and quality responses of crop, residual nutrient levels and changes in soil quality.

Custard apple

Asheesh Sharma *et al*. (2014) conducted an experiment on the effect of organic and inorganic fertilizers along with bio-fertilizers on plant environment variables of custard apple cv. Arka Sahan during 2010-11. Treatment T_{10} comprising 50% recommended dose of fertilizers+50% N through vermicompost and biofertilizers (*Azotobacter* 50 g+PSB 50 g+VAM 20 g) was found significantly superior over other treatments with respect to plant environment variables *viz*., Photosynthetic rate ($\mu molm^{-2}\ s^{-1}$), Transpiration rate ($mmolm^{-2}\ s^{-1}$), Stomatal conductance ($mmolm^{-2}\ s^{-1}$), Photosynthetic Active Radiation ($mmolm^{-2}\ s^{-1}$), Internal CO_2 concentration (ppm). Vapour Pressure Deficit (mb), Leaf temperature (^oC) and Relative Humidity (%) in custard apple cv. Arka Sahan. Jangid *et al*. (2021) reported that Effect of different sources of nitrogen on fruit quality and shelf life of custard apple (A*nnona squamosa* L.) cv. Sindhan soil application of 50% RDN from Urea+25% RDN from Poultry manures + 10 ml *Azotobacter* per plant treatment was recorded significantly maximum total soluble solids (25.19^{o}Brix), reducing sugar (18.83%), non-reducing sugar (6.20%), total sugar (24.98%) and ascorbic acid (21.05 mg/100 g pulp). Rikshita *et al.* (2023) studied that Impact of Integrated Nutrient Management on the Growth and Yield of Sugar apple (*Annona squamosa* L.) cv. Sindhan. The highest incremental plant height (66.00 cm), incremental canopy spread (north-south) (84.33 cm), incremental canopy spread (east-west) (90.67 cm), and maximum fruit weight (224.10 g), fruit length (7.58 cm), fruit girth (7.50 cm), the maximum number of fruit per tree (129.83), fruit yield per tree (27.87 kg) and fruit yield per hectare (7.72 tons) were observed under application of 2.5 kg of vermicompost, 50 ml of Azotobacter, and 50 ml of PSB per plant, along with 75% the recommended fertilizer dose (RDF). Anjali Massey *et al*. (2021) studied the effects of organic manures and green manuring practices on growth, yield attributes, quality and economics of lemongrass (*Cymbopogon flexuosus* L.) under custard apple (*Annona squamosa* L.) based agri-horti system. The highest growth, yield attributes and yield as well as oil composition, soil nutrient status, microbial populations as well as economics of crop cultivation were significantly increased due to the use of both organic manures and green manuring. The significant higher results were obtained with vermicompost (2.5 t/ha)+*Azotobacter,* which was found superior over other practices. Suchismita Naik conducted the experiment on custard apple application of RDF (25%) + Vermicompost (75%) was found best in terms of growth parameters *viz*., plant height (30.68 cm), number of leaves per plant (25.67), number of branches per plant (2.40), plant spread (37.18 cm), stem girth (2.71 cm), leaf area (28.16 cm^2), days taken to emergence of 1st new leaf after treatment (6.47 days) and chlorophyll content (35.55%). The maximum chlorophyll content (39.55%) of custard apple cv. NMK-1 Golden was observed with treatment T_3. Moreover, the treatment T_3 also showed 100% establishment of the custard apple plants cv.NMK-1 Golden.

Phalsa

Verma *et al.* (2014) revealed that the application of FYM+75 per cent NPK+*Azotobacter*+PSB+$ZnSO_4$ (0.4%) recorded maximum plant growth and fruit yield (5.06 kg per plant and 5.23 kg per plant) in both the year, respectively. Similarly, maximum physical characters *viz*., fruit length (1.13 and 1.15 cm), fruit breadth (1.37 and 1.35 cm), weight of fifty fruits (38.63 and 39.10 g) and juice per cent (51.11 and 51.92%) and pulp/stone ratio (1.60 and 1.62) as well as maximum chemical characters *viz*., TSS (27.64 and 27.91%), ascorbic acid (38.51 and 38.21 mg/100 ml juice), reducing sugars (19.38 and 19.40%), non reducing sugars (2.37 and 2.38%) and total sugars (21.74 and 21.78%) along with minimum acidity (2.24 and 2.20%) were obtained in the same treatment during both the years respectively. Mani *et al.* (2013) studied that application of *Azotobacter* inoculated treatment with 75% N substitution by phosphate solubilizing bacteria and remaining 25% through inorganic fertilizer in two equal splits at establishment and before flowering stage increased length of shoot, number of shoot, number of leaves per shoot, internodal lengths, number of fruit per node, number of fruiting node per shoot, fruit yield, fruit length, fruit width, juice per cent, pulp stone ratio and acidity. Basith *et al.* (2018) concluded that pruning of phalsa bushes around 20th December has resulted in morenumber of fruit clusters and yield under the Southern Telengana Agro-climatic conditions. Integrated application of 50% RDF along with organic manure and biofertilizers is best option to obtain higher yields and superior fruit quality in phalsa.

