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Effect Bio-Inoculants and Organic Supplementation a Growth and Yield of Pomegranate

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Abstract

The present research was carried in a seven year old pomegranate orchard cultivating *Bhagwa* variety during *hasta bahar* season, 2015-16. The experiment consists of six treatments that included application of 100 per cent recommended dose of fertilizer without (T_1) or with bio-inoculants (T_2), supplementation of 25 per cent (T_3 and T_4) and 50 per cent (T_5 and T_6) recommended dose of N through organics (neemcake + pongamiacake -1:1) without or with bio-inoculants. The field experiment was laid out in Randomized Block Design (RBD) and replicated four times. Pomegranate growth parameters did not record significant variation, however, the plant height and secondary branches were relatively more in bio-inoculants and organics supplemented treatments. Flowering patter was significantly influenced by organics and bio-inoculants application. Highest number of hermaphrodite flowers was observed in T_6 (139.0) and T_5 (122) as compared to T_1 (86). The number of fruits were also highest in T_6 (98.01) followed by T_5 (89.10) but, fruit weight (301.44g) and size (78.77 and 100.81 mm fruit diameter and length) was maximum in T_4 (292.2g, 77.19 and 102.55 mm fruit diameter and length). All the above yield parameters has resulted in highest fruit yield of 26.43 kg plant^{-1} and 19.56 t ha^{-1} in T_6 (50% RD N&P +Organics + Bio-inoculants) while, lowest yield was observed in T_1 (100% RDF) recording 17.06 kg plant^{-1} and 12.62 t ha^{-1}.

Keywords: Pomegranate; Neemcake; Pongamiacake; *Trichodermaharzianum; Pseudomonas Fluorescence*

Introduction

Pomegranate (*PunicagranatumL.*) is one of the important fruit crop in arid and semi-arid regions. The fruit is touted as 'super food' because of its nutritional and health promoting characters. It has wide adaptability and requires relatively low cost for its cultivation with drought tolerance and good economic returns with potential of export attributes. Hence, its area is expanding in recent years. In India, it is extensively grown in Maharashtra, Karnataka and Andhra Pradesh and it is an upcoming crop in Gujarat, Tamil Nadu, Uttar Pradesh, Haryana and Rajasthan. In Karnataka, pomegranate is cultivated on an area of 18.49 thousand ha with an annual production of 1.99 lakh tons and productivity of 10.75 MT ha^{-1}(KSHD, 2014), growing predominantly in districts of Chitradurga, Bellary, Bijapur, Tumkur, Koppal and Bagalkot.

Pomegranate is a hardy crop that is usually cultivated under low fertile soil. But, its intensive cropping involving *bahar* treatment (manipulation of flowering and fruit setting involving plant hormones) without proper nutrient management is deteriorating the plant health and making plants susceptible for several biotic and abiotic stresses. Hence, there is need for balanced nutrient application and enhancing its availability in soil that stimulates their uptake and assimilation by pomegranate. To achieve this present study was planned to integrate organic source, bio-inoculants and fertilizers to study its effect on pomegranate productivity. Bio-inoculants are the beneficial microbes that improve plant nutrition and promote plant growth. In recent years, they are increasingly used for suppression of plant diseases Heitefuss [1] and mobilization of nutrients in soil Saba [2]. Their application along with organics play crucial role in sustaining crop productivity. Among organic manures, the oil cakes posses higher plant nutrients, besides its potential pesticidal properties. Neem and pongamia cakes, by-products from bio-fuel industries can be effectively used as concentrated organic manure.

Use of organic sources of nutrients helps to conserve the soil health by maintaining the equilibrium of organic matter and soil

micro flora ultimately helping to improve physical, chemical and biological properties of the soil Walia [3]. The utility of neem and pongamia seed cake as a fertilizer as well as a pesticide on economically important crop species is well established Wani, Sreedevi [4] Ramesh [5] Shivakumar [6]. Hence, this study is formulated to integrate bio-inoculants and organics for exploiting nutrient management in pomegranate.

