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Assessment of Hast Bahar (Flowering Season) for Yield and Quality of Pomegranate at Farmer's Field

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ABSTRACT

An on-farm trail (OFT) on assessment of flowering season of pomegranate was tested. The experiment was conducted with three treatments comprising mrig bahar flowering as a control and hast bahar flowering with and without application of micronutrients and kaolin clay during June to February for three consecutive years from 2019–2022 in the different farmer fields at the Tharad taluka of Banskantha district, Gujarat, India. The treatment T_1 Mrig bahar (June-July) flowering recorded the maximum total number of flowers (293.67) hermaphrodite flowers (108.9) and fruit setting (71.85%). Further, T_1 exhibited the highest average number of fruits plant^{-1} (79.0) and maximum fruit yield (11.78 kg plant^{-1}) followed by T_3 and T_2 treatments (10.14 kg plant^{-1} and 9.02 kg plant^{-1}) respectively. In terms of total fruit yield, Treatment T_1 exhibited the highest fruit yield of (9813 kg ha^{-1}). Whereas, maximum individual fruit weight 179.44 g plant^{-1} and Total Soluble Solids (15.75°Brix) were found in Treatment T_3. Moreover, treatment T_3 Hast Bahar (Sept–Oct) flowering with foliar spray of micromix 0.2% and kaolin Clay 4.0%) has the lowest average fruit cracking (6.30%) and the lowest incidence of sunburn (8.80%) across the three years. However, treatment T_1 recorded highest average fruit cracking (18.90%). Further, during the Mrig bahar season, incidence of leaf spots and fruit rot was observed higher compared to the Hast bahar flowering. In case of economics, treatment T_3 obtained the highest average income of 411813 ha^{-1} as compared to treatment T_2 and T_3 ₹ 353074 ha^{-1} and 333425 ha^{-1}, respectively.

KEYWORDS: Bahar, Kaolin clay, quality, sunburn

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1. INTRODUCTION

Pomegranate (*Punica granatum* L.) is an important fruit crop of the tropical and subtropical regions and belongs to the family Punicaceae. Pomegranates are well-suited to semi-arid and subtropical climates, making them an invaluable crop for regions characterized by water scarcity and high temperatures. It is one of the most economical functional crops in the world, having wider ecological adoptability and high profitability (Erkan and Dogan, 2018). The fruits are used for table purposes and generally consumed as fresh fruit beverages, jam and jelly, (Brunda et al., 2022). It also processed to make products like wine (Cardinale et al., 2021). Pomegranate fruit is a good source of minerals such as iron, zinc, and manganese. It also contains vitamin C and antioxidants such as anthocyanin (Asadi et al., 2019). The fruit arils contain water (85%), sugars (10%), mainly fructose and glucose, and pectin (1.5%). (Sharma et al., 2017). It also has bioactive compounds that promote health (Kandylis et al., 2020). Pomegranate rind extracts tannin used as tanning material (Deniz, 2016), in fabric and leather dyeing in the leather processing industry (Polat et al., 2024) and also used for the pharmaceutical purposes (Maphetu et al., 2022).

India is one of the largest producers of pomegranates globally, with states like Maharashtra, Gujarat, Karnataka, Rajasthan, and Andhra Pradesh being the major contributors. The total area under cultivation is around 2.75 lakh ha. and production accounts for around 3.0 lakh mt (Anonymous, 2022). Gujarat is the second-largest pomegranate-growing state in India after Maharashtra having 0.45 lakh ha. area with the production of 6.96 lakh mt. Kutch and Banaskantha districts contribute the maximum area and production, which is about 77% of the total area of Gujarat. Since decades, the pomegranate area in northern Gujarat has increased substantially, particularly in Banaskantha districts, which share about 82% of the area of the north Gujarat region (Anonymous, 2021).

Pomegranate flowers bloom all year in tropical and humid climates. However, in the subtropical and arid regions, there are three distinct seasons for floweringi.e ambe bahar (Feb-March), mrig bahar (June–July) and hasta bahar (Sep –Oct) (Patil and Karale, 1985; Pal et al., 2014; Kumar et al., 2021b), but the yield and quality differ from season to season (Saroj and Kumar, 2019). The basic principle of Bahar management and crop regulation is to manipulate the natural flowering of the pomegranate plant in the desired season, which contributes to increased fruit yield, quality, and profitability (Shivran et al., 2020). It is a pivotal practice in pomegranate cultivation that requires careful attention and management. Farmers employ various techniques, including selective pruning, withholding of water, and use of ethrel application (Kumar et al., 2021a), to optimize bahar management and promote robust fruiting.