Bael

Singh *et al*. (2014) studied the response of organic manures, inorganic fertilizers, biofertilizers and their combination with foliar spray of 0.4 per cent boron on yield, physico-chemical characters and economic feasibility of bael cv. Narendra Bael-9. The physical characters of fruit *viz*., maximum fruit

length(17.21 cm), width (16.45 cm), weight 2.21kg, volume 2422 cm^3, reduction of skull thickness (1.78 mm), fibre content (56.25 g/kg pulp), number of seed per fruit (80), mucilage content (13.08%), time of fruit maturity (261 days), maximum advancement of fruit maturity (6.0 days) and fruit yield (6600 kg/tree). However, the chemical composition of fruit *viz*., maximum TSS(41.12°Brix), Acidity (0.146%) ascorbic acid (23.83 mg/100g pulp), reducing sugars (4.120%), non-reducing sugar (13.0%), total sugars (17.130%) and minimum acid content were recorded with the application of T_{10} (100% NPKB+biofertilizers+biopressmud+FYM).

Shararath *et al*. (2016) investigated experiment on the effect of organic and inorganic fertilizers on Bael grown in Gangetic alluvial soil. The highest fruit yield of 14.7 kg, Pulp content was maximum (74.9%), TSS content (48.0°Brix), Ascorbic acid content (10.78 mg/100 g) in the fruit pulp, fruit weight (1220 g) was observed in the treatment plant treated with FYM (16 kg)+mustard cake (2.4 kg). Vishwakarma *et al.* (2017) showed that maximum fruit length, fruit width, fruit weight, pulp weight, TSS and ascorbic acid were recorded with application of 50 kg FYM + 100% NPK+200 g each (*Azotobacter*+PSB).

Manila Tamarind

Arthi *et al.* (2023) revealed that application of 50% of NPK+5 kg vermicompost+10 kg FYM+phosphobacteria 100 g followed by (T_4) FYM 10 kg+vermicompost 5 kg+ phosphobacteria 100 g increased the fruit weight (g), fruit length (cm), fruit girth (cm), weight of the peel (g), number of arils, weight of the aril with seed (g), fruit yield (kg/tree/year) of Manila tamarind**.**

Ber

Bohane and Tiwari (2014) conducted an experiment at College of Horticulture, Mandsaur on five years old trees of ber cv. Gola and revealed that the application of 50 per cent recommended dose of NPK as vermicompost+50 per cent RDF NPK+50 g *Azotobacter*+50 g PSB significantly increased the fruit length and diameter, fruit volume, pulp weight, stone weight, TSS, ascorbic acid, reducing sugar, non-reducing sugar, total sugars, TSS/acid ratio and chlorophyll content in leaves over other treatments.

Aonla

Korwar *et al.* (2006) stated that the growth, yield and quality of aonla were influenced by different sources of nutrients. Combination of organics and inorganic nutrients increased the fruit yield and quality. Application of vermicompost improved the fruit quality. Mandal *et al*. (2013) concluded that the application of 100: 25:150 g NPK/plant+10 kg FYM+50 g PSB/ plant is beneficial for increasing vegetative growth as well as improving yield and yield attributing characters of aonla cv. NA-7 under red and lateritic region of West Bengal. Aal *et al.* (2020) study the "Effect of integrated nutrient management on quality and shelf life of Aonla (*Emblica officinalis* Gaertn.) cv. Gujarat Aonla-1. Among all the treatments, T_9 (50 % RDF through chemical fertilizer+25 % RDN through vermicompost+10 ml Anubhav Bio NPK Consortium/ tree) treatment was found most effective treatment and recorded significantly maximum in pulp weight at maturity stage, pulp:stone ratio at maturity stage, total soluble solids, ascorbic acid, shelf life and minimized the acidity in Aonla fruits.

Aal *et al.* (2020) reported that of two successive years of investigation revealed that growth of the plant in terms of height, basal girth and plant spread towards East-West and North-South direction was maximum in the plant received yearly application of mustard cake at 4 kg followed by the plant with FYM 16 kg+Mustard cake 2.4 kg. Highest fruit yield of 14.7 kg /plant was recorded from the plant received yearly application of FYM 16 kg+Mustard cake 2.4 kg this was associated with foliar N and P values of 1.60 and 0.46 percent respectively. The lowest yield was obtained from the control plants. Highest organic carbon content of soil (0.84%) was recorded from the plots of the treatment with FYM 16 kg+Mustard cake 2.4 kg/ plant. TSS and ascorbic acid content of the fruit were more in the plant received the treatment of FYM 16 kg+Mustard cake 2.4 kg. The acidity content in the pulp of different treated plants did not vary significantly 50 % RDF through chemical fertilizer+25 % RDN through vermicompost+10 ml Anubhav Bio NPK Consortium/tree was found beneficial to increases the fruit length (3.42cm), fruit diameter (3.96cm), fruit weight (41.06g), fruit volume (39.87cc), number of fruits per tree (2496) and fruit yield (16.34 t/ha) in aonla cv. Gujarat Aonla-1.

Sneha Singh *et al*. (2021) conducted a field experiment on evaluate the effect of integrated nutrient management on economic return for aonla production. Themaximum yield attributing characters such asfruit weight, fruit size, fruit volume, pulp: stone ratio, fruit yield, and economics *viz* total cost, gross return, the net return, and benefit: cost ratio were noted under the treatment T_7: 75% RDF+30 kg Vermicompost+250g *Azotobacter*+250g PSB.

