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Effects of Nano Fertilizer on Yield, Yield Attributes and Economics in Tomato (*Solanum lycopersicum* L.)

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A B S T R A C T

An experiment was undertaken during the winter season of 2018-19 on tomato (var. Utkal Pallavi), in order to assess the performance of new commercial nano-based water soluble, foliar fertilizer in comparison to commonly adopted water soluble foliar fertilizer with respect to yield, yield attributes and economics. The experiment was laid out in the randomized block design with eight treatments and three replications. Results revealed that the treatment T_6 (Pramukh foliar spray@ 5g/l + RDF- Recommended Dose of Fertilizer@ 125 kg N : 60 kg P_2O_5 : 100 kg K_2O/ha) was found to be the best with respect to the characters like fruit yield (510 q/ha), fruits per plant (81.6), fruit length (5.84 cm) and fruit girth (14.13 cm). As regards average fruit weight, T_3 (Nano- Max NPK foliar spray @5ml/l + RDF) was the best (56.3 g). The treatment T_5 (Pramukh foliar spray @4g/l + RDF) produced the maximum no. of flowers per cluster (9.73) and recorded the highest benefit: cost ratio (3.69). As regards days to 50% flowering, T_1 and T_3 recorded early 50% flowering (51.0 days after sowing). The treatment T_5 produced 2nd highest yield (509.26q/ha) followed by the treatment T_6 having highest yield and 2nd highest benefit: cost ratio (3.68).

Introduction

Nanotechnology encompasses understanding of the fundamentals involving physics, chemistry, biochemistry, biology and technology of nanometer-scale objects. It deals with very small sized particles which range between 1nm to 100 nm. Medicine, water and soil management, nano-fertilizers, pesticides, food technology, nano sensors, solar cells, electronics etc. are the various areas in which nanotechnology has been applied. Nano fertilizers can eliminate or lessen the problems such as leaching of nutrients, environmental pollution, plant damage, increasing salinity and toxicity etc.

caused by use of conventional inorganic fertilizers. Nano fertilizers are extremely soluble, provide precise concentration and slow release of nutrients due to greater surface area. These are also safer than the conventional inorganic fertilizers from the angle of soil and environmental degradation.

Tomato is globally known as "Protective Food". It contains vitamin-C and lycopene which is an antioxidant. It increases appetite and relieves constipation. As regards nano fertilizer, there are numerous uses of these fertilizers to increase the yield and growth of different crops. Tantawy *et al.,* (2014) reported that tomato fruit yield and nutritional status were significantly improved under nano calcium treatment of 0.5g/l concentration. Ambroszczyk *et al.,* (2016) showed that foliar application of Nano-Gro® increased early yield of tomato fruit (983 g/m^2) as compared with the control (780 g/m^2) and also increased lycopene, dry matter, chlorophyll and β-carotene content. Also, Khan (2016) observed that nano-titanium dioxide (Nano-TiO_2) @ 20mg/l as foliar spray enhanced growth and yield, antioxidative enzymes and accumulation of compatible solutes [Proline and Glycine Betaine] in tomato grown under 200 mM NaCl.

No research work has been conducted in Odisha as regards application of nano fertilizers in tomato. Therefore, an experiment was carried out with the objective of studying the effects of commercial nano-NPK fertilizer on yield, yield attributing characters and economics of treatments in tomato.

Materials and Methods

The experiment was conducted in the experimental field under the Department of Horticulture, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, during the winter season of 2018-19. The field was laid out in randomized block design with 8 treatments and 3 replications while spacing of 50 cm between rows and 30 cm between plants was given.

Mechanical composition of soil

The mechanical composition of initial soil sample was determined by Bouyoucos Hydrometer method, 1962. The textural class of the soil was loamy sand and the composition of sand, silt and clay were 79.6%, 14.3% and 6.1% respectively. The chemical composition of the initial soil sample is given in Table 1.

Nano-max NPK

The constituents of this fertilizer are multiple organic acids (protein lacto-gluconates) containing chelated major nutrients (N:P:K @ 4:4:4%) along with organic carbon (10%) and amino acids (6%). Manufacturer- J.U. Agri Science Pvt. Ltd., Indore, MP.

Multiplex pramukh

This fertilizer is constituted of N:P:K @ 19:19:19%. It is water soluble fertilizer which can be used as foliar spray or in fertigation. Manufacturer- Agriplex Pvt. Ltd., Mahalakshmi Layout, Bengaluru, Karnataka.