Material and Methods

A field experiment was carried out in seven years old pomegranate orchard with Bhagwa variety at Kaladagi village of Bagalkot district, Karnataka, during 2015-16 in *hasta bahar* season (August-February 2015-16). *Bahar* treatment is an important operation in pomegranate in which plants were given rest by stopping water for one month to create artificial stress. Consequently, light pruning operation was carried during the last week of July, 2015. Then, the leaves were defoliated during first week of August by spraying ethrel (2.5ml L^{-1}). After defoliation, the fallen leaves are collected and burnt. Then plants were irrigated followed by application of manures and fertilizers as per the treatment requirements. The new flushes appeared on tree between 8-12 days after Ethel spray and profuse flowering was observed during first to second week of September, 2015. The fruits were harvested in three pickings during January and February 2016. (Table 1) The farm yard manure was applied @ 20 kg $plant^{-1}$ to all treatments at *bahar* initiation. The bio-inoculants @ 200g each plant-1 were applied by mixing with oilcakes in two equal splits *viz*, basal and 60 days after *bahar* treatment (DABT). Recommended dose of potassium and phosphorus as per the treatment requirement were applied as basal dose while, nitrogen was applied as per the treatment requirement in three equal splits viz., ten days after organics and bio-inoculants application as basal dose and 30 & 60 days after *bahar* treatment (DABT) as top dressing.

Growth parameters like plant height, canopy circumference and number of primary and secondary branches were recorded at critical growth stages *viz*., before *bahar*, 60, 120 and 200 DABT. Yield parameters like flowering pattern, number of fruits per plant, fruit weight, fruit length and diameter and fruit yield were recorded after the harvest. The obtained data were subjected to statistical analysis using Microsoft excel to draw conclusions.

Table 1: The experiment was conducted with following six treatments using Randomized Block Design (RBD) with four replications.

T1-	100% RDF (Recommended Dose of Fertilizer) (400: 200: 200 N: P_2O_5:K_2O gram $plant^{-1}$)
T2-	100% RDF (400: 200: 200 N: P_2O_5:K_2O gram plant-1) + Bio-inoculants**
T3-	75% RD N & P_2O_5 (300: 150: 200 N: P_2O_5:K_2O gram plant-1) + 10 kg Oil cakes*
T4-	75% RD N & P_2O_5 (300: 150: 200 N: P_2O_5:K_2O gram plant-1) + 10 kg Oil cakes + Bio-inoculants
T5-	75% RD N & P_2O_5 (200: 100: 200 N: P_2O_5:K_2O gram plant-1) + 20 kg Oil cakes
T6-	75% RD N & P_2O_5 (200: 100: 200 N: P_2O_5:K_2O gram plant-1) + 20 kg Oil cakes + Bio-inoculants

* Oil cakes- Neem cake and Pongamiacake procured from bio-fuel park were applied in 1:1 proportion.
** Bio-inoculants-*Trichoderma harzianum* (Krishnaprabha- Trichokavach) and *Pseudomonas fluorescence* (DundanaRakshak), the two effective bio-inoculants specifically developed for pomegranate by bio-control lab, University of Horticultural Sciences, Bagalkot were used in this experiment.

Results and Discussion

Effect of bio-inoculants and organics supplementation on growth parameters

The effect of bio-inoculants and organics application on pomegranate plant height is presented in (Table 2). The plant height recorded significant difference only at 60 and 120 DBT. Application of organics along with bio-inoculants (T_6) recorded maximum plant height of 3.01m followed by T_2 (2.93m). At 120 DBT, application of bio-inoculants with or without organics increased plant height recording 3.43m in T_6, 3.26m in T_2 and 3.21m in T_4 treatments compared to un-inoculated treatments. Availability of nutrients and assimilation by plants have prominent role in stimulating the growth of plants. Higher uptake of nutrients in T_6 might have increased the plant height Dhillon [7] besides the plant promoting capability of bio-inoculants Luis [8]. The pomegranate canopy circumference did not vary significantly with the application of bio-inoculants and organics at any stages of crop growth (Table 2). In general the pomegranate canopy ranged from 2.96 - 2.86m, 3.22 - 3.07m and 3.32 - 3.13m at 60, 120 and 200 DBT respectively. The number of primary and secondary branches did not vary significantly however, the primary branches were in 2-3 numbers and about 5-7 numbers of secondary branches were arising from each primary branch (Table 3).

