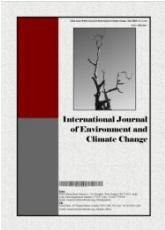

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Standardization of Integrated Nutrient Management for Growth and Yield of Tomato

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: "Standardization of integrated nutrient management for growth and yield of tomato".
Study Design: The experiment was laid out in a randomized block design (RBD) with 14 treatments with three replications maintained.
Place and Duration of Study: Experiment was carried out at the Instructional Farm, Faculty of Horticulture of Uttar Banga Krishi Vishwavidyalaya, and Pundibari, Cooch Behar during Rabi season of 2019 - 2020.
Methodology: The treatments consisted of different combinations of organic manures and inorganic fertilizers i.e., T_1 (Recommended NPK), T_2 (100% FYM), T_3 (100% VC), T_4 (100% PM), T_5 (100% NC), T_6 (100% VC + 100% FYM + 100% PM + 100% NC), T_7 (½ Recommended NPK + 50% FYM + 50% VC), T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM), T_9 (½ Recommended NPK + 50% FYM + 50% VC + NC), T_{10} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + NC), T_{11} (½ Recommended NPK + 50% FYM + 50% VC + PSB), T_{12} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + PSB), T_{13} (½ Recommended NPK + 50% FYM + 50% VC + NC + PSB) and T_{14} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + NC + PSB).
Results: All the growth and yield parameters were recorded maximum stem girth at last harvest (14.85mm), days to first flowering (27.46), number of truss per plant (20.59), individual fruit weight

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(127.71g), fruit yield per plant (4.49 kg) and yield per hector (79.62 t/ha) with treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM).
Conclusion: The application of treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM) shown enhanced tomato production with minimal alteration to environment.

Keywords: Tomato; integrated nutrient management; growth; yield.

1. INTRODUCTION

Tomato (*Solanum lycopersicon* Mill) belongs to the family Solanaceae, having diploid chromosome number (2n= 2X= 24) and commercially grown throughout the world. It was originated from Peru- Equador- Bolvia area of Andes (South America) and introduced in India in early 16th century [1], and became very important crop being rich in folic acid, vitamin A, B and C, potassium and oxalic acid content [2]. Tomato contains total sugars of 2.5 percent; amount of ascorbic acid differs from 16-65 mg/100g of fruit weight and total amino acid of 100-350 mg/100 g of fruit weight. It is a good appetizer and a good remedy for patients suffering from constipation.

Considering the fact that now a day's India is the second most populous country in the world, with the increasing population and day by day shrinkage in the cultivatable land resource made it utmost important to ensure pile up the required food at satisfactory level for the growing population, which is only possible by means of enhanced mass agricultural production and productivity. The introduction of high-yielding varieties in the mid 1960's coupled with increased use of fertilizers and irrigation are known collectively as the Green Revolution, which ensured the increased production that was needed to make India self-sufficient in food production. But the dangerous effect of synthetic chemical fertilizers begins right from their manufacturing as they produce hazardous byproducts and poisonous gases like NH_4, CO_2, and CH_4 etc which are deteriorating air quality drastically [3]. Application of fertilizers, pesticides and herbicides achieves very good production per unit area coupled with becoming one of the easiest and cheapest solution for most of the daily problems in crop husbandry, but excess application of them than that of the recommended dose to achieve quick visible effect due to lack of proper knowledge or being psychological impaired leading to devastating outcome by means of deterioration of environment in terms of poor soil health, depleting micro fauna and flora, water and air quality. It is destroying soil quality in terms of natural soil fertility by adversely affecting the soil dehydrogenase activity, physical parameters like texture, water holding capacity, chemical parameters like pH, salinity, soil organic matter content and increase the intensive fertilization (N, P and K) [4]. Even, if the farmers exposed to chemical pesticides spray for 18 months visual symptoms seen are burning/stinging of eyes (18.42%), blurred vision (23.68%), skin redness/itching (50%), excessive sweating/shortness of breath (34.2%), dry sore throat (21.05%) and burning of nose (28.9%) [5].