Pomegranate

Hiwale (2009) mentioned about an experiment carried out at CHES, Vejalpur on pomegranate crop and

reported that fruit characteristics of pomegranate like fruit weight (188.75 g), fruit length (69.72 mm), fruit retention per plant (57) and fruit yield (10.75 kg/ plant) were significantly observed maximum when plants treated with 50 per cent N through FYM+25 per cent N through castor cake+25 percent N through urea. Dighe *et al.* (2014) reported that total number of fruits per tree (86.27), marketable fruit yield (27.95 kg/ tree or 20.68 ton/ ha) and total fruit yield (31.06 kg/ tree or 22.98 ton/ha) were found significantly maximum when pomegranate plants treated with GRDF while average weight of fruit (370 g) were found significantly maximum in 50% RDN and 50% N through FYM treatment. Dutta Ray *et al.* (2014) investigated that the fruits of pomegranate treated with 300 g nitrogen+1 kg neem cake plant per hectare showed significantly maximum fruit weight (239.83 g), fruit length (7.75 cm), fruit yield (6.94 kg/plant), juice content (75.63%), total soluble solid (12.29°Brix), TSS/ acid ratio (31.36), reducing sugar (9.78%) and total sugar (10.74%) with minimum acidity (0.39%). Greeshma *et al.* (2017) carried out an experiment on pomegranate crop at Kaladagi village of Bagalkot district, Karnataka and recorded the highest number of hermaphrodite flowers (139.0), number of fruit (98.01) and marketable fruit yield (26.43 kg/plant & 19.56 t/ha) with application of 50% RDN & P_2O_5 (200: 100: 200 N:P_2O_5:K_2O g per plant)+20 kg oil cakes+bioinoculants treatment. Whereas, fruit weight (294.20 g) and size (77.19 & 102.55 mm fruit diameter and length) was noticed maximum in 75% RDN & P2O5 (300: 150: 200 N: P_2O_5:K_2O gram per plant)+10 kg oil cakes+bioinoculants treatment. Kirankumar *et al.* (2018) conducted an experiment on pomegranate at the farmer's field of Somerhalli village, Hiriyurtaluk of Chitradurga district, Karnataka and revealed that application of 100% recommended dose of fertilizers (RDF) along with vermicompost+poultry manure+*Azospirillum*+PSB+KSB has recorded the maximum aril weight (212.47 g), aril per cent (72.53%) and lowest seed: aril ratio (0.016). Whereas, maximum TSS (15.30°Brix), TSS/TA ratio (46.48%), reducing sugars (12.79%), non-reducing sugars (1.65%) total sugars (14.39%) and lowest titratable acidity (0.33%) was recorded in 100% recommended dose of fertilizers (RDF) along with vermicompost+poultry manure+*Azospirillum*+PSB+KSB.

Conclusion

Based on the research conducted by several researchers on various arid zone fruits on INM; it may be concluded that application of biofertilizers and organic manure along with recommended dose of fertilizers improved the overall plant growth, yield and quality parameters in arid zone fruit crops. It also increases fertilizer use efficiency, ecological safety and maintain soil health on long term basis.

References

Aal, J.M., Patel, K.M, Patel, S.J. and Sindha, D.J. 2020. Effect of Integrated Nutrient Management on Fruit Yield of Aonla (*Emblica officinalis* Gaertn.) cv. Gujarat Aonla-1. *Int. J. Curr. Microbiol. App. Sci.*, 9(10): 417-423.

Aal, J.M., Patel, K.M., Rathva, J.C and Nadoda, S.R. 2020. Effect of integrated nutrient management on fruit quality and shelf life of Aonla (*Emblica officinalis* Gaertn.) cv. Gujarat Aonla-1. *International Journal of Chemical Studies*, 8(5): 1227-1230.

Anjali Massey, Meena, R.N. and Ashvin Kumar Meena. 2021. Effects of organic manures and green manuring on growth, yield, economics and quality of lemon grass (*Cymbopogon flexuosus*). In: Custard apple (A*nnona squamosa*) Based Agri-Horti system. *Bangladesh J. Bot.*, 50(3): 499-506.

Anonymous. 2016. International Food Policy Research Institute, Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030; International Food Policy Research Institute: Washington, DC, USA.

Anonymous. 2018. Ministry of Agriculture and Farmers Welfare. Department of Agriculture, Cooperation & Farmers Welfare. Horticulture Statistics Division. New Delhi, India. Controller of Publication, 458.

Arthi, L.R., Kumar, S., Arumugam, Shakila and Prabudas, V. 2023. Standardization of integrated nutrient management for enhancing the yield of Manila tamarind (*Pithecellobium dulce* (Roxb) Benth cv. Local. *Crop Res.,* 58: 248-250.

Asheesh Sharma, Prerak Bhatnagar, M.C. Jain, J. P. Singh. 2014. Effect of integrated nutrient management on plant environment variables in custard apple cv. Arka Sahan. *International Journal of Basic and Applied Agricultural Research,* 12: 235-239.

Asheesh Sharma, Prerak Bhatnagar and Santosh Kumar. 2017. Study the correlation effect of integrated nutrient sources and their interaction on soil properties of Custard Apple (*Annona squamosa*) field. *Int. J. Pure App. Biosci.,* 5 (3): 978-981.

Basith, M.A., Khan, M.A., Ahire, L.M. and Murali, V. 2018. Response of phalsa (*Grewia subinaequalis* DC.) to the dates of pruning and integrated nutrient management under sandy loam conditions of Southern Telangana state of India. *An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Science, Agriculture & Engineering.* VIII, Special issue, 68-70.

Berwal, M.K., Haldhar, S.M., Ram, C., Shil, S., Kumar, R., Gora, J.S. and Singh, D. 2021. *Calligonum polygonoides* L. as Novel Source of Bioactive Compounds in Hot Arid Regions: Evaluation of Phytochemical Composition and Antioxidant Activity. *Plants*, 10, 1156.

Bohane, L. and Tiwari, R. 2014. Effect of integrated nutrient management on physico-chemical parameters of ber under Malwa plateau conditions. *Annals of Plant and Soil Research,* 16(4):346-348.