Table 2: Effect of bio-inoculants and organics supplementation on pomegranate plant height and canopy spread

Treatments	Growth Stages			
	Defoliation	60 DBT	120 DBT	200 DBT
	Plant height (m)			
T_1- 100% RDF	2.45	2.68	3.04	3.31
T_2- 100% RDF + Bio-inoculants	2.34	2.93	3.26	3.37

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T_3-75% RD N&P + Organics	2.47	2.82	3.03	3.14
T_4- 75% RDN&P + Organics + Bio-inoculants	2.39	2.87	3.21	3.24
T_5-50% RD N&P + Organics	2.41	2.63	2.90	3.26
T_6-50% RD N&P +Organics + Bio-inoculants	2.35	3.01	3.43	3.52
SEm±	NS	0.03	0.03	NS
CD at 5%	NS	0.10	0.11	NS
Canopy spread (m)				
T_1- 100% RDF	2.71	2.96	3.22	3.32
T_2- 100% RDF + Bio-inoculants	2.64	2.88	3.15	3.25
T_3-75% RD N&P + Organics	2.57	2.73	2.96	3.03
T_4- 75% RDN&P + Organics + Bio-inoculants	2.65	2.82	3.03	3.15
T_5-50% RD N&P + Organics	2.60	2.75	2.93	3.04
T_6-50% RD N&P +Organics + Bio-inoculants	2.67	2.83	3.07	3.13
SEm±	NS	NS	NS	NS
CD at 5%	NS	NS	NS	NS

Table 3: Effect of bio-inoculants and organics supplementation on number of branches.

Treatments	Primary branches	Secondary branches
T_1- 100% RDF	3.00	6.13
T_2- 100% RDF + Bio-inoculants	2.50	7.13
T_3-75% RD N&P + Organics	3.00	6.50
T_4- 75% RD N&P+ Organics + Bio-inoculants	2.63	6.25
T_5- 50% RD N&P +Organics	2.63	6.88
T_6- 50% RD N&P +Organics + Bio-inoculants	2.50	6.38
SEm±	NS	NS
CD at 5%	NS	NS

Effect of bio-inoculants and organics supplementation on yield parameters

The flowering pattern of pomegranate varied significantly with application of bio-inoculants and organics (Table 4). Profuse flowering was observed in T_6 (270.0) followed by T5 (249.0). Amongst the type of flowers, hermophrodite flowers were found in higher number and its per cent ranged from 42.9-51.4 to total number of flowers. Application of organics along with bio-inoculants showed higher amount of hermaphrodite flowers recording 139.0 in T6 compared to 86 in T_1. The highest number of intermediate flowers was recorded in T_6 (32.0) and T_4 (32.0) while, male flowers were found in T_6 (99.0) and T_5 (97.0). This could be attributed to the supply of N to pomegranate plants. Many researchers have opined that abundant nitrogen may reduce flowering in plants when it is under stress condition Corbesier [9]; Bernier [10]; Rideout [11].

Table 4: Effect of bio-inoculants and organics supplementation on pomegranate flowering pattern.

Treatments	Male flower	Herma-phrodite	Inter-mediate	Total
T_1- 100% RDF	85.0 (42.2)	86.0 (42.9)	30.0 (14.7)	201.0
T_2- 100% RDF + Bio-inoculants	88.0 (42.2)	92.0 (44.1)	29.0 (13.6)	209.0
T_3-75% RD N&P + Organics	90.0 (42.5)	99.0 (46.7)	23.0 (10.7)	212.0
T_4- 75% RD N&P+ Organics + Bio-inoculants	81.0 (37.9)	101.0 (47.3)	32.0 (14.7)	214.0

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T_5- 50% RD N&P +Organics	97.0 (38.9)	122.0 (48.7)	31.0 (12.3)	249.0
T_6- 50% RD N&P +Organics + Bio-inoculants	99.0 (36.6)	139.0 (51.4)	32.0 (11.9)	270.0
SEm±	2.02	2.18	0.93	3.45
CD at 5%	6.01	6.48	2.77	10.27

* Numbers in the parenthesis indicates the percent number of flowers to the total number of flowers

Application of organics and bio-inoculants significantly influenced the pomegranate yield parameters viz., number of fruits, fruit weight and fruit size (Table 5). Number of fruits per plant varied significantly among different treatments. Application of organics with (T_6- 98.01) or without (T_5- 89.10) bio-inoculants recorded significantly higher number of fruits compared to 100 per cent RDF with (T_2- 79.20) or without (T_1- 76.23) bio-inoculants. This could be attributed to flowering pattern. The fruit set in pomegranate depends on number of hermaphrodite flowers NRCP [12].