Considering all the undesirable facts associated with sole inorganic agricultural input system, in order to achieve the food demands of an increasing population in the first decades of the 21st century, there is need for balanced management of soil fertility status without any harmful manipulation of soil property or environmental factors by means of integrated approach. Integrated nutrient management (INM) is an approach that seeks to both increase agricultural production and safe guard the environment for future generations [6], that associated with a strategy that includes both organic (compost, farm yard manure, green manure, manure of gobar gas plant, oil cake, bone meal, steamed bone meal, fish manure, wood ash, sewage and sludge, biological sources, sugar cane press mud, coir pith, bio-fertilizers) and inorganic (major and micro nutrients) plant nutrients management to gain maximum crop productivity, prevent on-site soil degradation [7] and helps to meet future food supply needs. It is a modern system to increase availability of plant nutrients and transferring knowledge between the framers and researches based on nutrient application and conversion [8]. Keeping all these information in purviews, the present investigation was laid out to standardize the integrated nutrient management for growth and yield of tomato.

2. MATERIALS AND METHODS

Present experiment was conducted during the *rabi* season of the year 2020-21 for standardization of integrated nutrient management for growth and yield of tomato at

the Horticulture Instructional Farm, Uttar Banga Krishi Viswavidyalaya (U.B.K.V.), Pundibari, Coochbehar, which is geographically located at Teraiagro Climatic Zone of West Bengal situated at 26°19'86" N latitude and 89° 23'53" E longitude at an elevation of 43 meters above mean sea level having sandy loam textured soil with poor water holding capacity and moderate fertility status along with slightly acidic pH. The tomato Rocky (F_1 hybrid- Syngenta) used as experimental material, during this experiment applied recommended NPK dose as a sole inorganic cultivation, which is 200:100:100 kg NPK ha $^{-1}$ [9], standardized package of practices were used throughout the crop period and the experiment was laid out in a randomized block design (RBD) with 14 treatments maintaining three replications. The treatments consisted of different combinations of organic manures and inorganic fertilizers i.e., **T_1 (**Recommended NPK), **T_2** (100% Farmyard manure), **T_3** (100% Vermicompost), **T_4 (**100% Poultry manure), **T_5 (**100% Neem Cake), **T_6** (100% Vermicompost + 100% Farmyard manure + 100% Poultry manure + 100% Neem Cake), **T_7 (½** Recommended NPK + 50% Farmyard manure + 50% Vermicompost), **T_8** (½ Recommended NPK + 50% Farmyard manure + 30% Vermicompost + 20% Poultry manure), **T_9 (½** Recommended NPK + 50% Farmyard manure + 50% Vermicompost + Neem Cake), **T_{10} (½** Recommended NPK + 50% Farmyard manure + 30% Vermicompost + 20% Poultry manure + Neem Cake), **T_{11} (½** Recommended NPK + 50% Farmyard manure + 50% Vermicompost + Phosphate solubilizing bacteria), **T_{12} (½** Recommended NPK + 50% Farmyard manure + 30% Vermicompost + 20% Poultry manure + Phosphate solubilizing bacteria), **T_{13} (½** Recommended NPK + 50% Farmyard manure + 50% Vermicompost + Neem Cake + Phosphate solubilizing bacteria) and **T_{14} (½** Recommended NPK + 50% Farmyard Manure + 30% Vermicompost + 20% Poultry manure + Neem Cake + Phosphate solubilizing bacteria). Collection of data started from 30 days after transplanting from five randomly selected healthy plants from each replication. Data were recorded on the basis of plant growth characters viz., plant height at last harvest (cm), stem girth (mm), number of primary branches, flowering parameters viz., number of days taken for first flowering, number of truss per plant and yield parameters viz., days to maturity of fruits, number of fruits per truss, number of fruits per plant, fruit weight (g), fruit yield per plant (kg) and hectare (t/ha). The mean values under each replication under each treatment were statistically analyzed using Duncan Multiple Range Test using SPSS 16.

3. RESULTS AND DISCUSSION

In order to study the effect of organic, inorganic and their combinations of different quantities and to standardize the nutrient level to obtain better economic output with respect to plant growth, flowering and yield parameters, data were statistically analyzed and thoroughly discussed here under.

