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Effect of biofertilizer and *Jeevamrut* on flowering, fruiting and yield of pomegranate (*Punica granatum* L.)

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Abstract
Present investigation was comprised of two factors and laid out in Randomized Block Design with factorial concept with three replications. The first factor was biofertilizer (b) with four levels *i.e.* b_1 (Control), b_2 (*Azotobacter* + PSB + KSB each @ 5 ml/plant), b_3 (*Azotobacter* + PSB + KSB each @ 10 ml/plant) and b_4 (*Azotobacter* + PSB + KSB each @ 15 ml/plant) and the second factor was *jeevamrut* with three levels *i.e.* j_1 (Control), j_2 (drenching of *jeevamrut* 0.5 litre/plant) and j_3 (drenching of *jeevamrut* 1.0 litre/plant). Thus, there were total 12 treatment combination under study. The distance between plant to plant and row to row was 2.5 m × 2.5 m. The results indicated that the drenching of biofertilizer b_4 (*Azotobacter* + PSB + KSB each @ 15 ml/plant) gave maximum fruit set (67.78%), fruit weight (226.91 g), number of fruits per plant (68.72), yield per plant (13.49 kg), yield per hectare (21.59 t/ha) and minimum fruit drop (12.56%). Result showed that the drenching of *jeevamrut* 1.0 litre/plant (j_3) gave maximum fruit set (65.83%), fruit weight (225.35 g), number of fruits per plant (68.79), yield per plant (13.43 kg), yield per hectare (21.49 t/ha) and minimum fruit drop (12.71%). However, biofertilizer and *jeevamrut* showed non-significant effect on days taken to flowering initiation and days taken from flowering to harvesting.

Keywords: Biofertilizer, *jeevamrut,* pomegranate

Introduction
Pomegranate belonging to the family Lythraceae (Punicaceae) is one of the most appreciated table fruits of tropical and subtropical regions. It has both cultivated (*Punica granatum*) and wild type (*Punica protopunica*). It is believed to be originated from Iran. In general, pomegranate is diploid with chromosome number, 2n=18 (Maksudan *et al*, 2022) [1]. Apart from its demand for fresh fruits and juice, the processed products like wine and candy are also gaining importance in world trade.

Pomegranate starts fruiting in about 3-4 years after planting. According to seasonal changes, there are three flowering seasons in the India *viz*., June-July (*mrig* bahar) coinciding with the break of monsoon, February-March (*ambia* bahar) and September-October (*hasta* bahar). Although pomegranate may be induced to bear fruit in any of the seasons, ordinarily, only one bahar is taken from the crop and the season of fruiting adopted is mainly determined by the location demand, price and the availability of water. The fruits from *hasta* bahar are harvested during the month of March to April. They have very attractive rind with dark coloured arils. Since the availability of the fruits during this season is limited, they fetch high value. The fruits harvested from *hasta* bahar crop are found to be of superior in quality with less infestation. Optimum water stress cannot be developed during this period as withholding of irrigation coincides with the rainy season. This leads to poor flowering and fruit set which affect yield. Results of five-year study with cv. Ganesh have shown that it was highly profitable to take *hasta* bahar crop under rainfed condition (Raturi and Hiwale, 1991) [2].

Bio-fertilizers are usually prepared as carrier based inoculants containing effective microorganisms. Microorganisms used as bio-fertilizer include: Nitrogen fixers *e.g. Rhizobium spp*., Cyanobacteria, and *Azotobacter chroococcum*, potassium solubilizers *e.g.*

Bacillus mucilaginous, phosphorus solubilizers *e.g. Bacillus megaterium, Aspergillus fumigatus.* Biofertilizers proved as an environmentally friendly and renewable source of nutrients. Biofertilizers have been successfully used in several crops but in pomegranate very less work is available.

Jeevamrut is one such natural amendment which can either replace or complement and reduce the use of chemical fertilizers and reclaim the sustainability of the soil and environment. It is prepared from cow dung, cow urine, pulse flour, jaggery and one handful of forest soil. *Jeevamrut* is acidic in nature (4.93) and good source of macro and micro-nutrient *viz*., N (1.97%), P (0.172%), K (0.29%), Mn (47 ppm) and Cu (50 ppm) (Kumar *et al*., 2021) [3]. Soil application of *jeevamrut* create favourable conditions for the availability of nutrients by increasing pH in acidic soils and decreasing the pH in alkaline soils and maximizing nutrient availability at pH 6.5 to 7.8 (Kulkarni, 2019) [4].

Intensive cultivation involves indiscriminate use of chemicals along with improper nutrient management which is deleterious to the plant health and environment also. Due to these practices, the plants also become susceptible to several biotic and abiotic stresses. Due to farmer's perception that the productivity can be enhanced only using by such chemical fertilizers and pesticides, the use of such chemicals have reached to the hazardous limits. Such practices are also common among the pomegranate growers of the North Gujarat. It also causes soil health deterioration and disturbs the soil microorganisms and use of organic supplement in farming definitely reduce the chemical load and improve the quality of fruits. Among several approaches of chemical free crop production, biofertilizers and *jeevamrut* are very convenient, economic, yield responsive, eco-friendly and not hazardous to health. In pomegranate very less work has been done on chemical free production approach particularly biofertilizer and *jeevamrut*. Therefore, in pomegranate proper nutrition management through chemical free approach is required to get safe yield with sustainable production.