Das, B., Chakraborty, D., Singh, V.K., Aggarwal, P., Singh, R. and Dwivedi, B.S. 2014. Effect of integrated nutrient management practice on soil aggregate properties, its stability and aggregate-associated carbon content in an intensive rice–wheat system. *Soil Tillage Res*., 136: 9–18.

Davidson, E.A., Galloway, J.N., Millar, N. and Leach, A.M. 2014. N-related greenhouse gases in North America: innovations for a sustainable future. *Curr. Opin. Environ. Sustain.,* 9-10: 1–8.

Dighe, S.S., Masalkar, S.D., Kulkarni, S.S., Kadlag, K.D., Chavan, U.D. and Patil, R.S. 2014. Effect of integrated nutrient management on yield of pomegranate (*Punica granatum* L.) cv. Bhagwa. *Ecology Environment & Conservation,* 20:479-483.

Dutta Ray, S.K., Takawale, P.V, Chatterjee, R. and Hnamte, V. 2014. Yield and quality of pomegranate as influenced by organic and inorganic nutrients. *The Bioscan*, 9(2):617-620

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

Gora, J.S., Verma, A.K., Singh, J. and Choudhary, D.R. 2019. Climate Change and Production of Horticultural Crops. In Agriculture Impact of Climate Change; CRC Press: Boca Raton, FL, USA, pp. 45–61.

Grebmer, V.K.J., Bernstein, R., Alders, O., Dar, R., Kock, F., Rampa, M., Wiemers, K., Acheampong, A., Hanano, B. and Higgins, R. 2020. Global Hunger Index—One Decade to Zero Hunger: Linking Health and Sustainable Food Systems; Welthungerhilfe: Bonn, Germany.

Greeshma, R.B.C., Suma, R., Nagaraja, M.S. and Kulapati, H. 2017. Effect of bio inoculants and organic supplementation on growth and yield of pomegranate. *International Journal of Environmental Sciences & Natural Resources,* 4(4):1-5.

Hiwale, S.S. 2009. The pomegranate. New Delhi, New India Publishing Agency. 158.

Jangid, R., Masu, M. M, Bhattacharjee, P. and Warang, O.S. 2021. Effect of different sources of nitrogen on fruit quality and shelf life of custard apple (*Annona squamosa* L.) cv. Sindhan. *Journal of Pharmacognosy and Phytochemistry,* 10(1): 824-826.

Kirankumar, K.H., Shivakumara, B.S., Suresha, D.E., Madaiah, D. and Sarvjna, B.S. 2018. Effect of integrated nutrient management on quality and biochemical parameters of pomegranate cv. Bhagwa under central dry zone of Karnataka. *International Journal of Chemical Studies*, 6(1): 5- 6.

Korwar, G.R., Pratibha, G., Ravi, V. and Palanikumar, D. 2006. Influence of organics and inorganics on growth, yield of aonla (*Emblica officinalis* Gaertn.) and soil quality in semi-arid tropics. *Indian Journal of Agricultural Sciences*, 76 (8):457-61.

Kumar, K. and Goh, K.M. 1999. Crop Residues and Management Practices: Effects on soil quality, soil nitrogen dynamics, crop yield, and nitrogen recovery. *Advances in Agronomy*, 68:197-319.

Kumar, R.M., Hiremath, S.M. and Nadagouda, B.T. 2015. Effect of single-cross hybrids, plant population and fertility levels on productivity and economics of maize (*Zea mays*). *Indian J. Agron.*, 60: 431–435.

Mandal, K.K., Rajak, A., Debnath, S. and Hasan, M.A. 2013. Integrated nutrient management in aonla cv. NA-7 in the red lateritic region of West Bengal. *Journal of Crop and Weed,* 9(1):121-123.

Mani, S., Meena, M.L., Kumar, V. and Ram, R.B. 2013. Impact of INM on growth and yield of phalsa *(Grewia subinaequalis* D.C.). *Environment and Ecology*, 31(2B): 898-903.

NHB. Indian Horticulture Database-2019; National Horticulture Board, Ministry of Agriculture and Farmer Welfare, Government of India: New Delhi, India, 2019.

Patel, D.R. and Naik, A.G. 2010. Effect of pre-harvest treatment of organic manures and inorganic fertilizers on post-harvest shelf life of sapota cv. Kalipatti. *Indian Journal of Horticulture*, 67(3):381-386.

Rathore, M. 2009. Nutrient content of important fruit trees from arid zone of Rajasthan. *J. Hortic. For.,* 1: 103–108.

Rathore, M. 2009. Nutrient content of important fruit trees from arid zone of Rajasthan. *J. Hortic. For.*, 1: 103–108.

Rikshita, R., Gondaliya, N.D., Polara, Yukta J.P., Sandip Makhmale and Shivani, R.P. 2023. Impact of integrated nutrient management on the growth and yield of sugar apple (*Annona squamosa* L.) cv. Sindhan. *The Pharma Innovation Journal*, 12(7): 3151-3154.

Sanwal, S.K. Mann, A. Kumar, A. Kesh, H. Kaur, G. Rai, A.K. Kumar, R. Sharma, P.C. Kumar, A. and Bahadur, A. 2022. Salt Tolerant Eggplant Rootstocks Modulate Sodium Partitioning in Tomato Scion and Improve Performance under Saline Conditions. *Agriculture*, 12: 183.

Sharath, A.A., Ghosh, S.N. and Das, B.C. 2016. Integrated nutrient management in bael (*Aegle marmelos* Corr.) in

New Alluvial soil. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, 2 (1): 41-46.

Singh, A. and Kumar, S. 2017. Effect of integrated nutrient management on physico chemical characters of bael (*Aegle marmelos* Correa) cv. Narendra Bael-9. *International Journal of Current Microbiology and Applied Sciences*, 6(6):287-296.