3.1 Growth Parameters

All the growth characters were significantly affected by different combinations of organic manures and recommended NPK treatments (Table 1). The results revealed that maximum plant height (92.13 cm) recorded with treatment T_1 (recommended NPK), followed by treatment T_{14} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + NC + PSB) (90.96 cm), which significantly differed from other treatments and lowest plant height recorded with treatment T_3 (100% VC) (79.06 cm). These findings clearly indicated that Rocky being a hybrid variety that needs more nitrogen for new cell development and enlargement, which was ensured by application of recommended doses of NPK in inorganic form then organic or their combinations. Treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM) shown highest stem girth (14.85 mm) followed by treatment T_{12} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + PSB) (14.70 mm) and lowest stem girth observed with treatment T_5 (100% NC) (11.26 mm). The highest number of primary branches (7.38) got with treatment T_7 (½ Recommended NPK + 50% FYM + 50% VC), followed by treatment T_9 (½ Recommended NPK + 50% FYM + 50% VC + NC) (6.49) and lowest number recorded in treatment T_3 (100% VC) (4.76). These results are similar to Verma et al., (2020) reported that maximum value for plant height (47.67 cm), number of branches per plant (24.67) with application of T1 (Farmyard Manures and Vermicompost @ 15-20t/ha), Meena and Verma (2019) concluded that application of RDF (100:50:60 NPK kg/ha) gave highest plant height (117.13 cm) and number of primary branches (12.07), Chopra et al., [10] said that the characters like highest plant height (145.86 cm) recorded with 50 percent RDF and agro-residue vermicompost (ARV) at the rate 5 t/ha, Singh et al. [11] reported that maximum plant height (99.41 and 90.31 cm) obtained in Integrated Nutrient Management plot during

Kharif and Rabi seasons, Laxmi et al. [1] showed that 50 percent RDF and 50 percent FYM combination recorded maximum plant height (133.53 cm), Singh, (2014) reported that the maximum tomato plant height (114.12 cm) were recorded in treatment combination of 14.33 mt/ha FYM, 7.20 mt/ha vermicompost and NPK and Prativa and Bhattarai (2011) reported that maximum plant height (116.16 cm) were recorded with application of 16.66 mt/ha FYM, 8.33 mt/ha vermicompost and NPK combination.

3.2 Flowering Parameters

The data represented in Table 1 was indicating that the combination of organic manures and recommended dose of NKP affected significantly on flowering. The treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM) shown minimum number of days taken for first flowering (27.46), followed by treatment T_{10} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + NC) (27.89) and maximum number of days taken for first flowering (29.30) in the treatment T_{14} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + NC + PSB). Maximum number of truss per plant (20.59) recorded in the treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM), followed by treatment T_6 (100% VC + 100% FYM + 100% PM + 100% NC) (19.41) and lowest number of truss per plant (12.43) recorded in treatment A_5 (100% NC). The treatment T_7 (½ Recommended NPK + 50% FYM + 50% VC) recorded the maximum number of fruits per truss (6.23), followed by Treatment T_{13} (½ Recommended NPK + 50% FYM + 50% VC + NC + PSB) (4.2833) and treatment T_2 (100% FYM) (4.28) recorded minimum number of fruits per truss. These results are similar to Mohit et al. [12] revealed that treatment T_4 (NPK 75 percent and FYM 25 percent (6.25 t/ha) was exhibited minimum days taken to first flowering (49.00), Dixit et al., (2018) recorded maximum number of clusters per plant (7.60) was recorded in vermicompost (50 percent) and poultry manure (50 percent) treatment combination, Chopra et al. [10], Mengistu et al. [4] and Laxmi et al. [1].