Materials and Methods

Experimental site: The experiment was placed out at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Mehasana district which is situated at 23°53' N latitude and 72° 43' E longitude at an elevation of 90.6 meters above mean sea level. It is 10 km far from Mehasana and 60 km from Ahmedabad. The region covered under North Gujarat Agro Climatic Zone IV of Gujarat.

Experimental design and treatments

The experimental design was Randomized Block Design with Factorial concept with three replications. The recommended dose 60% RDF with 50 kg FYM applied in all treatments by making 15 cm deep ring and 60 cm away from the main trunk. In the experiment nutrition was given in the below mentioned way.

1. Fifty kilogram FYM along with 60% RDF (NPK @ 375 g, 150 g and 150 g per plant) was applied as basal application, the RDF is 625 g, 250 g, 250 g NPK per plant
2. Drenching of biofertilizer was done after 15 days of FYM and RDF application as per treatment
3. Drenching of *jeevamrut* was done after 15 days, 45 days, 75 days and 105 days of FYM and RDF application as per treatment
4. Basal application time was decided as second week of September

Treatment details are as under

Factor-A: Biofertilizers (b) with four levels
b_1: Control (without biofertilizer)
b_2: *Azotobacter* + PSB + KSB each @ 5 ml/plant
b_3: *Azotobacter* + PSB + KSB each @ 10 ml/plant
b_4: *Azotobacter* + PSB + KSB each @ 15 ml/plant
Factor-B: *Jeevamrut* (j) with three levels
j_1: Control (without *jeevamrut*)
j_2: Drenching of *jeevamrut* @ 0.5 litre/plant
j_3: Drenching of *jeevamrut* @ 1.0 litre/plant

In present study, pomegranate cv. Bhagwa was selected and treatment were allotted randomly which were replicated thrice. The observations were recorded from two randomly selected plants which were tagged in each treatment and replication. The observation on flowering behaviour and yield parameter were determined and they were statistically analyzed.

Results and Discussion

Effect of biofertilizer on flowering behaviour of pomegranate

Influence of biofertilizer was found significant in flowering behaviour traits *viz*., fruit set and fruit drop. The maximum fruit set *i.e.* 67.78% and minimum fruit drop 12.56% recorded under treatment b_4 (*Azotobacter* + PSB + KSB each @ 15 ml/plant). While, days taken to flowering initiation and days taken from flowering to harvesting was found non-significant. Binepal *et al*. (2013) [5] verified that the application of biofertilizers increased nutrient status as well as their uptake by the plants. They promote hormonal activity and induce their synthesis and reduce the flower and fruit drop caused by hormonal imbalance, hence results in maximizing the fruit set percentage. *Azotobacter*, phosphorus solubilizing bacteria and potassium solubilizing bacteria in the treatments, which are responsible to make more nitrogen, phosphorus and potassium available to plants might have minimize the fruit drops (Nurbhanej and Varu, 2019) [6]. Results found by Sourabh *et al*. (2018) [7] in guava and Jat *et al*. (2021) [8] in pomegranate were on the similar line as reported in present experiment.

Effect of *jeevamrut* on flowering behaviour of pomegranate

Results pertaining to the drenching of *jeevamrut* had significant influence on flowering behaviour traits *viz*., fruit set and fruit drop. The maximum fruit set of 65.83% and minimum fruit drop 12.71% found in treatment j_3 (drenching of *jeevamrut* 1.0 litre/plant). However, days taken to flowering initiation and days taken from flowering to harvesting was found non-significant. The higher fruit set might be due to increased nutrient availability from the *jeevamrut* which have increased various endogenous hormonal levels in plant tissue and resulted in enhanced flowering, pollen germination and pollen tube growth which ultimately increased fruit set percentage (Godage *et al*., 2013) [9]. Similar results have been reported by Choudhary *et al*. (2022) [10]in pomegranate. In the present experiment the maximum fruit setting was reported in j_3 treatment (drenching of *jeevamrut* 1.0 litre/plant) which have indirectly affected the fruit drop.

Interaction effect of biofertilizer and *jeevamrut* on flowering behaviour

The result indicated that interaction between biofertilizer and *jeevamrut* was found statistically non-significant for days taken to flowering initiation, days taken from flowering harvesting, fruit set (%) and fruit drop (%).