Singh, J.K., Singh D.K. and Singh, H.K. 2014. Integrated nutrient management studies on yield, physico-chemical characteristics and economic feasibility of bael (*Aegle marmelos* Correa) cv. Narendra Bael-9. *The Asian Journal of Horticulture,* 9 (2): 342-346.

Sneha Singh, Bhanu Pratap, Govind Vishwakarma, Ankita Rao and Alok Kumar Singh. 2022. Evaluation of Economic Feasibility for Aonla Production with the Aid of Integrated Nutrient Management. *Agriculture Association of Textile Chemical and Critical Reviews Journal*, 10(1): 39-44.

Suchismita Naik, Vijay Bahadur, Vipin M. Prasad, Saket Mishra, Anupriya Paul and Suchit John. 2021. Effect of Different Combinations of Organic Manures and Inorganic Fertilizers on Growth and Establishment of Custard Apple (*Annona squamosa*) cv. NMK-1 Golden Biological Forum – *An International Journal,* 13(3): 206-211.

U.N. 2021 World Population Prospects. Available online: https://population.un.org/wpp/.

Verma, R.S., Singh, H.K. and Verma, S.S. 2014. Effect of integrated nutrient management on plant growth, fruit yield and quality of phalsa (*Grewia subinaequalis* D.C.). *Asian Journal of Horticulture*, 9(1):48-52.

Vishwakarma, G., Yadav, A.L., Kumar A., Singh, A. and Kumar, S. 2017. Effect of integrated nutrient management on physicochemical characters of bael (*Aegle marmelos* Correa) cv. Narendra Bael-9. *International Journal of Current Microbiology and Applied Sciences*, 6(6):287-296.

Research Article

ISAH Indian Journal of Arid Horticulture

Year 2021, Volume-3, Issue-1&2 (January - December)

Performance of parthenocarpic cucumber (*Cucumis sativus* L.) under polyhouse condition as influenced by organic amendments

Piyusha Sharma[1], K.D. Ameta*[1], R.B. Dubey[2], R. A. Kaushik[1], Devendra Jain[3], K. K. Sharma[1] and R. Sharma[1]

[1]Department of Horticulture, [2]Department of GPB and [3]Department of MBBT
Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

ARTICLE INFO

Key Words: Cucumber, BD 500, BD 501, Dashparni, Silica, Biodynamic.

doi: 10.48165/ijah.2021.3.1.10

ABSTRACT

The study revealed that various treatment combinations of biodynamic, silica and *Dashparni* imparted significant effects on growth, yield and quality parameters of cucumber var. Nagene grown under protected cultivation. Out of various treatments, the treatment T_{10} (BD 500 @75g/ha + BD 501 @2.5g/ha+ Silica @1% + *Dashparni* @10%) was found superior for most of parameters studied *i.e.* vine length at 30 DAS (1.67 m), 60 DAS (2.67 m), final harvest (3.63 m), leaf area (509.17cm^2), days to first anthesis (26.07), days to first harvest (36.07), fruit weight (131.70 g), fruit volume (130.57 cc), fruit length (18.43 cm), fruit diameter (3.63 cm), number of branches (6.13), number of fruits per vine (31.43) yield per vine (4.20 kg), yield per square meter (10.07 kg) and yield per acre (40.30 t), whereas least performing treatment was found to be T_1 *i.e.* control.

Introduction

Cucumber (*Cucumis sativus* L.) belonging to family cucurbitaceae is a warm season vegetable, grown throughout the world under tropical and subtropical conditions. It is said to be the native of Northern India (Pursglove, 1969). It is one of the quickest maturing vine vegetables and widely grown throughout the country. The immature fruits of cucumber are said to have cooling effect, prevent constipation and indigestion. It is one of the most important vegetables and popular among polyhpouse growers due to early production and high profitability (Rajawat *et al.,* 2021). There is an urgent need to increase production of vegetable to feed millions of mouths, which seems possible only by increasing productivity. Land is limiting factor, hence boom in production can be achieved only through vertical harvesting (Ameta *et al.,* 2019). Parthenocarpic and gynoecious cucumber cultivars increase the potential to yield a high fruit load in controlled environments resulting in a high harvest index. Plants exhibiting a high harvest index will more efficiently use the limited growing area in a growth chamber (Meena *et al.,* 2017). In recent years, undoubtedly chemical fertilizers have played a critical role in providing nutrients for intensive crop production which heralded green revolution in the country and have changed India from a region of food scarcity to food sufficiency. But increased use of chemical fertilizers in an unbalanced manner has

*Corresponding author.
E-mail address: kdameta100@gmail.com (K.D. Ameta)
Received 05.01.2024; Accepted 07.03.2024

created problem of nutrient deficiencies, diminishing soil fertility and unsustainable crop yields (Dhakar *et al.,* 2023). These problems can be overcome by the use of organic amendments like biodynamic, silicon and *Dashparni* should be added to enrich fertility, improve soil structure, help to combat both abiotic and biotic stresses and work as natural insecticides. Among biodynamic preparations, uses of BD 500 and BD 501 have shown significant effect on crop growth, yield and disease minimization. BD 500 stimulates microorganisms and increases the availability of nutrients including trace elements. BD 501 complements BD 500 but works in atmosphere by enhancing photosynthetic uptake and increasing assimilation of nutrients.