Seeds of tomato var. Utkal Pallavi were sown in the nursery bed on 23.10.2018 and transplanting was done on 19.11.2018.Before transplanting, FYM @25t/ha was applied to the main field. Recommended basal dose of Urea (20%), Single Super Phosphate (100%) and Muriate of Potash (20%) were also applied to the main field. Fifteen days after transplanting, Urea (40%) and Muriate of Potash (40%) were applied as first top dressing and thirty days after transplanting, the remaining 40% Urea and Muriate of Potash was applied as second top dressing. Respective doses of Nano-Max NPK and

Pramukh fertilizers were applied three times to the subplots on 04.12.2018, 19.12.2018 and 04.01.2019 respectively. Recommended packages were adopted for all other cultural practices.

Five sample plants were tagged randomly from different sub plots leaving the border plants for recording observations. Observations on days to 1st flowering, days to 50% flowering, flowers per cluster, fruit length, fruit girth, fruit weight, fruits per plant, fruits per cluster and fruit yield were recorded systematically and periodically.

Plot yields were recorded at 4-5 days interval and the total yield was expressed in terms of quintals per hectare. The data were statistically analysed for randomized block design as suggested by Panse and Sukhatme (1985) (Table 2).

Results and Discussion

Days to 1st flowering (Days after sowing)

No significant differences were observed regarding days to 1st flowering. However, the values ranged from 44.33 days to 47.67 days after sowing (Table 3). The treatment T_4 produced early flowering in 44.33 days after sowing followed by T_8 and T_6. Late flowering (47.67 days after sowing) was seen in T_1.

Days to 50% flowering (Days after sowing)

There were no significant differences with regard to days to 50% flowering (Table 3). The values in this respect ranged between 51 days and 53.67 days after sowing. However, T_1 and T_3 gave early 50% flowering in 51 days followed by T_8 and T_6 treatments. The late (53.67 days after sowing) 50% flowering was obtained in T_7 treatment. The fact that T_1 and T_3 gave early 50% flowering conforms to the findings of Laware and Raskar (2014) and Shukla *et al.,* (2017).

Flowers per cluster

No significant differences were found with regard to no. of flowers per cluster (Table 3). However, the values ranged between 8.73 and 9.73. T_5 treatment produced the maximum (9.73) no. of flowers per cluster followed by T_3 and T_8. The least value (8.73) was observed in case of T_1treatment.

Fruit weight (g)

Significant differences were observed with respect to fruit weight of tomato plants, which ranged from 49.83g to 56.93g (Table 4). However, T_3, T_7, T_8, T_2, T_6 and T_4 treatments showed similar results. T_3 gave significantly better result than T_1 and T_5. Yassen *et al.,* (2017) also reported that fruit weight was better with nano-fertilizer application. Highest fruit weight (56.93g) was seen in case of T_3 and the lowest (49.83g) in case of T_1.

Fruit length (cm)

It was evident from Table 4 that there were no significant differences among treatments with regard to fruit length, which ranged between 5.44cm and 5.84cm.

However, T_6 produced maximum (5.84cm) fruit length followed by T_2 and T_3.This is in consonance with the reports of Yassen *et al.,* (2017). The lowest value (5.44cm) was observed in T_5.

Fruit girth (cm)

It was observed from Table 4 that there were significant differences in case of fruit girth, which ranged from 12.34cm to 14.13cm. T_6, T_7, T_2, T_3 and T_8 were at par and T_1, T_5 and T_4 were inferior to T_6. The treatments T_8, T_4, T_5 and T_1 recorded similar results. T_6 gave maximum (14.13cm) and T_1 gave minimum (12.34cm) fruit girth.

Table.1 Chemical composition of initial soil sample

Particulars	Value obtained	Method
Organic carbon (%)	0.6	**Walkley and Black's rapid titration (1934)**
Total N (kg/ha)	48	**Total nitrogen content (kg/ha) = % of organic carbon x 80**
Available P (kg/ha)	3.76	**Olsen's method(1954)**
Available K (kg/ha)	126.6	**Flame-Photometer using ammonium acetate extracts (Jackson, 1973)**
pH(1:2.5::Soil:water)	6.5	**pH meter with 1:2.5 soil water ratio(Jackson, 1973)**
Electrical conductivity (µS)	**111.6**	**Electrical conductivity meter**

Table.2 Details of treatments

Sl. No.	Treatments
T_1	**Nano-Max NPK @ 3ml/l of water foliar spray + RDF**
T_2	**Nano-Max NPK @ 4ml/l of water foliar spray + RDF**
T_3	**Nano-Max NPK @ 5ml/l of water foliar spray + RDF**
T_4	**Pramukh @ 3g/l of water foliar spray + RDF**
T_5	**Pramukh @ 4g/l of water foliar spray + RDF**
T_6	**Pramukh @ 5g/l of water foliar spray + RDF**
T_7	**Nano-Max NPK @ 4ml/l foliar spray + Pramukh @ 4g/l of water foliar spray + RDF**
T_8	**Control (Only RDF)**

