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Research Article

IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON THE PLANT GROWTH AND YIELD ATTRIBUTE OF POMEGRANATE (*Punica granatum* L.) cv. Ganesh

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Abstract: The experimental plot was laid out in a randomized complete block design with three replications and nine treatments. The growth and yield parameters such as Plant height (m), Plant spread (m), Leaf area (cm²), Fruit set (%), Fruit cracking (%), Number of fruits per plant, Average fruit weight (g), Fruit yield per plant (kg), Fruit length (cm) and Fruit diameter (cm) over control were recorded during course of the investigation. The study results indicated that, the superior values for Plant height (4.35 m), Plant spread (3.78 m), Leaf area (9.40 cm²), Fruit set (41.10%), Fruit cracking (23.10%), Number of fruits per plant (124), Average fruit weight (250g), Fruit yield per plant (32.98 kg), Fruit length (9.40cm) and Fruit diameter (9.32 cm) were recorded in a plant treated with T5 treatment (100% RDF + FYM + *Trichoderma*) Which was closely followed by treatment T9 (75% RDF + FYM + *Trichoderma*).

Keywords: *Pomegranate, Ganesh, Fruit set, Fruit cracking 100% RDF + FYM + Trichoderma*

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Introduction

The pomegranate (*Punica granatum* L.), which belongs to the monogeneric Punicaceae family, is mainly found in Iran, where it is believed to have originated. Additionally, it is grown economically in nations such as India, Morocco, Spain, Egypt, Afghanistan, Myanmar, Japan, China, the United States, and Central Asia. Pomegranate has eight gametic chromosomes [1]. It is a well-known and well-loved fruit plant. Pomegranate is derived from the Latin name of the fruit, Malum granatum, which means "grainy apple." Pomegranate is grown commercially in Maharashtra, Karnataka, Andhra Pradesh, Gujarat, Uttar Pradesh, Tamil Nadu and Rajasthan in India. In India, the total area under this fruit is currently 261 thousand hectar with an annual production of 2315 thousand MT. In Haryana, it covers an area of 216 hectar and produces 26.13 MT per year [2].

The adoption of an integrated nutrient management (INM) strategy is essential for preserving the health of the land and increasing the output of high-quality fruits. By maximizing the advantages from all potential sources of plant nutrients in an integrated manner, integrated nutrient management is the process of keeping soil fertility and nutrient availability to plants at an optimal level in order to retain intended agricultural output. As a result, it is a traditional approach in which we first determine what exactly is required by plants for optimum level of production, in what different forms at what different timings in the best possible method and how best these forms can be integrated to achieve highest productivity levels with efficiency at economically acceptable limits in an environment friendly manner. Adopting strategies such as applying organic manures (such as FYM and vermicompost) and using bio fertilizers in addition to inorganic fertilizers can help accomplish integrated nutrient management [3].

Material and Methods

The details related to materials used and methodologies adopted for the present study are described under the following headings. The detail of the treatments is: T_1 (control), T_2 (100% RDF), T_3 (100% RDF + FYM), T_4 (100% RDF+ *Trichoderma*), T_5 (100% RDF + FYM + *Trichoderma*), T_6 (75% RDF), T_7 (75% RDF+ FYM), T_8 (75% RDF+ *Trichoderma*) and T_9 (75% RDF + FYM + *Trichoderma*) with randomized block design with three replications [4]. The half dose of nitrogen, full dose of phosphorus, full dose of potash, FYM and *Trichoderma* were applied as soil application during the 1st week of February and remaining dose of nitrogen was applied during last week of February in both the growing season. The first foliar spray of GA_3 and nutrients was done at 3rd week of March and second was done at last week of May during both the year of 2018-19 and 2019-20, respectively. growth and yield parameters were analysed different methods *i.e*., Fruit set (%) and Fruit cracking (%).

Fruit set (%)=(Number of fruits set)/(Total number of flowers)×100

Fruit cracking %=(Number of fruits cracked)/(Total number of fruits)×100

Results and Discussion

Growth and Yield Attribute Characters

Data presented in [Table-1] reveals that there was significant difference among treatments for plant height during both the years 2018-19 and 2019-20. During the year 2018-19 maximum plant height (4.20 m) was observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which was found to be statistically at par with treatment T_9 (75% RDF + FYM + *Trichoderma*), whereas minimum (3.53 m) with treatment T_1 (Control).