In northern Gujarat, pomegranate area has increased substantially, but the productivity and quality of fruits are deteriorating. The farmers of Banaskantha district take Mrig bahar crop,. but the mrig bahar crop fails due to the incidence of various foliar diseases (Addangadi et al., 2021), predominantly Alternaria black spots, Cercospora spots, Phytophthora fruit rot, and Anthracnose, (Chavan and Dhutraj, 2017).This is also known as plug in the local name in the region.The soil of the region having low carbon contents (Kumar et al., 2015), which is neutral to mildly alkaline and deficit of micronutrients (Panchal et al., 2023). Moreover, the fruit quality is also deteriorating due to the incidence of fruit cracking and sun burning. Therefore, the on-farm trail on the assessment of hast bahar (flowering season) for yield and quality of pomegranate at the farmer's field was planned to evaluate the growth and yield performance in the local environment and field situation.

2. MATERIALS AND METHODS

An on-farm trail (OFT) assessment of hast bahar (flowering season) for yield and quality of pomegranate was done at different farmer fields under the KVK Banaskantha-II Jurisdiction area. A total of 15 trials were conducted in the villages Karnasar (24°22'05"N71°41'42"E), Budhanpur(24° 25'40"N71°38'25"E), Dodgam (24°20'01"N71°35'51"E)and Uchpa (24°25'08"N71°33'53"E) of Tharad Taluka, Gujarat, Indiaduring June to February of 2019–20, 2020-21 and 2021–22 in a total area of 2.0 ha. The trail was conducted on a five-year-old 'Bagawa' cultivar of pomegranate. The pomegranate plants were grown on sandy loam soil at 4×3 m^2 apart and irrigated by a drip irrigation system. A total of 50 plants were selected at one farmer's field for the treatment application and marked with the tag. Farmers of the regions practicing Mrig bahar season (Jun–July Flowering) in pomegranate; therefore, the treatment T_1 Mrig Bahar (Jun–July Flowering) was taken as control/farmer practices, T_2 Hast bahar (Sep–Oct Flowering), and T_3 Hast bahar (Oct–Nov Flowering)+Foliar spray of micromix 0.2% and Kaolin clay 4%. The mircomix grade IV, containing five micronutrients, viz., zinc (Zn) 6.0%, iron (Fe) 4.0%, copper (Cu) 0.5%, manganese (Mn) 1.0%, and boron (B) 0.5%, was foliar sprayed at 20, 40, and 60 days after defoliation. However, kaolin clay was sprayed three times at intervals of 140, 160, and 180 days after defoliation. All the selected plants were fairly uniform in growth and vigor. The plants were given uniform cultural operations during the trial. The observations on total number of flowers, number of hermaphrodite flowers, number of fruits per plant, fruit weight, and fruit yield (kg $tree^{-1}$ and kg ha^{-1}) were recorded. Fruit setting (%) was calculated using the formula (Fruit set

(%)=Number of fruitless Number of perfect flowers^{-1}×100), fruit cracking and Sun Burning percentage were recorded using the formula (Fruit cracking (%)=Number of cracked fruits Total number of fruits^{-1}×100), and fruit sun burn (%) =Number of sunburned fruits Total number of fruits^{-1}×100) (Al-Saifet al., 2022). However, percentage disease and pest incidence was calculated by the formula (Number of infected plantstotal number of assessed plants^{-1}×100). The farmer's feedback was also recorded to refine the technology if needed.

3. RESULTS AND DISCUSSION

3.1. Weather conditions at the study area

The variations in the weather conditions between the two flowering seasons and across the years studied. During the Mrig bahar season, the maximum temperature ranges from approximately 32.41°C to 33.79°C, while the minimum temperature varies between 19.55°C and 20.70°C. Similarly, humidity levels fluctuate between 55.33% and 67.52%. In contrast, during the Hast Bahar season, temperature and humidity variations are more pronounced. Further, temperature and humidity observed low as compare to the rainy season that favoured low disease incidence during hast bahar. Moreover, Sunshine hours during the Mrig bahar season range from 5.57 to 6.75 hours, while Hast Bahar season, sunshine hours fluctuate between 7.63 and 8.83 hours.