Silicon (Si) beneficial effects on growth have been reported in a wide variety of crops, including horticultural crops (Cai and Qian, 1995). Si helps to combat both abiotic and biotic stresses, further excess of Si has no toxic reports so far (Ma and Yamaji, 2006). In cucumber, it was reported that addition of silicon of Si (100 mg/l) could increase the chlorophyll content, RuBP carboxylase activity (ribulose-bis-phosphate), root fresh weight and dry weight in cucumber plants grown in recirculating nutrient solution (Adatia and Besford, 1986). *Dashparni* ark is one of natural pesticide which used to control pest and diseases and improve richness of soil. Moreover, it acts as an enriched for greenery of the plants which is used for all kinds of agricultural crops (Ganvir, 2022).

Material and Methods

The experiment under polyhouse was conducted at Hi-Tech Unit, Rajasthan College of Agriculture, Udaipur (24°35'N latitude 74°42' longitude at 585.5 meters above mean sea level) during July-October, 2023 in *Kharif* season on cucumber var. Nagene. The trial was laid out in Completely Randomized Design with three replications. The polyhouse was covered with aluminate sheet and ultra violet stabilized low density polyethylene sheet having 200-micron thickness with provision of foggers. The experiment was comprised of ten treatments T_1 (Control), T_2 (BD 500 @75g/ha), T_3 (BD 501 @2.5g/ha), T_4 (BD 500 @75g/ha) + BD 501 @2.5g/ha), T_5 (Silica @1%), T_6 (*Dashparni* @10%), T_7 (BD 500 @75g/ha + Silica @1% + *Dashparni* @10%), T_8 (BD 501 @2.5g/ha + Silica @1% + *Dashparni* @10%), T_{10} (BD 500 @75g/ha + BD 501 @2.5g/ha + Silica @1% + *Dashparni* @10%) for polyhouse cultivation of cucumber, the seeds were sown in raised beds of 1 meter width and 45 cm above from ground level along with length of polyhouse were prepared. Basal dose of FYM was applied and mixed in the soil one week before sowing. Spray of BD 501 in soil was done before 1 day of sowing in morning hours. Seeds were sown at approximately 2 cm depth. All the cultural practices including irrigation and hoeing were carried out as per the standard commercial procedures. Plants were vertically trained with nylon ropes. Observation regarding vine length at 30 DAS, 60 DAS, final harvest (m), leaf area (cm^2), days to first anthesis, days to first harvest, fruit weight (g), fruit volume (cc), fruit length (cm), fruit diameter (cm), number of branches (at final harvest), number of fruits per vine, yield per vine (kg), yield per square meter (kg) and yield per acre (t) were recorded on selected five tagged plants of each treatment and further analysed.

The length of vine was measured at 30, 60 days after sowing and at final harvest from the base of stem to the highest tip of the plant with the help of measuring tape and mean value was expressed in meter. Leaf area was measured at full maturity stage with the help of leaf area meter and then mean value was expressed in cm^2. The number of days taken for anthesis and number of days taken to first picking from the date of sowing in each tagged plant and average value was expressed in days. Total number of branches of the individual plants was counted at the time of final harvest. Fruits were harvested when they attend horticulture maturity. Number of marketable fruits were counted at each picking and summed for all the picking. Five marketable fruits were randomly selected from each replication during the picking and weight of individual fruit was measured in grams with the help of digital balance and average was computed. Fruit length was measured with the help of meter scale, fruit diameter was measured with the help of vernier caliper from the center of each fruit and average value was expressed in cm. Fruit volume was measured by water displacement method and measured in cubic centimeter. Total yield per plant was derived by multiplying average number of fruits per plants by average weight of fruit and expressed in gram. Total yield per square meter area was derived from yield per plant and respective crop geometry. The yield per acre was calculated by multiplying yield per square meter with 4000 and expressed in ton. In polyhouses approx. 40 per cent area is used in path, hence calculation was done including this area not only for effective area of planting *i.e.* approx. 60 per cent. The recorded observations were analysed statistically as per the procedure advocated by Panse and Sukhatme (1985) for drawing inferences.

Results and Discussion

The results (Tables 1 and 2) of the study revealed significant differences in the response of various growth and yield parameters to different treatments. In general, different

treatments increased growth and yield in cucumber over control. The results showed that higher vine length at 30 DAS(1.67 m), at 60 DAS (2.67 m), at final harvest (3.63 m), leaf area (509.17 cm^2), number of branches (6.13), number of fruits per vine (31.43), fruit weight (134.70 g), fruit volume (130.57 cc), fruit length (18.43 cm), fruit diameter (3.63 cm), yield per vine (4.20 kg) and yield per square meter (10.07 kg), yield per acre (40.30 t) and minimum days to first anthesis (26.07) were reported for treatment T_{10} (BD 500 @7 5g/ha + BD 501 @2.5g/ha + Silica @1% + *Dashparni* @10%), whereas treatment T_8 (BD 500 @75g/ ha + Silica @1% + *Dashparni* @ 10%) and T_9 (BD 501 @ 2.5g/ ha + Silica @ 1% + *Dashparni* @10%) were found best for earliness as both these treatments took least equal days for first harvest (35.63). Best performance shown by treatment T_{10}, might be due to presence of biodynamic preparations, silica and *Dashparni* as constituents of this treatment combination as BD 500 causes significant internal changes in the soil, the principal changes are a significant drop in pH, an increase in aerobic status and production of nitrate causing more vine length, similarly BD 501, enhances the photosynthesis, and as such compliment the activity of the preparation BD 500, which works mostly in the root zone of the plant. Findings of Sharma *et al.* (2012) was in conformity with this study as significantly higher plant height has been recorded in cumin. Increased vine length in cucumber is also associated due to presence of silica as silicon deposited in the walls of epidermal cells after absorption by plants, contributes considerably to stem strength (Savant *et al.*, 1999). The increase in growth parameter due to the stimulation of growth by silicon could be either indirect, owing to the protective effects of silicon against pathogens or direct as it impacts both morphological changes and physiological processes in plants as it is involved directly or indirectly in cell metabolism. Present results are in conformity with the findings of Gowda *et al.* (2015).

