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EFFECT OF FOLIAR SPRAY OF NANO UREA ON GROWTH, YIELD AND ECONOMICS OF TOMATO

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ABSTRACT

A field experiment entitled "Effect of foliar spray of nano urea on growth, yield and economics of tomato (*Solanum lycopersicum* L.)" was carried out on medium black calcareous soil having pH 8.1 and EC 0.52 dS/m during *Rabi* season of 2023-24 at Vegetable Research Station, Junagadh Agricultural University, Junagadh (Gujarat). The experiment was laid out in randomized block design with three replications. The experiment comprising of 12 treatments *viz.*, T_1 (Control), T_2 (100% RDN + Water spray at 30 and 45 DAT), T_3 (75% RDN + 2 foliar spray of 1% urea), T_4 (75% RDN + 2 foliar spray of 2% urea), T_5 (75% RDN + 2 foliar spray of 0.2% nano urea), T_6 (75% RDN + 2 foliar spray of 0.4% nano urea), T_7 (75% RDN + 2 foliar spray of 0.6% nano urea), T_8 (75% RDN + 3 foliar spray of 1% urea), T_9 (75% RDN + 3 foliar spray of 2% urea), T_{10} (75% RDN + 3 foliar spray of 0.2% nano urea), T_{11} (75% RDN + 3 foliar spray of 0.4% nano urea) and T_{12} (75% RDN + 3 foliar spray of 0.6% nano urea). The tomato (GT-6) was transplanted on 29th November, 2023 at a spacing of 75 cm × 60 cm using seed rate of 300-350 g/ha with standard package of practices.

***Key words*: Tomato, Foliar spray, Nano urea, Growth, Yield and Economics**

Introduction

Tomato (*Solanum lycopersicum* L.) is a *solanaceous* crop with chromosome number 2n = 24 and one of the most popular vegetables grown all over the world. It tops in the list of processed vegetables in the world (Dhaliwal *et al.*, 1999). Tomato is grown worldwide for local use or as an export crop. World tomato production grew faster between year 2000 and 2019, as its growth went up to 16 per cent in year 2019 (FAOSTAT, 2021). It is cultivated as a cash crop as well as a vegetable crop on commercial lines in almost all parts of India. Its fruits are abundantly rich in vitamins A and B and an excellent source of vitamin C, mineral, organic acids and also contain various flavoring compounds, which enrich the taste and flavor of all vegetable dishes prepared from it. Besides, being popular for salad and soup, tomato is mixed in cooked vegetable curries. It is also one of the most important raw materials for processing industry for making several processed products.

The 100 g fruit contains 94.22 g water, 2.7 g carbohydrates, 17 kcal energy, 0.89 g protein, 0.24 g total fat, 1.21 g dietary fibre, 0.59 g ash, 3.74 mg sodium, 12.1 mg magnesium, 22.9 mg phosphorus, 10.9 mg sulphur, 48.3 mg chlorine, 265 mg potassium, 10.9 mg calcium, 56.8 µg manganese, 0.13 mg iron, 0.049 mg copper, 0.09 mg zinc, 92 µg vitamin A, 0.024 mg thiamine, 0.005 mg riboflavin, 0.543 mg niacin, 23.7 mg vitamin C and 0.77 mg vitamin E (Hedges and Lister, 2005). It is the richest fruit among natural foods by which the stomach and intestine remain in good condition and thus has very good medicinal property.

Nano urea contains 4.0% total nitrogen (w/v). These particles are evenly dispersed in water. Nano urea because of its small size (20-50 nm) and higher use efficiency (>80%). When sprayed on leaves of plant (2-4 mL/l) at critical growth stages, it increases the instant availability of nutrients to the growing plant parts, increases chlorophyll formation, rate of photosynthesis, dry matter production and thus overall growth of the plants. Nano urea (30-40 nm) can easily penetrate the stomata and easily get entered through plasmodesmata (40 nm) and subsequently take part into the metabolism by binding itself with various carrier proteins. Unused nitrogen is retained in the plant vacuole and released slowly for appropriate plant growth and development (Kumar *et al*., 2021).

In modern agriculture and horticulture, foliar feeding of nutrients and growth regulators has become a widely adopted practice. This method plays a crucial role in ensuring efficient nutrient use, especially during the critical growth stages of crops, thereby contributing to improved yields. To enhance the nutrient use efficiency of applied fertilizers, it is essential to determine and implement the optimal combination and appropriate levels of both basal (soil-applied) and foliar (leaf-applied) nutrient applications. Basal fertilization provides necessary support during the early growth stages, establishing a strong foundation for crop development. In contrast, foliar feeding ensures that crops receive targeted nutrition during key physiological stages, promoting better performance and higher productivity.