During the year 2019-20, all the treatment significantly improved. The plant height in pomegranate, the maximum plant height was (4.35 m) was noticed in treatment T_5 (100% RDF + FYM + *Trichoderma*), whereas it was minimum (3.60 m) with treatment T_1- Control. [Table-1] shows the effect of integrated nutrient management on plant spread has been presented. During the year 2018-19, all the treatments they significantly improved. Maximum tree spread (3.68 m) was observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which is significantly higher than all other treatments whereas minimum plant spread was recorded (3.14 m) with treatment T_1 (Control).

Table-1 Effect of integrated nutrient management on plant height, plant spread and leaf area of pomegranate

Treatment	Plant Height (m)		Plant spread (m)		Leaf area (cm²)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1- Control	3.53	3.60	3.14	3.23	7.54	7.62
T_2- 100% RDF	3.64	3.75	3.31	3.40	8.12	8.30
T_3- 100% RDF + FYM	3.95	4.07	3.54	3.63	8.95	9.10
T_4- 100% RDF + *Trichoderma*	3.77	3.91	3.38	3.46	8.57	8.71
T_5- 100% RDF + FYM + *Trichoderma*	4.20	4.35	3.68	3.78	9.40	9.72
T_6- 75% RDF	3.60	3.70	3.24	3.35	7.95	8.05
T_7- 75% RDF + FYM	3.86	3.98	3.41	3.51	8.70	8.80
T_8- 75% RDF + *Trichoderma*	3.70	3.83	3.33	3.41	8.31	8.50
T_9- 75% RDF + FYM + *Trichoderma*	4.03	4.16	3.58	3.68	9.20	9.42
C.D. at 5%	0.18	0.13	0.10	0.10	0.37	0.42

Table-2 Effect of integrated nutrient management on fruit set and fruit cracking of pomegranate

Treatment	Fruit set (%)		Fruit cracking (%)	
	2018-19	2019-20	2018-19	2019-20
T_1- Control	34.40	35.10	30.80	30.10
T_2- 100% RDF	35.95	36.80	28.80	27.50
T_3- 100% RDF + FYM	38.50	39.30	25.30	24.40
T_4- 100% RDF + *Trichoderma*	37.20	38.10	26.80	25.90
T_5- 100% RDF + FYM + *Trichoderma*	39.80	41.10	24.00	23.10
T_6- 75% RDF	35.45	36.10	29.50	28.30
T_7- 75% RDF + FYM	37.90	38.50	26.00	25.10
T_8- 75% RDF + *Trichoderma*	36.70	37.30	27.30	26.15
T_9- 75% RDF + FYM + *Trichoderma*	39.05	40.00	24.80	23.40
C.D. at 5%	0.78	0.98	1.22	1.42

During the year 2019-20, all the treatments they significantly improved. The plant spread in pomegranate, the maximum plant spread (3.78 m) was recorded in treatment T_5 (100% RDF + FYM + *Trichoderma*) while, minimum value was recorded (3.23 m) in treatment T_1 (control).

Data pertaining to the effect of different nutrient application on leaf area has been presented in [Table-1]. Perusal of the data revealed that all the treatments of integrated nutrient management affected leaf area significantly during both the years of study.

During the year 2018-19, maximum leaf area (9.40 cm²) was observed with treatment T_5- 100% RDF + FYM + *Trichoderma* which was statistically at par with T_9- 75% RDF + FYM + *Trichoderma* (9.20 cm²) and minimum leaf area (7.54 cm²) was observed with treatment T_1(Control).

In the year 2019-20, all the treatments they significantly improved. The maximum leaf area (9.72 cm²) was obtained in treatment T_5 (100% RDF + FYM + Trichoderm a) which was significantly higher than all the treatment except T_9 (75% RDF + FYM + *Trichoderma*), while it was minimum with treatment T_1 i.e.Control (7.62 cm²).

Data regarding effect of integrated nutrient management on fruit set is depicted in [Table-2]. The perusal of data indicated that different treatments had significant effect on fruit set in both growing years. All the treatments they significantly enhanced. Among all the treatments, maximum fruit set fruit set (39.80 %) was observed with treatment T_5 (100% RDF + FYM + *Trichoderma*) which was significantly at par with treatment T_9 (75% RDF + FYM + *Trichoderma*), however lowest fruit set was observed in treatment T_1 (34.40 %).

During the year 2019-20, all the treatments they significantly improved. The fruit set in pomegranate, the maximum fruit set (41.10 %) was noticed in treatment T_5 (100% RDF + FYM + *Trichoderma*), however minimum fruit set was observed (35.10 %) in treatment T_1 (Control).

