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A farmer participatory approach to integrated nutrient management in tomato

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Abstract
In order to examine the technological gap in tomato production and gauge the efficacy of INM technology, Krishi Vigyan Kendra, in the Saharsa district of Bihar, performed farmer-participatory trials at farmers' fields in two villages. The study's results showed that treatment T_3 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] performed best in terms of the number of primary branches per plant (6.89), the number of flowers per plant (53.23), the minimum number of days to flowering (41.87), the number of days to 50% flowering (44.36), the number of days to first flowering (49.63). There were 8.86 pickings, 25.22 fruit per plant, a maximum weight of 50.57g for a fruit, 1.46 kg of yield per plant, and 381.56q of fruit per ha. A partial budget study showed that the net returns from T_3 were higher than the farmers' practice (Rs. 141298/ha), at Rs. 256904/ha. B:C ratios of up to 2.96 in T_3 and 1.90 in farmer practices were discovered.

Keywords: INM, organic manures, chemical fertilizers, and tomato growth and yield

Introduction

The tomato, or *Solanum lycopersicon* L., is one of the most widely cultivated fruits and vegetables worldwide. It is one of the vegetables that is grown the most in India and has gained popularity over the past 60 years. Small home gardens and market gardeners cultivate it for both fresh consumption and processing. In terms of acreage and tomato output, India comes in second. In India, Uttar Pradesh, Karnataka, Maharashtra, Haryana, Punjab, and Bihar are the top tomato-producing states. It is a self-pollinating crop, and the region between Peru and Equador is thought to be its origin. Portugal is credited with introducing it. It is grown in tropical and subtropical regions of the world in soilless culture or hydroponic systems as well as in commercial fields, household gardens, and greenhouses. It contains antioxidants, vitamins, and minerals, all of which are crucial for human health. It is one of the more well-known vegetables with significant commercial value. It can be eaten raw or cooked, and is used to make a variety of products, including sauce, pickles, puree, paste, syrup, ketchup, soup, and powder. Despite having 94% water by weight, ripe tomatoes are a strong source of vitamins A and B as well as an excellent source of vitamin C. They also have a high nutritional value. It tastes good, reduces constipation, and looks quite appealing. The tomato is widely regarded as a "Protective Food" and provides small and marginal farmers with a very good source of income. It contains a lot of vitamins, minerals, and organic acids.

Tomato growth, yield, and fruit quality are significantly influenced by a variety of interrelated factors. INM is the most significant and fundamental component among them. The ongoing use of chemical fertilizers raises the level of heavy metals in the soil, disrupts soil health, and renders the soil unfit for long-term plant development. The use of organic, inorganic, and microbial components in integrated nutrient management improves soil environment, maintains proper nutrient levels, and creates favorable conditions for a high yield of tomatoes with desired quality.

Utilizing both organic and inorganic fertilizer sources improves the physical condition of the soil while also raising crop output and serving as a storehouse of nutrients for succeeding crops. The quality of the product is also increased by bio organic nutrients. When compared to products derived from inorganic production, vegetables produced organically fetch a higher price.

Additionally, the quality and proper use of techniques will help to maintain the soil's fertility. In addition to balancing the nutrition supply, organic manures also enhance the chemical and physical characteristics of soil. Vermicompost has a definite impact on plant development and yield because it is known to stimulate protein synthesis in plants. The most important nutrient is nitrogen, which is a component of protein and increases the plant's ability to use light for photosynthetic energy, increasing output. Since phosphorus is a component of coenzymes, phospholipids, and nucleic acids and is crucial for the transmission of energy, it is the most important element.

Materials and Methods

The present study was carried out by KVK, Saharsa under the guidance of Bihar Agricultural University, Sabour, Bhagalpur, Bihar as well as ICAR-ATARI (Zone-IV) during Rabi season as an On-Farm Trial at ten farmers' fields. The farmers, who grow tomato and suffer low production and productivity, had been chosen for the experiment. The area under each trial is 0.3 ha (i.e. 1 bigha). In each trial, there were three treatments. The treatments considered are presented in Table 1 where T_1 i.e. the farmers' practice has been followed as control. Each farmer's field was treated as one replication. Three treatments with suggested agronomic techniques were used in the experiment, which was carried out using a Randomized Block Design with 10 replications (10 farmers). Tomato seedlings that are 30 days old, with a spacing of 60 cm between rows and 45 cm between plants, are transplanted into the plots in the late afternoon, immediately followed by irrigation to ensure the seedlings' appropriate establishment. Parameters for growth and yield were observed and recorded.