3.3 Yield Parameters

The observations recorded on days to maturity of fruits, number of fruits per plants, fruit weight (g), fruit yield per plant (kg) and fruit yield per ha under the different combination of organic manures and recommended dose of NKP has been presented in Table 1. Among the treatments T_{11} (½ Recommended NPK + 50% FYM + 50% VC + PSB) taken minimum number of days to fruit maturity (58.31), followed by treatment T_5 (100% NC) (58.39) and highest (59.94) recorded in the treatment T_4 (100% PM). Highest number of fruits per plant (57.56) was shown treatment T_4 (100% PM) followed by treatment T_{10} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + NC) (51.12) and treatment T_2 (100% FYM) (41.87) was recorded least number of fruits per plant. This outcome might be due to poultry manure enhanced the nutrient (both macro and micro nutrients) availability in plants. It also improved the bulk density and water holding capacity of soil, which in turn enhanced the division of meristematic tissue, vegetative growth and metabolic reactions in plants due to which there was an increase in the number of fruits per plant. Phosphorus helped in the formation of stronger flower buds and flowers, which in turn increased the fruits per plant. Also, zinc, boron and copper significantly increased the number of fruits per plant Oke et al. [13]. Treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM) recorded maximum individual fruit weight (127.71 g), followed by treatment T_{11} (½ Recommended NPK + 50% FYM + 50% VC + PSB) (124.59 g) and minimum weight of fruit (90.1567 g) in treatment T_3 (100% VC). Treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM) reported highest fruit yield per plant (4.49 kg) followed by treatment T_{12} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + PSB) (4.22 kg) and lowest fruit yield per plant recorded in treatment T_2 (100% FYM) (3.10kg). Maximum yield per hector (79.62 t/ha) reported in treatment T_8, followed by treatment T_{12} (½ Recommended NPK + 50% FYM + 30% VC + 20% PM + PSB) (74.69 t/ha) and minimum fruit yield per hector reported in treatment A_2 (100% FYM) (41.64 t/ha). These results are similar to the findings recorded by Verma *et al*., (2020) concluded that maximum value for number of fruits per plant (7.33), fruit weight (12.03 g), fruit yield per plant (0.78 kg) and yield per ha (27.27t/ha) with application of T1 (Farmyard Manures, Vermicompost at 15-20t/ha), Mohit et al. [12] revealed that the treatment T4 (NPK 75 percent and FYM 25 percent (6.25 t/ha) was exhibited minimum days taken to first flowering (49.00), found superior in terms of number of fruits/plant (11.00), fruit diameter (4.76 cm) and fruit weight per plant (1080 g) and fruit yield per ha (399.99 q/ha), Kumari and Tripathi [14] reported that integrated nutrient management with 80 percent NPKM, 20 percent N through FYM, VC (50:50) and

Table 1. Growth and Yield parameters as influenced by integrated nutrient management in tomato

Treatment	Growth Parameters			Flowering Parameters			Yield Parameters				
	Plant Height at last harvest (cm)	Stem girth at last harvest (mm)	Number of primary branches	Days to first flowering	Number of truss per plant	Days to maturity of fruits	Number of fruits per truss	Number of fruits per plant	Fruit weight (g)	Yield per plant (kg)	Yield per ha (t/ha)
A1	92.13^{h}	12.15^{c}	4.92^{b}	29.02^{a-b}	14.71^{b}	59.59^{b-c}	5.74^{g-h}	47.76^{c}	112.21^{d}	3.76^{b-d}	66.41^{c}
A2	82.15^{b}	13.80^{f}	5.09^{c}	29.17^{a-b}	14.66^{b}	58.63^{a-b}	4.28^{a}	41.87^{a}	105.97^{c}	3.10^{a}	41.64^{a}
A3	79.06^{a}	12.00^{b}	4.76^{a}	29.07^{a-b}	14.80^{b}	59.03^{a-c}	4.97^{d}	50.23^{d-e}	90.16^{a}	3.18^{a}	47.75^{a}
A4	85.53^{c-d}	11.91^{b}	5.54^{d}	28.03^{a-c}	15.83^{c}	59.94^{c}	5.02^{d-e}	57.56^{f}	101.91^{b}	4.10^{c-f}	55.33^{e}
A5	79.79^{a}	11.26^{a}	5.50^{d}	28.13^{a-c}	12.43^{a}	58.39^{a-b}	5.24^{f}	47.66^{c}	102.84^{b}	3.40^{a-b}	74.11^{b}
A6	84.09^{c}	14.39^{h}	6.26^{f}	27.96^{a-c}	19.41^{g}	58.83^{a-c}	5.68^{g}	48.87^{c-d}	114.97^{e}	3.92^{c-e}	44.47^{d-e}
A7	84.09^{c}	13.67^{k}	7.38^{i}	28.04^{a-c}	18.84^{f-g}	59.29^{a-c}	6.23^{i}	49.16^{c-d}	111.53^{d}	3.81^{b-e}	52.53^{c}
A8	84.73^{c-d}	14.85^{l}	6.35^{f}	27.46^{c}	20.59^{h}	59.32^{a-c}	4.56^{b}	50.23^{d-e}	127.71^{i}	4.49^{f}	79.62^{f}
A9	86.71^{d-e}	14.38^{h}	6.49^{g}	27.89^{c-b}	15.03^{b}	58.58^{a-b}	4.78^{c}	47.95^{c}	123.88^{g-h}	4.11 $^{c-f}$	66.87^{e}
A10	86.62^{d-e}	14.60^{i}	5.92^{e}	28.75^{a-c}	14.72^{b}	59.35^{a-c}	4.96^{d}	51.12^{e}	118.52^{f}	4.18 $^{c-f}$	73.31^{e}
A11	87.80^{e-f}	14.11^{g}	5.09^{c}	28.30^{a-c}	15.20^{b-c}	58.31^{a}	4.97^{d}	47.52^{c}	124.59^{h}	4.14 $^{c-f}$	73.13^{e}
A12	88.53^{e-f}	14.70^{j}	6.68^{h}	28.10^{a-c}	18.07^{e}	58.80^{a-c}	4.89^{c-d}	49.03^{c-d}	122.49^{g}	4.22 $^{e-f}$	74.69^{e}
A13	89.21^{f-g}	13.19^{d}	6.65^{h}	28.57^{a-c}	17.18^{d}	59.44^{a-c}	5.86^{h}	45.83^{b}	119.80^{f}	3.72^{b-c}	66.82^{c}
A14	90.96^{g-h}	13.67^{e}	6.33^{f}	29.30^{a}	18.11^{e-f}	59.45^{a-b}	5.15^{e-f}	50.17^{d-e}	119.41^{f}	4.21^{c-f}	73.31^{e}
Sem	0.62	0.03	0.04	0.41	0.24	0.34	0.051	0.53	0.66	0.14	0.78
CD5%	1.78	0.09	0.08	1.19	0.69	0.98	0.15	1.54	1.90	0.41	2.26
CD1%	2.41	0.12	0.11	1.61	0.93	1.33	0.21	2.08	2.57	0.56	3.06