3.2. Flowering and fruit setting

The results on total number of flowers, numbers of hermaphrodite flower and fruit setting per cent presented in Table 1 show that the treatment T_1 Farmer Practice (Mrig bahar) Jun–July Flowering recorded maximum total number of flowers, hermaphrodite flowers and fruit setting per cent 293.67, 108.9 and 71.85 respectively. Fallowed by the treatment, T_3 (Hast Bahar, with foliar spray of Micromix 0.2% and Kaolin Clay 4.0%). It appears that T_1 had the highest total number of flowers and hermaphrodite flowers, as well as the highest fruit setting percentage. T_2 had the lowest total number of flowers, hermaphrodite flowers, and fruit setting percentage. Numbers of total flower and percent of hermaphrodite flower was found less in Hast bahar with and without use of substances. The poor flowering might be due to the insufficient of stress requirement for flower initiation during winter.(Shivran et al., 2020). Hasta bahar start after the rainy season and hence it is difficult to give proper rest for the plants therefore the flowering gets less (Raghunath and Rangappa, 2017). However, the fruits quality increases due to the bright sun shine hours during fruit development.

Table 1: Performance of flowering season on flowering and fruit setting of pomegranate

Treatments	Total no. of flower	No. of hermaphrodite flower	Fruit setting (%)
T_1: Farmer practice (Mrig bahar) Jun–July flowering	293.67	108.99	71.85
T_2: Hast Bahar (Sep–Oct flowering)	173.37	94.86	61.96
T_3: Hast bahar, foliar spray of micromix 0.2% and Kaolin clay 4.0%	195.53	98.61	64.03

3.3. Yield and quality performance

The data presented in the Table 2 reveals variations in yield and quality parameters among three distinct treatments. Specifically, Treatment T_1 exhibited the highest average number of fruits per plant 79, followed by T_3 with 68, and T_2 with 60. Furthermore, the fruit yield per plant was observed to be highest in Treatment T_1 at 11.78 kg, followed by T_2 with 10.14 kg and T_3 with 9.02 kg. In terms of total fruit yield, Mrig bahar exhibited the highest yield at 9813 kg ha^{-1}, followed by Treatment T_3 with 8444 kg ha^{-1}. The maximum individual fruit weight was found in Treatment T_3 at 179.44 grams, followed by T_2 with 166.05 grams, while T_1 had the lowest at 148.2 grams. The findings suggest that Treatment T_3, which involves Hast bahar with a foliar spray of Micromix 0.2% and Kaolin clay 4.0%, demonstrates superior fruit yield per hectare compared to Treatment T_1, which has the lowest yield. Furthermore, The TSS data (Figure 1) revealed that the highest total soluble solids (TSS) content was observed in T_3 (Hast bahar with foliar spray of micromix 0.2% and Kaolin clay

Table 2: Performance of flowering season on yield attributes of pomegranate at farmers fields

Treatments	No. of fruit (plant^{-1})	Average fruit weight (g)	Fruit yield (kg plant^{-1})	Fruit yield (kg ha^{-1})
T_1: Farmer practice (Mrig bahar) Jun–July flowering	79.0	148.2	11.78	9813
T_2: Hast Bahar (Sep–Oct flowering)	60.0	166.05	9.02	7510
T_3: Hast bahar, foliar spray of micromix 0.2% and Kaolin clay 4.0%	68.0	179.44	10.14	8444