The examination of data pertaining to fruit cracking as influenced by different treatment combinations [Table-2]. During the year 2018-19, minimum fruit cracking (24.00 %) was observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which remained statistically at par with treatment T_9 (75% RDF + FYM + *Trichoderma*) and maximum fruit cracking (30.80 %) was observed with treatment T_1 i.e., Control.

During the year 2019-20, minimum fruit cracking (23.10 %) was noticed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which remained statistically at par with treatment T_9 (75% RDF + FYM + *Trichoderma*) and treatment T_3 (100% RDF + FYM) and maximum fruit cracking (30.10 %) was observed with treatment T_1- (Control).

Data illustrating influence of different integrated nutrient treatments on number of fruits per plant is presented in [Table-3] revealed that during the year 2018-19, maximum number of fruits per plant (120) were observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which was statistically at par with treatment T_9 (75% RDF + FYM + *Trichoderma*) (116) and minimum (95) with treatment T_1. All treatments proved superior over control.

During the year 2019-20, maximum number of fruits per plant (124) were obtained in treatment T_5 (100% RDF + FYM + *Trichoderma*) which were found statistically at par with treatment T_9 (75% RDF + FYM + *Trichoderma*) (121) and minimum (97) in treatment T_1. All the treatments significantly superior over the control.

[Table-3] depicts a positive relationship between average fruit weight and different nutrient treatments during both the years of experimentation. Perusal of the data revealed that all the treatments increased fruit weight significantly superior during both the years of study. During the year 2018-19, maximum fruit weight (250 g) was observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which is significantly superior than all other treatments except T_9 (75% RDF + FYM + *Trichoderma*), T_3 (100% RDF + FYM), T_7 (75% RDF + FYM) and T_4 (100% RDF + *Trichoderma*) however they minimum fruit weight (226 g) was recorded in treatment T_1 (Control). During the year 2019-20, the maximum fruit weight (266 g) of pomegranate was observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which remained statistically at par with treatments T_9 (75% RDF + FYM + *Trichoderma*) and T_3 (100% RDF + FYM) and minimum fruit weight (235.00 g) was observed in treatment T_1 (Control).

Data pertaining to the effect of integrated nutrient management had significant influence on fruit yield per plant during both the years i.e., 2018-19 and 2019-20 [Table-3]. During the year 2018-19, highest fruit yield (30.00 kg) was observed with treatment T_5 (100% RDF + FYM + *Trichoderma*) while it was lowest (21.47 kg) observed with treatment T_1 (Control).

Observations pertaining to fruit yield per plant were recorded and the results are presented in [Table-3]. The different integrated nutrient management treatments significantly improved fruit yield per plant in 2019-20 years of experimentation. The highest fruit yield (32.98 kg) was noticed in treatment T_5 (100% RDF + FYM + *Trichoderma*) however minimum fruit yield (22.79 kg) was observed in treatment T_1 (Control). All the treatments superior over the control.

Data pertaining to the fruit length of two seasons of Pomegranate as influenced by various integrated nutrient treatments have been presented in [Table-4]. Perusal of the data revealed that all the treatments of integrated nutrient management increased fruit length significantly during both the years. All the treatments significantly increased.

Table-3 Effect of integrated nutrient management on number of fruits per plant, fruit weight and fruit yield per plant of pomegranate

Treatment	Number of fruits per plant		Average Fruit weight (g)		Fruit yield per plant (kg)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1- Control	95	97	226	235	21.47	22.79
T_2- 100% RDF	104	109	236	244	23.17	24.89
T_3- 100% RDF + FYM	113	118	245	253	27.01	29.38
T_4- 100% RDF + *Trichoderma*	107	112	239	250	26.22	28.34
T_5- 100% RDF + FYM + *Trichoderma*	120	124	250	266	30.00	32.98
T_6- 75% RDF	99	102	234	244	23.94	26.71
T_7- 75% RDF + FYM	111	115	243	252	27.31	28.75
T_8- 75% RDF + *Trichoderma*	101	106	237	249	24.54	26.60
T_9- 75% RDF + FYM + *Trichoderma*	116	121	246	254	28.19	30.73
C.D. at 5%	5.20	3.70	11.67	13.93	1.27	1.37

Table-4 Effect of integrated nutrient management on fruit length and fruit diameter of pomegranate