(RDF- Recommended Dose of Fertilizer@125kgN:60kgP_2O_5:100 kg K_2O/ha)

Table.3 Effects of nano-fertilizer on reproductive growth of tomato

Treatments		Days to 1st flowering (DAS)	Days to 50% flowering (DAS)	Flowers per cluster
T_1	Nano-Max NPK (3ml/l) + RDF	47.67	51.00	8.73
T_2	Nano-Max NPK (4ml/l) + RDF	47.67	53.00	9.30
T_3	Nano- Max NPK (5ml/l) + RDF	46.67	51.00	9.50
T_4	Pramukh (3g/l) + RDF	44.33	52.33	9.00
T_5	Pramukh (4g/l) + RDF	46.33	52.00	9.73
T_6	Pramukh (5g/l) + RDF	45.67	51.67	9.30
T_7	Pramukh (4g/l) + Nano-Max NPK (4ml/l) + RDF	46.67	53.67	9.00
T_8	Control (only RDF)	45.33	51.33	9.37
SE(m)±		1.10	1.13	0.33
CD(0.05)		NS	NS	NS
CV(%)		4.13	3.77	6.27

Table.4 Effects of nano-fertilizer on yield and yield attributes of tomato

Treatments		Fruit weigh t(g)	Fruit length (cm)	Fruit Girth (cm)	Fruits per cluster	Fruits per plant	Yield per plot (in kg)	Yield (q/ha)
T_1	Nano-Max NPK (3ml/l) + RDF	49.83	5.58	12.34	5.80	51.60	19.91	368.70
T_2	Nano-Max NPK (4ml/l) + RDF	54.13	5.73	13.23	6.10	57.00	21.76	402.96
T_3	Nano- Max NPK (5ml/l) + RDF	56.93	5.64	13.20	6.33	63.67	24.26	449.26
T_4	Pramukh (3g/l) + RDF	52.33	5.55	12.68	6.53	63.27	23.73	439.44
T_5	Pramukh (4g/l) + RDF	49.97	5.44	12.35	6.53	66.33	27.50	509.26
T_6	Pramukh (5g/l) + RDF	53.53	5.84	14.13	6.30	81.60	27.54	510.00
T_7	Pramukh (4g/l) + Nano-Max NPK (4ml/l) + RDF	55.60	5.61	13.60	6.50	63.20	21.69	401.67
T_8	Control (only RDF)	54.50	5.59	13.01	6.87	62.07	23.00	425.93
SE(m)±		2.24	0.15	0.44	0.24	4.42	1.46	
CD(0.05)		6.79	NS	1.34	0.74	13.41	4.43	
CV(%)		7.27	4.75	5.86	6.60	12.05	10.68	

Table.5 Final soil analysis of treatments

Treatments		Total nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)	pH	Electrical conductivity (µS)	Organic carbon(%)
T_1	Nano-Max NPK (3ml/l) + RDF	92.8	31.96	112.7	6.4	300.1	1.16
T_2	Nano-Max NPK (4ml/l) + RDF	78.0	29.67	97.8	6.2	276.8	0.97
T_3	Nano- Max NPK (5ml/l) + RDF	54.4	17.53	63.4	6.2	202.5	0.68
T_4	Pramukh (3g/l) + RDF	72.0	15.89	86.2	6.3	290.6	0.90
T_5	Pramukh (4g/l) + RDF	97.6	18.59	82.4	6.4	384.9	1.22
T_6	Pramukh (5g/l) + RDF	64.8	15.73	79.6	6.8	209.8	0.81
T_7	Pramukh (4g/l) + Nano-Max NPK (4ml/l) + RDF	105.6	26.27	87.0	6.6	268.2	1.32
T_8	Control (only RDF)	60.8	14.42	62.7	6.5	204.1	0.76

Table.6 Economics of treatment

Treatments		Yield (q/ha)	Gross income (Yield x Rs.10/- per kg) (in rupees)	Total cost of cultivation (in rupees)	Net income (in rupees)	Benefit/cost ratio
T_1	Nano-Max NPK (3ml/l) + RDF	368.70	3,68,700	1,42,225	2,26,475	2.59:1
T_2	Nano-Max NPK (4ml/l) + RDF	402.96	4,02,960	1,44,287	2,58,673	2.75:1
T_3	Nano- Max NPK (5ml/l) + RDF	449.26	4,49,260	1,46,350	3,02,910	3.06:1
T_4	Pramukh (3g/l) + RDF	439.44	4,39,440	1,37,443.75	3,01,996.25	3.19:1
T_5	Pramukh (4g/l) + RDF	509.26	5,09,260	1,37,912.5	3,71,347.5	3.69:1
T_6	Pramukh (5g/l) + RDF	510.00	5,10,000	1,38,381.25	3,71,618.75	3.68:1
T_7	Pramukh (4g/l) + Nano-Max NPK (4ml/l) + RDF	401.67	4,01,670	1,49,443.75	2,52,226.25	2.68:1
T_8	Control (only RDF)	425.93	4,25,930	1,32,756.25	2,93,173.75	3.20:1

Fruits per cluster

Significant differences were found regarding no. of fruits per cluster, which ranged between 5.80 and 6.87 (Table 4). T_8, T_5, T_4, T_7, T_3 and T_6 were at par. Yassen *et al.*, (2017) made similar observations. However, T_8 recorded maximum (6.87) and T_1recorded minimum (5.80) no. of fruits per cluster.