Materials and Methods

An experiment was conducted during *Rabi* season of 2023-24 at Vegetable Research Station, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) located at 21.5°N latitude and 70.5°E longitude with an altitude of 60 m above mean sea level. The mean maximum and minimum temperature during the crop growth and development period were ranged between 28.1^{0}C to 39.0 ^{0}C and 11.0 ^{0}C to 23.1 ^{0}C, respectively. The soil of the experimental site was clayey in texture (Sand 22.38%, silt 14.35% and clay 63.27%) with a pH of 8.1. The soil had medium organic carbon (0.62) and available N (297.80 kg/ha), P (27.55 kg/ha) and K (235.42 kg/ha). Three times replicated experiment consisted of twelve treatments were laid out in randomized block design (RBD). The experiment comprised 12 treatments in combination of soil application and foliar spray of nano urea *viz*., T_1 (Control), T_2 (100% RDN + Water spray at 30 and 45 DAT), T_3 (75% RDN + 2 foliar spray of 1% urea), T_4 (75% RDN + 2 foliar spray of 2% urea), T_5 (75% RDN + 2 foliar spray of 0.2% nano urea), T_6 (75% RDN + 2 foliar spray of 0.4% nano urea), T_7 (75% RDN + 2 foliar spray of 0.6% nano urea), T_8 (75% RDN + 3 foliar spray of 1% urea), T_9 (75% RDN + 3 foliar spray of 2% urea), T_{10} (75% RDN + 3 foliar spray of 0.2% nano urea), T_{11} (75% RDN + 3 foliar spray of 0.4% nano urea) and T_{12} (75% RDN + 3 foliar spray of 0.6% nano urea). As per recommendation, half nitrogen, full phosphorus and potassium were applied as basal dose in the previously opened furrows to all the plots in the form of urea, DAP and MOP, respectively. Remain half dose of nitrogen was applied at 30 DAT through urea as top dressing at evening. (75.0:37.5:62.5 N:P_2O_5:K_2O kg/ha).

Table 1: Effect of different treatments on the growth parameters of tomato.

Treat-ments	PH	LAPP		NBPP	
		At 60 DAT	At 75 DAT	At 60 DAT	At harvest
T_1	57.33	98.7	127.7	1.50	2.00
T_2	75.00	188.3	217.3	2.50	3.10
T_3	65.67	115.3	144.3	1.96	2.50
T_4	64.33	130.0	159.0	2.06	2.60
T_5	65.33	147.5	176.5	2.13	2.63
T_6	82.67	208.7	237.7	2.73	3.33
T_7	71.00	176.7	195.7	2.66	3.17
T_8	63.33	116.6	145.6	2.03	2.57
T_9	71.33	184.0	213.0	2.36	2.97
T_{10}	64.33	149.3	178.3	2.14	2.71
T_{11}	77.00	195.4	224.4	2.43	3.03
T_{12}	66.00	145.0	174.0	2.10	2.60
S.Em.±	4.38	10.9	11.7	0.16	0.17
C.D. at 5%	12.87	32.2	34.2	0.48	0.51
C.V.%	11.08	12.28	11.05	12.85	10.95

PH: Plant height (cm)At harvest; **LAPP:** Leaf area (cm^2) per plant; **NBPP:** Number of branches per plant

Growth Parameters

Plant height (cm)

Five plants were selected randomly from each experimental plot and tagged. Plant height from the base of the plant to the top of longest leaf was measured with the help of a meter scale at harvest. Mean values were worked out for all the treatments and recorded in cm.

Leaf area at 60 and 75 DAT

The leaf area of five randomly tagged plants in each experimental plot was computed at the 60 and 75 DAT by using LI-COR LI-3100C portable leaf area meter with a transparent belt conveyor with an electronic digital display and is expressed in cm^2.

Number of branches per plant

Number of branches of all the five tagged plants was recorded plot wise at 60 DAT and at harvest average value was recorded.

Yield Attributes and Yield

Number of fruit per plant

Total number of fruits harvested at every picking from five tagged plants were taken into consideration to work out mean number of fruits per plant. This was worked out for every treatment separately.

Table 2: Effect of different treatments on the yield attributes and yield of tomato.

Treatments	Number of fruits per plant	10-fruit weight (g)	Fruit length (cm)	Fresh fruit yield (t/ha)
T_1	42.36	570.09	3.18	26.88
T_2	55.33	660.01	4.82	36.30
T_3	44.66	663.33	4.06	29.47
T_4	46.10	610.66	4.03	31.55
T_5	45.83	618.67	4.28	34.03
T_6	60.80	676.66	5.05	40.06
T_7	54.50	619.33	4.22	36.34
T_8	47.33	631.23	3.70	30.00
T_9	55.10	616.06	4.30	36.37
T_{10}	49.40	626.65	4.05	34.04
T_{11}	56.34	672.69	4.93	38.16
T_{12}	46.03	613.66	4.18	33.15
S.Em.±	2.20	20.64	0.29	1.82
C.D. at 5%	6.47	60.54	0.86	5.33
C.V.%	7.59	5.66	12.06	9.29

10-fruits weight (g)

The same ten fruits taken for recording the weight with the help of electronic balance and total fruits weight in grams was recorded.

Fruit length (cm)

Length of five fruit was measured in cm from the base to the tip of the fruit and average was recorded for each treatment.