Treatment	Fruit length (cm)		Fruit diameter (cm)	
	2018-19	2019-20	2018-19	2019-20
T_1- Control	7.25	7.30	7.15	7.21
T_2- 100% RDF	8.70	8.81	8.58	8.65
T_3- 100% RDF + FYM	9.05	9.15	8.95	9.07
T_4- 100% RDF + *Trichoderma*	8.90	9.07	8.79	8.86
T_5- 100% RDF + FYM + *Trichoderma*	9.30	9.40	9.24	9.32
T_6- 75% RDF	8.45	8.60	8.36	8.50
T_7- 75% RDF + FYM	9.02	9.13	8.94	9.06
T_8- 75% RDF + *Trichoderma*	8.80	8.95	8.67	8.80
T_9- 75% RDF + FYM + *Trichoderma*	9.20	9.31	9.09	9.19
C.D. at 5%	0.21	0.24	0.27	0.33

During the year 2018-19, maximum fruit length (9.30 cm) was observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) followed by treatment T_9 (9.20 cm) and minimum fruit length (7.25 cm) was observed in treatment T_1- Control.

During the year 2019-20, maximum fruit length (9.40 cm) was noticed in treatment T_5- 100% RDF + FYM + *Trichoderma* which was significantly higher than all other treatments except T_9 (75% RDF + FYM + *Trichoderma*) however minimum fruit length (7.30 cm) was observed in treatment T_1 (Control).

The fruit diameter of two seasons of Pomegranate as influenced by various nutrients treatments have been presented in [Table-4]. Perusal of the data showed that all the treatments of integrated nutrient management enhanced fruit diameter significantly during both the years of study. During the year 2018-19, all the treatments significantly increased. The maximum fruit diameter (9.24 cm) of pomegranate was observed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which remained statistically at par with treatment T_9 (75% RDF + FYM + *Trichoderma*) while minimum fruit diameter (7.15 cm) was noticed in treatment T_1.

During the year 2019-20, maximum fruit diameter (9.32 cm) was noticed in treatment T_5 (100% RDF + FYM + *Trichoderma*) which was statistically at par with treatment T_9 (75% RDF + FYM + *Trichoderma*), treatment T_3 (100% RDF + FYM) and treatment T_7 (75% RDF + FYM) and minimum fruit diameter (7.21 cm) was observed in treatment T_1- Control.

The growth parameters of plant were significantly influenced by the integrated nutrient treatments. Results showed the maximum increase in plant height, plant spread and leaf area were found with the application of 100% RDF + FYM + *Trichoderma* which was significantly superior among treatments during the both the i.e., year 2018-19 and 2019-20. The notable improvement with respect to growth parameters with the use of bio-fertilizers, organic manures and inorganic fertilizers may be attributed due to sufficient availability of nitrogen, phosphorus, potassium and other essential nutrients. In other terms the expansion in vegetative growth parameters may be because of the generation of more chlorophyll content with inoculation of nitrogen fixers. The other logical explanation behind increased vegetative growth might be the creation of plant growth regulators by microorganism in rhizosphere, which are absorbed by the roots. While, under control, less availability of nutrients for uptake resulted poor in vegetative growth parameters. The similar results have also been observed by Shrivastava, (2008) [5] in Papaya, Mandal *et al*. (2013) [6], Mustafa *et al*. (2013) [7] and Yadav *et al*. (2007) [8] in Aonla.

The increase in plant spread with the application NPK, FYM and *Trichoderma* over the span of investigation gets the backing of Singh *et al*. (2015) [9] and Verma and Rao (2013) [10] in Strawberry.

Leaf area was increased significantly with the application of NPK, FYM and *Trichoderma* at various treatment combinations. Increase in leaf area might be due to increased growth of plant in the form of height and number of leaves, which accumulated more photosynthates and thereby increased leaf area. These results get the support of Singh *et al*. (2015) in Strawberry. The results are also in confirmation with the findings of Yadav *et al*. (2010) [11] who reported that combined application of bio-fertilizers, vermicompost with inorganic fertilizers significantly increased the leaf area of Strawberry. The increased nutrient availability from the organic matter and FYM might have increased various endogenous hormonal levels in the plant tissue might be responsible for enhanced pollen germination and tube growth, ultimately increased the fruit set and minimum fruit cracking [12,13]. The maximum fruit set as result of applied full RDF + FYM + *Trichoderma* may be due to increased photosynthetic rate and carbohydrate accumulation as a result of multifarious role of FYM, RDF and biofertilizer to allow most favourable conditions of soil with increased availability of plant nutrient responsible for fruit growth and development.