BD-500 and BD-501 as bio-enhancers are rich source of microbial consortia, macro and micro nutrient and plant growth promoting substance including immunity enhancers. Results of the study are in conformity with findings of Aarya *et al.* (2023). *Dashaparni* extract also boosted overall growth of plants indirectly through imparting disease resistance as reported by Chavan *et al.* (2023), further, *Dashparni* also having cow dung and cow urine as its constituents, that might be a reason for luxurious growth of crop plants. Increased fruit weight, fruit length, fruit diameter and fruit volume in treatment T_{10} might be due cumulative effects of various components of treatment *i.e.* Biodynamic, *Dashparni* and silica. Findings of Diwan *et al.* (2019) was in close proximity with present results. Similarly, Patel *et al.* (2021) observed beneficial effect of foliar application of *Dashparni*. Highest yield due to application of BD 500 and BD 501 has been reported by Sharma *et al.* (2012) while working with cumin, similarly highest yield due to application of silica has been reported by Abbas *et al.* (2015) while working with okra.

Table 1: Effect of organic amendments on growth and flowering attributes of cucumber as influenced by various organic amendments.

Treatment	Treatment details	Vine length (cm)			Leaf area (cm^2)	Days to first anthesis	Number of branches
		30 DAS	60 DAS	at final harvest			
T_1	Control	1.07	2.10	3.10	413.73	29.13	4.67
T_2	BD 500 (75g/ha)	1.20	2.20	3.23	434.93	27.90	5.10
T_3	BD 501 (2.5g/ha)	1.23	2.23	3.30	439.77	29.20	5.13
T_4	BD 500 (75g/ha) +BD 501 (2.5g/ha)	1.37	2.43	3.47	450.13	27.60	5.57
T_5	Silica (1%)	1.23	2.27	3.20	440.77	29.83	5.27
T_6	*Dashparni* (10 %)	1.27	2.27	3.20	437.20	28.40	5.30
T_7	Silica (1%) + *Dashparni* (10 %)	1.37	2.47	3.43	456.13	27.90	5.60
T_8	BD 500(75g/ ha) +Silica (1%) +*Dashparni* (10 %)	1.63	2.57	3.53	491.87	26.73	5.87
T_9	BD 501(2.5g/ha) +Silica (1%) +*Dashparni* (10 %)	1.60	2.60	3.60	493.63	26.10	5.93
T_{10}	BD 500 (75g/ha) +BD 501 (2.5g/ha) +Silica (1%) +*Dashparni* (10 %)	1.67	2.67	3.63	509.17	26.07	6.13
	C.D. (P=0.05)	NS	NS	NS	7.491	2.304	0.396
	SE(m) ±	0.204	0.157	0.149	2.522	0.776	0.133

NS= non-significant

Table 2: Effect of organic amendments on fruit and yield traits of cucumber as influenced by various organic amendments.

Treatment	Treatment details	Days to first harvest	Number of fruits / vine	Fruit weight (g)	Fruit volume (cc)	Fruit length (cm)	Fruit diameter (cm)	Yield/vine (kg)	Yield/m^2 (kg)	Yield/acre (t)
T_1	Control	39.63	26.97	121.27	116.40	12.80	2.50	3.27	7.83	31.33
T_2	BD 500 (75g/ha)	38.67	27.37	124.00	120.90	14.73	2.70	3.40	8.13	32.57
T_3	BD 501 (2.5g/ha)	39.40	29.60	125.10	121.27	15.17	2.87	3.67	8.90	35.60
T_4	BD 500 (75g/ha) +BD 501 (2.5g/ha)	37.07	29.00	128.13	124.50	16.60	2.97	3.70	8.90	35.67
T_5	Silica (1%)	38.43	28.50	124.40	120.40	15.37	2.57	3.53	8.53	34.03
T_6	*Dashparni* (10 %)	37.60	28.13	123.73	118.83	14.60	2.70	3.47	8.37	33.40
T_7	Silica (1%) + *Dashparni* (10 %)	36.50	29.20	128.43	124.43	16.73	2.90	3.73	9.00	36.00
T_8	BD 500(75g/ ha) +Silica (1%) +*Dashparni* (10 %)	36.07	30.17	130.77	126.53	17.60	3.53	3.93	9.50	37.90
T_9	BD 501(2.5g/ha) +Silica (1%) +*Dashparni* (10 %)	36.07	30.10	131.03	128.60	17.57	3.40	3.93	9.47	37.87
T_{10}	BD 500 (75g/ha) +BD 501 (2.5g/ha) +Silica (1%) +*Dashparni* (10 %)	35.63	31.43	134.70	130.57	18.43	3.63	4.20	10.07	40.30
	C.D. (P=0.05)	2.294	2.396	3.486	4.962	1.652	0.371	0.340	0.824	3.269
	SE(m) ±	0.772	0.807	1.174	1.670	0.556	0.125	0.115	0.277	1.100

Conclusion

On the basis of results obtained in present investigation it is concluded that among the different treatments used, treatment T_{10} (BD 500 @75g/ha + BD 501 @2.5g/ha + Silica @1% + *Dashparni* @ 10%) proved the most beneficial for most of parameters studied *viz.,* leaf area, days to first anthesis, days to first harvest number of branches per plant, fruit weight, fruit length, fruit diameter, number of fruits per plant, fruit volume, yield per vine, yield per square meter and yield per acre of cucumber grown under polyhouse condition.