Results and Discussion

1. Effect of different treatments of INM on growth characters of tomato

The information in Table 1 shows that treatment T_3 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] had the lowest plant height (47.19 cm), which was followed by treatment T_2 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha)]. While treatment T_1 (RDF 250:75:40 NPK) had the tallest plants (59.63 cm). Amongst T_1 (F.P.) and T_3, there was a significant height difference in the plants. It was shown that the main factor contributing to the increased plant height in T_1 (F.P.) was the use of larger doses of nitrogenous fertilizer. The investigation supports and agrees with Kumaran *et al*. (1998) [6] and Naidu *et al*. (2002) [10]'s conclusions.

Treatment T_3 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha) + lime + boric acid (1%), + 1% zinc sulphate] had the highest number of primary branches/plant (6.89) followed by the treatment T_2 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha)] whereas the lowest number of primary branches/plant (4.54) was found in treatment T_1 [(RDF 250:75:40 NPK]. In contrast to farmer's practice, the INM plot had the most primary branches, demonstrating the value of organic matter in plant growth and the production of more members of flower clusters as well as the importance of balanced fertilizer management. Investigations by Naidu *et al*. (2002) [10], Reddy *et al*. (2002) [12], and Kumar and Sharma (2007) [5] produced similar findings.

The quantity of flowers per plant varied significantly depending on the treatment. Treatment T_3 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] was observed significantly the superior followed by T_2 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha)] which recorded 53.23 and 46.51 flowers per plant, respectively, and was at par. Treatment T_1 (RDF 250:75:40 NPK) had the fewest flowers per plant (29.73). This may be because there is a greater supply of key nutrients for plants, which are necessary in greater amounts for their growth and development. Nitrogen quickens the onset of the growth and reproductive stages as well as protein synthesis, which supports traits that increase production. Biswas *et al*. (2015) [1] reported similar outcomes.

The treatment T_3 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] that was at par showed the lowest number of days taken into blooming (41.87). Treatment T_1 (RDF 250:75:40 NPK) had the highest number of days to flower per plant (53.33). This quality helps you get a better return. This characteristic might be used in the breeding program. Both Kumar *et al.* (2011) [4] and Laxmi *et al*. (2015) [7] reported similar findings.

The data clearly showed that the treatments' impact on days till 50% blooming was greatly affected. The treatment T_3 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] that was at par had the shortest number of days to 50% flowering (44.36). Treatment T_1 (RDF 250:75:40 NPK) had the highest number of days to blooming per plant (56.77). This might be because nitrogen promoted cell division and differentiation in plants. As a result, the plant continued to stay in the vegetative stage, which caused an imbalance in the C: N ratio and delayed flowering at higher nitrogen levels. The results concur with those of Kumar *et al*. (2007) [5], Kumar *et al*. (2011) [4], and Renuka and Sankar (2001) [13].

2. Effect of different treatments of INM on Yield Attributes and Yield of Tomato.

The treatment T_3 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] produced the shortest time taken to first fruit setting in tomato, valued at 49.63, and was followed by T_2 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha)] and T_1 (RDF 250:75:40 NPK). T_1 (RDF 250:75:40 NPK) produced the longest time to first fruit setting in tomato, with a value of 59.33. Organic components improved the biological functions of microorganisms, which improved the plants' reproductive responses. The commencement of the flowers takes less time as a result. Increased photosynthetic activities are the result of increased phosphate and nitrogen availability, which is also ensured by soil organic matter. Fruit set thus appears more quickly than in control plots. Singh *et al*. (2012) [14] reported similar outcomes as well.

The different ways that organic and inorganic manure were treated had a big impact on how many pickings there were. The maximum number of picking was recorded in treatment T_3 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)], followed by treatments T_2 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha)] and T_1 (RDF 250:75:40 NPK), valued at 7.15 and 6.23, respectively. Increased availability of macro- and micronutrients for plants may be to blame for this. Nitrogen speeds up protein synthesis, growth, and reproduction phases, which increases the amount of picking. Yeptho *et al*. (2012) [16] reported corresponding outcomes.

The diverse applications of organic manure and artificial fertilizers resulted in a noticeably increased number of fruits per plant. The treatment T_3 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] valued at 25.22 was discovered to be substantially better than the other treatments, followed by T_2 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha)] and T_1 [(RDF 250:75:40 NPK)] valued at 22. The lowest was reported for therapy T_1 (RDF 250:75:40 NPK), which had a value of 17.43. This may be because there is a greater supply of macro and micronutrients for plants, which are needed in greater amounts for their growth and development. Nitrogen quickens the onset of the growth and reproductive stages as well as protein synthesis, which supports traits that increase production. Both Meena Kumari and Shekhar (2012) [9] and Pal *et al*. (2015) [11] observed similar findings.