The yield of the crop is an ultimate objective of the growers to get maximum returns per unit area and per unit time. The fruit yield of the crop significantly increased with the application of different treatments of RDF, FYM and *Trichoderma*. The application of 100% RDF + FYM + *Trichoderma* maximized the number of fruits, fruit weight and average fruit yield in both the years of study. The above-mentioned response of the crop to applied NPK is quite obvious due to early induction of flowers, fruit set and number of fruits per tree are the major component of Pomegranate production. These parameters are highly affected due to nutrient management. The increase in yield was mainly attributed to relative increase in the availability of nutrients and better solute uptake by the plants. Findings are in accordance with the results of Stalin *et al*. (1994) who reported the maximum number of fruits and higher average fruit yield under nutrient application might be attributed to adequate nutrition under these treatments which resulted into favourable metabolic process, availability of photosynthates to fruit development and adequate hormonal balance to augment fruit setting. The results are also in agreement with Prasanna and Dhandar (1996) [14] and Khattak *et al*. (2005) [15]. The increase in number of fruits, fruit weight and fruit volume might be attributed to fact that there was increasing in level of nutrients in assimilating area of fruit due to which the rate of production was enhanced.

Similarly, due to rational partitioning of dry matter to economic sink, the yield attributes were improved. The above results are in conformity with the findings of Hari *et al*. (2008) [16]. Among the fertilizer treatments the combination of manures and biofertilizers exhibited profound effect on number of fruits per plant and average fruit yield. Results indicated that the efficiency of organic manures was more when supplemented with bio-fertilizers. The supply of nutrients during entire period of fruit growth, ultimately resulting in accumulation of more photosynthates leading to a greater number of fruits and yield of fruits. The increase in both number and weight basis might be attributed to the fact that there was increase in levels of nutrients in assimilating area of crop due to which the rate of dry matter production was enhanced. The above results are in conformity with the findings of Ram *et al*. (2007) [17] and Hari *et al*. (2008) in Guava.

The superior physical fruit quality with respect to fruit length and fruit diameter were observed under 100 per cent RDF + FYM + *Trichoderma*. The increase in quality of fruits were associated with dry matter content due to the fact that better nutrient availability and enhancing the uptake of solvent from rhizosphere resulting in accumulation of more photosynthates and their translocation as well as synthesis of different growth regulator [18]. The increase in fruit weight and weight of arils might be on account of incorporation of vermicompost, FYM and bio-fertilizers. Organic manures and bio-fertilizers have direct relation in N fixation, solubilizing phosphorus, production of phytohormone which increased the uptake of nutrients. These observations agree with the Dutta *et al*. (2010) [19] and Lata *et al* (2011) [20] who reported that the quality improvement of fruits might be due to proper supply of nutrients and induction of growth hormones which stimulated cell division, cell elongation increase in number of fruits and weight of fruits, better root development and better translocation of water uptake and deposition of nutrients. This might be attributed due to improvement in fertilizer use efficiency while applied along with the organics. Devi *et al*. (2012) [21] also concluded that the addition of biofertilizers along with organic manures were more effective than use of organic manures alone in enhancing fruit growth parameters. The findings are in accordance with Kumar (2010) [22] and Atom (2013) [23].

Conclusion

On the basis of results obtained, it may be concluded that application of the treatments T_5 100 per cent RDF + FYM + *Trichoderma* proved most effective in enhancing growth parameters i.e., plant height, plant spread, leaf area, fruit set and fruit cracking which was on at par with 75 per cent RDF + FYM + *Trichoderma*. In case of yield parameters, number of fruits per plant, average fruit weight, fruit yield/ plant, fruit length and fruit diameter 100 per cent RDF + FYM + *Trichoderma* found most effective treatment which was found to be at par with 75 per cent RDF + FYM + *Trichoderma*. This aspect can be further investigated and tested in screening for plant growth yield attributes at arid region of Haryana.

Application of research: Study of plant growth and yield attribute of pomegranate (*Punica granatum* L.) cv. Ganesh

Research Category: Integrated Nutrient Management

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Study area / Sample Collection: Chaudhary Charan Singh Haryana Agricultural University, Hisar, 125004, Haryana, India

Cultivar / Variety / Breed name: Pomegranate (*Punica granatum* L.) cv. Ganesh

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
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