Table 5: Effect of bio-inoculants and organics supplementation on pomegranate yield parameters.

Treatments	No. of fruits per plant	Fruit weight (g)	Fruit diameter (mm)	Fruit length (mm)
T_1- 100% RDF	76.23	230.50	68.94	90.69
T_2- 100% RDF + Bio-inoculants	79.20	271.20	77.28	96.91
T_3-75% RD N&P + Organics	81.18	254.77	71.65	93.90
T_4- 75% RD N&P+ Organics + Bio-inoculants	85.14	294.20	77.19	102.55
T_5- 50% RD N&P +Organics	89.10	243.50	72.22	91.61
T_6- 50% RD N&P +Organics + Bio-inoculants	98.01	282.20	74.14	93.08
SEm±	NS	2.81	0.86	1.16
CD at 5%	NS	8.34	2.58	3.45

Hermaphrodite flowers are considered as perfect flowers and have positive correlation to fruit bearing capacity Babu [13]. Pomegranate fruit weight (Table 5) was found to be maximum in treatments T_4 and T_6 that recorded fruit weight of 294.2g and 282.2g respectively. The lowest fruit weight of 230. 5g was observed in T_1 (230.5g). Pomegranate fruit size was significantly influenced by different treatments. The maximum fruit diameter of 77.28mm was found in T_2treatment, while fruit length was highest in T_4-102.55mm. The treatment receiving 100 per cent RDF (T_1) recorded lowest fruit diameter (68.94mm) and length (90.69mm).

Table 6: Effect of bio-inoculants and organics supplementation on pomegranate fruit yield.

Treatments	Fruit yield (kg plant^{-1})	Fruit yield (t ha^{-1})
T_1- 100% RDF	17.06	12.62
T_2- 100% RDF + Bio-inoculants	21.94	16.24
T_3-75% RD N&P + Organics	20.17	14.93
T_4- 75% RD N&P+ Organics + Bio-inoculants	24.80	18.35
T_5- 50% RD N&P +Organics	21.23	15.71
T_6- 50% RD N&P +Organics + Bio-inoculants	26.43	19.56
SEm±	0.77	0.40
CD at 5%	2.30	1.20

Effect of bio-inoculants and organics supplementation on fruit yield

The pomegranate fruit yield varied significantly (Table 6) due to different treatments. The highest marketable fruit yield of 26.43 kg plant-1 and 19.56 t ha-1 was recorded in T_6 followed by T_4 recording 24.80 kg plant-1 and 18.35 t ha-1 fruit yield. This may be attributed to higher availability of P, K, S and micronutrients (Fe, Mn and Zn) with addition of neem and pongamia cake which is a source of these nutrients. Further, activity of bio-inoculants might have stimulated its enhanced availability and further assimilation by pomegranate plants. Similar findings on enhanced pomegranate fruit yield were observed with application of neem cake Ray [14] and bio-inoculants Shukla [15] and Mir [16-20] by many researchers. Application of 100 per cent RDF (T_1) recorded lowest fruit yield of 17.06 kg plant^{-1} and 12.62 t ha^{-1} that was significantly enhanced to 21.94 kg plant^{-1} and 16.24 t ha^{-1} with the application of bio-inoculants (T2) compared to 100 per cent RDF [21,22].

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Conclusion

The application of organics (neem + pongamia cake in 1:1) to supplement 50 per cent N & P_2O_5 along with bio-inoculants (*Trichodermaharzianumand Pseudomonas fluorescence*) are effective in obtaining in higher pomegranate yield. However, the pomegranate fruit quality was found superior when 25 per cent of N & P_2O_5 was supplemented with organics along with bio-inoculants. This study established the importance of quantity and time of nitrogen application on pomegranate flowering pattern and fruit yield.

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