Significantly, the treatment T_3 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] recorded the highest fruit weight (50.57 gm), and it was followed by T_2 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha)], which had a weight at harvest of 45.32 gm. However, the treatment T_1 (RDF 250:75:40 NPK) valued at 38.43 grams had the lowest fruit weight. It might be connected to a higher prevalence of illness and pests in farming practices compared to INM plots. The administration of more nitrogenous fertilizer and improperly managed plant protection techniques in the tomato plant were to blame. The results concur with Singh *et al*. (2002) [15] and Reddy *et al.* (2002) [12]'s conclusions.

The last indicator of an experiment's success or failure for any treatment is the yield of the crop, and in this case, the tomato's fruit output was noted. Significantly, the treatment T_3 [(RDF 200:100:80 N: P: K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] recorded the highest fruit yield (381.56 q/ha), followed by T_2 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha), which was valued at 311.45 q/ha and was at par. However, treatment T_1 (RDF 250:75:40 NPK) reported the lowest fruit production per hectare, which was valued at 239.22 q/ha. The likely cause of the increased fruit yield may be the cumulative effects of nutrients (Macro and micro) on vegetative growth, which ultimately result in more photosynthetic activities. Meanwhile, application of fertigation grade nitrogen levels improved the water metabolism and water relations in the plants as well as the carbohydrate and nitrogen metabolism of pectic substances. The use of various quantities of fertilizers, organic manures, and micronutrients in combination considerably boosted the growth, yield, and quality of tomato as compared to control, according to findings that are consistent with those of Chatterjee *et al*. (2013) [2] and Gulati *et al.* (2013) [3]. It justifies showed that the two fertilizers' soil applications encouraged the development of tomato plants.

3. Economic Performance of Tomato Production using INM Module

The combination of organic manure, inorganic fertilizer, and micronutrients yielded the highest gross return and benefit ratio. In T_3, a benefit cost ratio of 2.96 was determined in contrast to T_1, which had a benefit cost ratio of 1.90 (Table 3). Due to less crop loss from pests than in T_1, the better net return was reported in T_3. In addition, Meena *et al.* (2012) [8] discovered that using INM in tomatoes lowers input costs overall because there are fewer instances of insect pests and diseases compared to crops grown using farmer's techniques.

Table 1: Effect of INM on Growth Parameters of Tomato

Treatment	Plant height (cm)	No. of primary branches/plant	Number of flowers per plant	Minimum days to flowering	Days to 50% Flowering
T_1: Farmers practices (N:P:K= 250:75:40 kg/ ha)	59.63	4.54	29.73	53.33	56.77
T_2: RDF(N:P:K=200:100:80 kg/ha) + FYM (200 q/ha)	54.11	5.71	46.51	44.76	46.51
T_3: RDF (N:P:K=200:100:80 kg/ha) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)	47.19	6.89	53.23	41.87	44.36
S.Em±	0.63	0.13	0.59	0.89	0.43
CD @ 5%	1.76	0.36	1.82	2.27	1.33

Table 2: Effect of INM on Yield Attributes and Yield of Tomato

Treatment	Days to first fruiting	No. of picking	Avg. no. of fruit/plant	Avg. Weight of fruit (g)	Yield/plant (kg)
T_1: Farmers practices (N:P:K= 250:75:40 kg/ ha)	59.33	6.23	17.43	38.43	1.0
T_2: RDF(N:P:K=200:100:80 kg/ha) + FYM (200 q/ha)	53.45	7.15	22.61	45.32	1.33
T_3: RDF (N:P:K=200:100:80 kg/ha) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)	49.63	8.86	25.22	50.57	1.46
S.Em±	0.57	0.17	0.49	1.21	0.03
CD @ 5%	1.65	0.46	1.31	3.46	0.09

Table 3: Economic Performance of Tomato Production using INM Module

Treatment	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	Benefit cost ratio
T_1: Farmers practices (N:P:K= 250:75:40 kg/ ha)	239.22	74000	215298	141298	1.90
T_2: RDF(N:P:K=200:100:80 kg/ha) + FYM (200 q/ha)	311.45	79500	280305	200805	2.52
T_3: RDF (N:P:K=200:100:80 kg/ha) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)	381.56	86500	343404	256904	2.96
S.Em±	5.87	-	-	-	-
CD @ 5%	16.95	-	-	-	-

4. Conclusion

Based on the findings of the experiment, it was determined that integrated nutrient management improved the majority of the tomato's growth, phenolological, and yield characteristics. In terms of plant height, number of leaves per plant, number of fruit clusters per plant, days to first flowering, days to 50% flowering, yield, and net profit, treatment T_3 [(RDF 200:100:80 N:P:K) + FYM (200 q/ha) + Lime + Boric acid (1%) + Zinc Sulphate (1%)] performed well.

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