Fruits per plant

It was evident from Table 4 that there were significant differences regarding no. of fruits per plant. However, T_6 was superior to T_5, T_3, T_4, T_7, T_8, T_2 and T_1 respectively. T_8 was found to be at par with T_1, T_2, T_3. Several researchers (Harish and Gowda (2017); El-Metwally *et al.*, 2017; Yassen *et al.*, 2017) made a similar observations. The highest (81.60) value was obtained in T_6 and the lowest (51.60) was in T_1.

Yield per plot and per hectare

Significant differences were found regarding yield per plot. T_6, T_5, T_3 and T_4 treatments were at par. T_8 was found to be at par with T_1, T_2 and T_3. This is in agreement with the findings of several researchers (Owolade *et al.*, 2008; Moghaddasi *et al.*, 2013; Tantawy *et al.*, 2014; Liu and Lal 2014; Khan 2016; Khanm *et al.*, 2017; Davarpanah *et al.*, 2017; Jyothi and Hebsur 2017; Raddy *et al.*, 2017; Rathnayak *et al.*, 2018). T_6, T_5, T_3 and T_4 were found superior than T_8, T_2, T_7 and T_1.

The highest yield (27.54 kg/plot) (510 q/ha) was obtained in T_6 followed by T_5 (509.26 q/ha) and T_3 (449.26 q/ha) and the lowest yield (19.91 kg/plot) (368.7 q/ha) was recorded in T_1 (Table 4).

Final soil analysis of treatments

Total nitrogen (kg/ha)

It was evident from Table 5 that the total nitrogen content of soil for different treatments varied from 54.4 kg/ha (T_3) to 105.6 kg/ha (T_7).

Available phosphorus (kg/ha)

A perusal of Table 5 showed that the available phosphorus of soil for different

treatments ranged from 14.42 kg/ha (T_8) to 31.96 kg/ha (T_1).

Available potassium (kg/ha)

It was evident from Table 5 that the available potassium content of soil from different treatments ranged from 62.7 kg/ha (T_8) to 112.7 kg/ha (T_1).

pH

It was observed from Table 5 that the pH range varied for different treatments from 6.2 (T_2 and T_3) to 6.8 (T_6).

Electrical conductivity (µS)

It was seen from Table 5 that electrical conductivity ranged for different treatments from 204.1 µS (T_8) to 384.9 µS (T_5).

Organic carbon (%)

It was observed from Table 5 that organic carbon for different treatments ranged from 0.68% (T_3) to 1.32% (T_7).

Economics of treatments

A perusal of Table 6 showed that gross income was highest in case of the treatment T_6 (Rs.5,10,000/-) followed by T_5 (Rs.5,09,260/-) and T_3 (Rs.4,49,260/-) and the minimum was seen in T_1 (Rs.3,68,700/-). Total cost of cultivation was found minimum for T_8 (Rs.1,32,756.25/-) followed by T_4 (Rs.1,37,443.75/-) and T_5(Rs.1,37,912.5/-) and the maximum was observed in case of T_7 (Rs.1,49,443.75/-). Net income was maximum in T_6 treatment (Rs.3,71,618.75/-) followed by T_5 (Rs.3,71,347.5/-) and T_3 (Rs.3,02,910/-) and the least was seen in T_1 (Rs. 2,26,475/).The highest B:C ratio was recorded in T_5 (3.69) followed by T_6 (3.68) and T_8 (3.20) and the lowest was in T_1 (2.59).

The treatment T_6 (Pramukh foliar spray@ 5g/l + RDF) was found to be the best with respect to the characters fruit yield/ha, fruits per plant, fruit length and fruit girth. As regards average fruit weight, T_3 (Nano-Max NPK foliar spray @5ml/l + RDF) was the best. The treatment T_5 (Pramukh foliar spray @4g/l + RDF) produced the maximum no. of flowers per cluster and the treatments T_1 and T_3 recorded early 50% flowering. The treatment T_5recoredhighest benefit: cost ratio and 2nd highest yield followed by the treatment T_6 having highest yield and 2nd highest benefit: cost ratio.

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