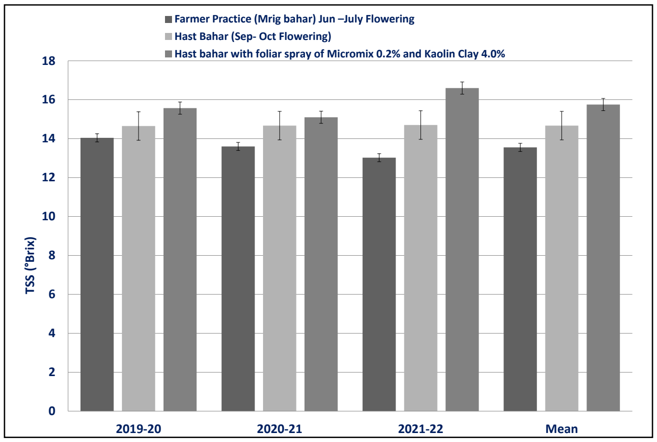

Figure 1: Performance of flowering seasons on TSS content (°Brix) of pomegranate

4.0%), measuring 15.75°Brix. In contrast, T_2 Hast Bahar (Sep–Oct Flowering) recorded a TSS content of 14.67°Brix. The lowest TSS content was recorded in T_1 Farmer Practice (Mrig bahar) during Jun–July Flowering, measuring 13.55°Brix. Moreover, treatment T_3 is characterized by higher average fruit weight. These outcomes imply that Treatment T_3 may be the most efficacious in terms of both fruit yield and fruit quality among the three treatments. The production during Mrig bahar (Jun–July flowering) was recorded higher than the Hast bahar (Sep–Oct flowering). Though rainy season crop give higher yield, but the qualities deteriorated and the fruit is often infested by many pests and diseases, (Singh et al., 2006; Rawal and Ullasa, 1988). Further, there was difference in TSS of fruit juice during different bahar treatments. The fruits harvested during November–December had low content of TSS compare to those harvested during Feb march. This might be due to the bright sunshine during fruit ripening enhanced the sugar level in fruit. (Hiwale, 2009) also reported a good crop in the September flowers because the period of fruit development coincided with maximum moisture availability and cool climate, leading to fewer incidences of insect pests, diseases, and fruit cracking, thereby improving the quality of fruits.

3.4. Sun burning and cracking

The data presented in Table 3 indicated that T_3 (Hast Bahar with foliar spray of micromix 0.2% and Kaolin clay 4.0%) has the lowest average fruit cracking percentage (6.3%), followed by T_2 Hast Bahar (Sep–Oct flowering) with 9.4%, and T_1 farmer practice (Mrig bahar) during Jun–July flowering with the highest average fruit cracking percentage of 18.9%. Moreover, T_3 (Hast bahar with foliar spray of micromix 0.2% and Kaolin clay 4.0%) treatment has the lowest percentage of sunburn across the three years, with a mean of 8.8%. On the other hand, treatment T_1 farmer practice (Mrig bahar) during June–July flowering has the highest

Table 3: Performance of flowering season on incidence of fruit cracking and sun burning in pomegranate at famer's field

Treatments	Fruit cracking (%)	Sun burning (%)
T_1: Farmer practice (Mrig bahar) Jun –July flowering	18.90	22.70
T_2: Hast Bahar (Sep–Oct flowering)	9.37	11.13
T_3: Hast bahar, foliar spray of micromix 0.2% and Kaolin clay 4.0%	6.30	8.80

percentage of sunburn with a mean of 22.7%. The finding is in agreement with (Singh et al., 1990; Singh et al., 2006; Singh and Kingsly, 2007). However, treatment T_2 Hast Bahar (Sep–Oct flowering) falls in between with a mean of 11.1%. Further, Hast bahar flowering with a foliar spray of Micromix 0.2% and Kaolin clay 4.0% performed better in terms of reducing fruit cracking and sun burning compared to Hast bahar and Mrig bahar without any substance application. Fruit cracking is a physiological disorder that occurs during fruit growth and development (Singh et al., 2014), which significantly affects fruit quality. In general, cracking is associated with adverse environmental conditions (Abd and Rahman, 2010; Singh et al., 2020), especially during fruit development and maturity. The nutrients, mainly boron, calcium, zinc, and potash deficiency, are also major factors that cause cracking in pomegranate (Saei et al., 2014). The cracking is more evident when the fruits are at maturity (Hoda and Hoda, 2013). Sun scalding is also a major threat to pomegranate in the arid region of India. It is the most important agent causing losses in Iran and other pomegranate-producing countries (Farazmand, 2013). Kaolin is a white clay particle that reduces heat stress and sunburn by covering the plant surface (Melgarejo et al., 2004). Foliar sprays of kaolin clay are effectively used in a variety of fruit trees (Hamdy et al., 2022) to reduce sunburn and improve the physical and chemical quality of fruits (Colavita et al., 2011; Ennab et al., 2017). It also enhances photosynthesis and the uptake of nutrients (Zaky, 2018). In the present trail, the low incidence of fruit cracking and sun burning during hast bahar might be due to the application of Micromix 0.2% and Kaolin clay 4.0%, which improved the nutritional status of the crop and reduced the effect of temperature fluctuation due to the Kaolin clay on fruit and leaf surfaces..

3.5. Incidence of diseases

The data depicted in Table 4 showed the highest incidence of leaf spot (26.1%) and fruit rot (10.70%), respectively, during Mrig bahar flowering (Treatment T_1) in all consecutive years. However, Hast bahar with a foliar spray of Micromix 0.2% and Kaolin clay 4.0% (Treatment T_3)

Table 4: Performance of flowering season on incidence of disease in pomegranate at famer's field