Acknowledgement

I thank Department of Horticulture, RCA, Udaipur for giving me opportunity for the completion of this research work. I emphatically express my deep sense of gratitude towards my Major Advisor, Dr. K.D. Ameta, Associate Professor, Department of Horticulture, RCA, Udaipur, for his sensible and inspiring guidance, discreet approach, persistent encouragement during the entire course of investigation.

References

Aarya, S., Sharma, A., Barche, S., Uikey, P. and Arya, V. (2023). Effect of biodynamic package with biofertilizer and vermicompost on the growth parameters of Radish (*Raphanus sativus*) under Malwa region of Madhya Pradesh. *The Pharma Innovation Journal*, 12(12): 204-208.

Abbas, T., Balal, R. M., Shahid, M. A., Pervez, M. A., Ayyub, C. M., Aqueel, M. A. and Javaid, M. M. (2015). Silicon-induced alleviation of NaCl toxicity in okra (*Abelmoschus esculentus*) is associated with enhanced photosynthesis, osmoprotectants and antioxidant metabolism. *Acta Physiologiae Plantarum*, 37 :1-15.

Adatia, M.H. and Besford, R.T. 1986. The effects of silicon on cucumber plants grown in recirculating nutrient solution. *Annals of Botany*, 58: 343-351.

Ameta, K.D., Kaushik, R.A., Dubey, R.B. and Rajawat, K.S. 2019. Protected cultivation- an entrepreneurship for modern agriculture. *Biotech Today*, 9(1):35-40.

Cai, D.L. and Qian, F.J. 1995. Effect of silicon fertilizer on yield and quality of apples. *Journal of Regional Research and Development*, 14: 64-66.

Chavan, C. D., Kurlapkar, D. D. and Gaikwad, D. K. 2023. Effectiveness of foliar applications of plant extracts on pomegranate plantlets. *Current Agriculture Research Journal*, 11(2): 534-540.

Dhakar, R., Ameta, K. D., Choudhary, R. and Doodhwal A. 2023. Standardization of fertigation scheduling in tomato under poly-house. *Frontiers in Crop Improvement*, 11: 1063-1068.

Dutta, A. K., Majee, S. K. and Das, R. 2018. Effect of BD-501 and panchagavya on yield and quality of garden pea cv. Arkel. *International Journal of Latest Engineering and Management Research*, 3(2): 50-53.

Gaikwad, B.B., Bhosle, B.B. and Bhede, B.V. 2020. Evaluation of different bio-pesticides against aphid on okra. *Journal of Entomology and Zoology Studies*, 8: 339-345.

Ganvir, S.S., Mahalle, S.P. and Deshmukh, V.A. 2022. Organic inputs agro-based entrepreneurship. *International Research Journal of Modernization in Engineering technology and Science*, 4: 2101-2106.

Gowda, D. C. M., Lingaiah, H., Nachegowda, V. and Anil., S. 2015. Effect of specialty fertilizers on growth and yield of tomato (*Solanum lycopersicum* L.). *Plant Archives*, 15: 335-338.

Ma, J. F. and Yamaji, N. 2006. Silicon uptake and accumulation in higher plants. *Trends in Plant Science*, 11: 392-397.

Panse, V.G. and Sukhatme, P.V. 1985. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research Publication.

Patel, M. M., Meena, L. K., Arvadiya, L. K., Patel, D. D. and Zinzala, M. J. 2021. Comparative study on improved organic practices of summer greengram (*Vigna radiata* L.). *International Journal of Chemical Studies,* 9(1): 2368-2370.

Pursglove, J.W. 1969. Tropical Crops Dicotyledons Longmans. *Green and Corporation Limited London and Herlow*. 544-545.

Rajawat, K.S., Ameta, K. D., Tak, J., Singh, M. and Choudhary, R. 2021. Response of organic and inorganic nutrient sources on soil nutrient status of cucumber production under protected cultivation. *Current Journal of Applied Science and Technology*, 40 (44): 44-49.

Ram, R.A. and Kumar, A. 2019. Bio-dynamic agriculture: An advance stage of organic farming. *Journal of Eco- friendly Agriculture* 14: 34-37.

Savant, N. K., Korndorfer, G. H., Datnoff L. E. and Gii. 1999. Silicon nutrition and sugarcane production. *Journal of Plant Nutrition*, 22: 1853-1903.

Sharma, S. K., Laddha, K. C., Sharma, R. K., Gupta, P. K., Chatta, L. K. and Pareek, P. 2012. Application of biodynamic preparations and organic manures for organic production of cumin (*Cuminum cyminum* L.). *International Journal of Seed Spices*, 1: 7-11.

Somendra, M., Ameta, K.D., Kaushik, R.A., Meena, S.L. and Singh, M. 2017. Performance of cucumber (*Cucucmis sativus* L.) as influenced by humic acid and micro nutrients application under polyhouse condition. *International Journal of Current Microbiology and Applied Science.* 6(3): 1763 -1767.

Somasundaram, E., Sankaran, N., Meena, S., Thiyagarajan, T. M., Chandaragiri, K. and Panneerselvam, S. 2007. Response of green gram to varied levels of biodynamic compost (organic nutrition) foliar spray. *Madras Agricultural Journal*, 90: 169-172.

Trivedi, A., Sharma, S. K., Hussain, T., Sharma, S. K. and Gupta, P. K. 2013. Application of biodynamic preparation, bio control agent and botanicals for organic management of virus and leaf spots of blackgram (*Vigna mungo* L. Hepper). *Academia Journal of Agricultural Research*, 4: 60-64.