**Means followed by the same superscript are not significantly different using DMRT at P<0.05*

PGPR had the highest fruit yield (606.51 q/ha) of tomato, Chopra et al. [10] said that among various treatments investigated, the character like highest number of fruits/plant (45.12) and fruit yield per plant (5680.88 g) was recorded with 50 percent RDF and agro-residue vermicompost (ARV) at the rate 5 t/ha, Kirankumar et al. [15] shown that an average yield of tomato in demonstration fields ranged from 194.50 to 215.55 q/ha whereas in local practice it was 161.85 and 172.65 q/ha, Kumar et al. [16] was found that application of 43.5 tonnes of farm yard manure (FYM) and 50 percent of recommended dose of fertilizers (RDF) gave maximum fruit yield (284.81q/ha) over control (198.6q/ha), Rajeev et al. [17] reported that combination of RDF 25percent, FYM 25percent, azotobactor 25percent and azospirillum 25percent given minimum number of days to first flowering (37.72) and maximum number of clusters per plant (9.78), number of fruit per plant (15.95), Fruit diameter (60.69 cm), fruit weight (68.28 g), fruits yield per plant (1.09 kg), fruit yield per plot (17.44 kg) and fruit yield (363.60 q/ha), Avhad et al. [18] revealed that the application of GRDF 300: 150:150 kg NPK and FYM 20 t/ha gave highest value of number of fruits per plant (42.62), average weight of fruit (86.33 g) and fruit yield per plant (2.54 kg) and Singh et al. [11] concluded that maximum average fruit weight (96.00 and 94.80 g) and marketable fruit yield (1025 q/ha and 955 q/ha respectively) obtained in Integrated Nutrient Management field during Kharif and Rabi seasons in comparison to farm practice.

Due to application of organic manures in the form of FYM, vermi compost, poultry manure and neem cake along with recommended dose of NPK might has improved the soil physical properties such as soil structure, better moisture holding capacity, aeration etc and leading to the adequate supply of nutrients to the plants, which might have promoted the maximum vegetative growth and the enrichment of biological activity. Release of organic acids might have degraded and mobilized the occluded soil nutrients to available form and the increased microbial activity in organic manures stimulated the growth and yield Ojeniyi et al. [19].

4. CONCLUSIONS

On the basis of present investigation on integrated nutrient management, it may be concluded that application of combination treatments of organic manures and recommended dose of NPK in tomato has a significant positive result and gives researchers an opportunity to demonstrate the productivity potential and profitability of the recently developed technology under real farming situation, which are advocating for long time and application of treatment T_8 (½ Recommended NPK + 50% FYM + 30% VC + 20% PM) gave highest stem girth at last harvest (mm), number of truss per plant, individual fruit weight (g), fruit yield per plant (kg) and fruit yield per hector that could be recommended for rural farm practice to enhance tomato production.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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