Table 1: Effect of biofertilizer and *jeevamrut* on flowering behaviour

Treatment	Days taken to flowering initiation	Days taken from flowering to harvesting	Fruit set (%)	Fruit drop (%)
Drenching of biofertiizer (b)				
b_1: Control	34.81	176.60	54.44	16.62
b_2: 5 ml/plant	33.50	175.29	60.00	14.76
b_3: 10 ml/plant	32.67	173.44	63.33	13.51
b_4: 15 ml/plant	32.50	172.79	67.78	12.56
S.Em.±	0.615	2.223	2.241	0.422
CD @ 5%	NS	NS	6.38	1.20
Drenching of *jeevamrut* (j)				
j_1: Control	34.10	176.60	57.50	16.19
j_2: 0.5 litre/plant	33.19	173.70	60.83	14.18
j_3: 1.0 litre/plant	32.81	173.30	65.83	12.71
S.Em.±	0.533	1.925	1.941	0.365
CD @ 5%	NS	NS	5.52	1.04
Interaction (j X b)				
S.Em.±	1.066	3.850	3.882	0.731
CD @ 5%	NS	NS	NS	NS
CV%	5.53	3.82	10.95	8.82

Effect of biofertilizer on yield and yield contributing traits of pomegranate

Result pertaining to the drenching of biofertilizer had significant influence on all the yield parameters except number of pickings. Among them maximum fruit weight of 226.91 g, maximum number of fruits per plant *i.e.* 68.72, maximum yield per plant of 13.49 kg and maximum yield per hectare 21.59 t were observed under treatment b_4 (*Azotobacter* + PSB + KSB each @ 15 ml/plant). The significant increase in fruit yield is a cumulative effect of increased fruit setting and higher number of fruits because reduction in fruit drop and higher fruit weight by the drenching of biofertilizer might have affected the physiological process resulting into higher production (Kumar *et al*., 2019) [3]. Result recorded by Binepal *et al*. (2013) [5] in guava, Dutta *et al*. (2016) [12] and Sau *et al*. (2017) [13] in mango and Jat *et al*. (2023) [14] in pomegranate.

Effect of *jeevamrut* on yield and yield contributing traits of pomegranate

The influence of *jeevamrut* significantly differed in yield and yield contributing traits. It was observed that maximum fruit weight of 225.35 g, maximum number of fruits per plant *i.e.* 68.79, maximum yield per plant of 13.43 kg and maximum yield per hectare 21.49 t was recorded under treatment j_3 (drenching of *jeevamrut* 1.0 litre/plant). Whereas, the number of pickings was found non-significant. Higher fruit number was mainly due to better growth and improvement in the physiological condition which caused higher percentage of fruit setting, retention and reduced fruit drop. Beneficial effect of *jeevamrut* might be attributed to the availability of sufficient amounts of plant nutrients throughout the growth period especially at critical growth periods of plants resulting in better uptake, plant vigour and superior yield attributes (Thejaswini *et al*., 2022) [15]. The results were in close accordance with Jhade *et al*. (2020) [16] in papaya and Choudhary *et al*. (2022) [10] in pomegranate.

Interaction effect of biofertilizer and *jeevamrut* on yield and yield contributing traits

Result showed the statistically non-significant trend of interaction between biofertilizer and *jeevamrut* on fruit weight, number of fruits per plant, yield per plant, yield per hectare and number of pickings.

Table 2: Effect of biofertilizer and *jeevamrut* on yield and yield contributing traits

Treatment	Number of pickings	Fruit weight (g)	Number of fruits per plant	Yield per plant (kg/plant)	Yield per hectare (t/ha)
Drenching of biofertiizer (b)					
b_1: Control	3.83	207.81	64.33	11.85	18.96
b_2: 5 ml/plant	3.83	212.82	65.50	12.03	19.25
b_3: 10 ml/plant	3.89	218.81	67.56	12.82	20.51
b_4: 15 ml/plant	3.94	226.91	68.72	13.49	21.59
S.Em.±	0.081	2.911	1.045	0.365	0.583
CD @ 5%	NS	8.28	2.97	1.04	1.66
Drenching of *jeevamrut* (j)					
j_1: Control	3.83	206.28	64.79	11.84	18.94
j_2: 0.5 litre/plant	3.88	218.13	66.00	12.38	19.81
j_3: 1.0 litre/plant	3.92	225.35	68.79	13.43	21.49
S.Em.±	0.07	2.52	0.90	0.32	0.51
CD @ 5%	NS	7.17	2.57	0.90	1.44
Interaction (j X b)					
S.Em.±	0.140	5.042	1.809	0.632	1.010
CD @ 5%	NS	NS	NS	NS	NS
CV%	6.25	4.03	4.71	8.72	8.72

Conclusion

On the basis of experimental results, it can be concluded that the drenching of biofertilizers (*Azotobacter* + PSB + KSB each @ 15 ml/plant) at 15 days after application of FYM and fertilizer and drenching of *jeevamrut* 1.0 litre/plant at 15, 45, 75 and 105 days after application of FYM and RDF along with 60 per cent RDF *i.e.* 375: 150: 150 g NPK per plant is beneficial with respect to the flowering and yield in pomegranate cv. Bhagwa.

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Conflict of Interest
None.

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