Treatments	Disease incidence (%)	
	Leaf spots	Fruit rot
T_1: Farmer practice (Mrig bahar) Jun –July flowering	26.10	10.70
T_2: Hast Bahar (Sep–Oct flowering)	5.03	3.20
T_3: Hast bahar, foliar spray of micromix 0.2% and Kaolin clay 4.0%	5.30	2.70

registered the lowest incidence of leaf spots and fruit rot, which was 5.3 and 2.7%, respectively. Further, during the Mrig bahar flowering season, the incidence of leaf spots and fruit rot was observed to be highest compared to the Hast bahar flowering (Treatment T_2). The Hast Bahar flowering season with a foliar spray of Micromix 0.2% and Kaolin clay 4.0% (Treatment T_3) was found to be the most effective in reducing leaf spot and fruit rot incidence compared to Hast Bahar without any substance application. The impact of leaf spot and fruit rot was most pronounced in the Mrig Bahar flowering season (Addangadi et al., 2021). During the rainy season (August, September and October), when the Mrig bahar fruits develop, there is an upsurge in disease occurrence due to the conducive environment (Singh et al., 2011; Kumar et al., 2021b). This resulted in a decrease in both fruit production and quality during the fruit harvest in the months of November and December, according to (Padule and Kaulgand, 1991). Conversely, in the colder spring season, the less favourable conditions for diseases led to a reduction in their incidence. The hast bahar crop was less prone to these diseases (Raghunath and Rangappa, 2017), thereby maintaining good fruit quality. Nevertheless, when micromix were sprayed during the hast bahar, the disease incidence was reduced. The effect of micronutrients on disease severity can be attributed to their involvement in the physiology and biochemistry of the plant (Marschner, 1995). According to Dordas (2008), micronutrients affect disease resistance indirectly, and among the micronutrients, Mn and zinc can control a number of diseases. Mn plays an important role in lignin biosynthesis and phenol biosynthesis, while Zn enhances the resistance of the plant by stabilizing root cell membranes (Khoshgoftarmanesh et al., 2017; Bastakoti, 2023).

3.6. *Economics*

The data on gross return, net return, and B:C ratio shown in Table 5 indicates that treatment T_3 (Hast Bahar, with foliar spray of Micromix 0.2% and Kaolin Clay 4.0%) obtained the highest average income of ₹ 411813 ha^{-1} as compared to treatment T_2 (Hast Bahar (Sep-Oct flowering) and T_1 (Farmer Practice Mrig Bahar (Jun–July flowering)) of ₹ 353074 ha^{-1} and ₹ 333425 ha^{-1}, respectively. The net profit and B:C ratio were found to be the maximum (₹ 340993 ha^{-1}and 5.8) and (₹ 304150 ha^{-1} and 4.4) compared to the farmer's practice (₹ 248373 ha^{-1} and 3.9), respectively. Further, the cost-benefit analysis of all the treatments revealed that the Hast Bahar, with foliar sprays of Micromix 0.2% and Kaolin Clay 4.0%, found 16.73% less gross cost compared to Farmer Practice Mrig Bahar (Jun–July flowering), and the net benefit was also 37.29% higher than the Mrig Bahar crop. Due to the incidence of diseases and pests, plant protection costs increased during Mrig Bahar, but during Hast Bahar, production costs were recorded as lower. This might be as a result of low disease and insect infestation, rising fruit quality, and a low frequency of fruit creaking and sunburn during hast bahar. Moreover, during hast bahar, there was limited availability of fruit fetching high prices (Shivran, 2020) and (Kumar et al., 2019).

Table 5: Economics of different flowering season of pomegranate at farmer's field

Treatments	Gross cost (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
T_1: Farmer practice (Mrig bahar) Jun –July Flowering	85052.3	333425	248373	3.90
T_2: Hast bahar (Sep–Oct Flowering)	65257.3	353074	304150	4.41
T_3: Hast bahar, foliar spray of micromix 0.2% and Kaolin clay 4.0%	70819.7	411813	340993	5.80

Sale of pomegranate: ₹ 37 kg^{-1} in 2019–20 (1US$=₹ 74.31 INR); Sale of pomegranate: ₹ 46 kg^{-1} in 2020–21 (1 US$=₹ 75.45 INR); Sale of pomegranate: ₹ 50 kg^{-1} in 2021–22 (1US$=81.62 INR)

4. CONCLUSION

The Mrig bahar crop was found better in terms of fruit yield, but this crophad the highest disease incidence, the highest cost of production, and the lowest fruit quality. However, the hast bahar crop during the winter season was found superior in fruit quality, with a low cost of production and a low incidence of sunburn and fruit cracking. Moreover, foliar sprays of micromix 0.2% and Kaolin clay 4.0% in the Hast bahar crop gave a higher net profit and B:C ratio.

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