Fruit yield (t/ha)

The fruit yield obtained from each plot (including five tagged plants) in each picking was sum up which gave the total fruit yield per plot and thereafter with the use of multiplication factor the yield was converted into per hectare basis for each treatment.

Results and Discussion

Growth parameters

Plant height (cm)

A significantly higher plant height (82.67 cm) recorded under the treatment T_6 (75% RDN + 2 foliar spray of 0.4% nano urea). This significant increase in plant height can be attributed to the synergistic effect of foliar application of nano fertilizers and basal application of conventional fertilizers. This combination likely enhanced the auxin metabolism and enzymatic activity within the plants, promoting cell elongation and enlargement. Furthermore, the high surface area of nano fertilizers compared to conventional forms improves nutrient absorption and metabolic efficiency, ultimately contributing to increased plant growth. The results were in conformity with the results obtained by Abbas and Reema (2019), Mishra *et al.*, (2020), Al-Mugheer and Al-Jumaili (2021), Reddy *et al.*, (2022), Samui *et al.*, (2022) and Singh *et al.*, (2023).

Leaf area

Under treatment T_6 (75% RDN + 2 foliar spray of 0.4% nano urea) recorded significantly the higher leaf area at 60 DAT and 75 DAT. The increase in leaf area may be attributed to the enhanced reactivity of nano fertilizers, which is due to their larger specific surface area and higher surface energy. These nano-scale properties facilitate greater interaction with plant tissues, thereby improving nutrient absorption and promoting leaf development (Dhoke *et al.*, 2013). These findings were acknowledged with the references Maswada and Abd El-Rahman (2014), Hamoda *et al.*, (2016), Manikandan and Subramanian (2016), Mahil and Kumar (2019), Merghany *et al.*, (2019), Al-Jabri *et al.*, (2020), Kumar *et al.*, (2020) and Mishra *et al.*, (2020).

Table 3: Effect of different treatments on the economics of tomato.

Treatments		Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B: C ratio
T_1	Absolute control	295680	77850	217830	3.79
T_2	100% RDN + Water spray at 30 and 45 DAT	399336	86369	312968	4.62
T_3	75% RDN + 2 foliar spray of 1% urea	324170	86975	237195	3.72
T_4	75% RDN + 2 foliar spray of 2% urea	347050	87022	260028	3.98
T_5	75% RDN + 2 foliar spray of 0.2% nano urea	374330	87647	286683	4.27
T_6	75% RDN + 2 foliar spray of 0.4% nano urea	440623	88367	352256	4.99
T_7	75% RDN + 2 foliar spray of 0.6% nano urea	399776	89087	310689	4.48
T_8	75% RDN + 3 foliar spray of 1% urea	330000	87004	242996	3.79
T_9	75% RDN + 3 foliar spray of 2% urea	400070	87081	312989	4.59
T_{10}	75% RDN + 3 foliar spray of 0.2% nano urea	374440	88097	286343	4.25
T_{11}	75% RDN + 3 foliar spray of 0.4% nano urea	419796	89267	330529	4.70
T_{12}	75% RDN + 3 foliar spray of 0.6% nano urea	364613	90437	274176	4.03

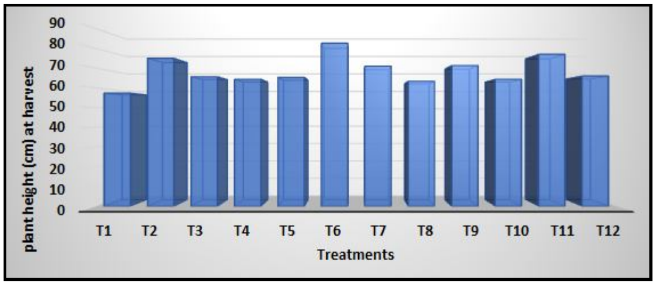

Fig. 1: Effect of different treatment on plant height (cm) at harvest of tomato.

Number of branches per plant

Data revealed that application of treatment T_6 (75% RDN + 2 foliar spray of 0.4% nano urea) led to a remarkable increase of number of branches per plant at 60 DAT (2.73) and at harvest (3.33). The observed increase in the number of branches following foliar application of nano fertilizers can be attributed to several physiological enhancements. This efficient nutrient uptake supports the activation of key enzymes involved in plant growth. For instance, the application of nano-potassium fertilizers has been shown to enhance the activity of nitrate reductase, a crucial enzyme in nitrogen assimilation, leading to improved photosynthetic activity and biomass accumulation. Additionally, nano fertilizers can stimulate the activity of antioxidant enzymes (Nekrasova *et al.*, 2011) such as peroxidase and catalase, which play vital roles in protecting plant cells from oxidative stress and supporting overall plant health. The small size of these particles allows for better penetration into plant tissues, ensuring more than 80% availability to the crop, thereby promoting robust growth and development. These results are in accordance with the findings of Parvin *et al.*, (2013), Mishra *et al.*, (2020), Ojha *et al.*, (2022), Singh *et al.*, (2023).

Yield attributes and Yield

Number of fruits per plant

Significantly the higher number of fruits per plant (60.80) was recorded with treatment T_6 (75% RDN + 2

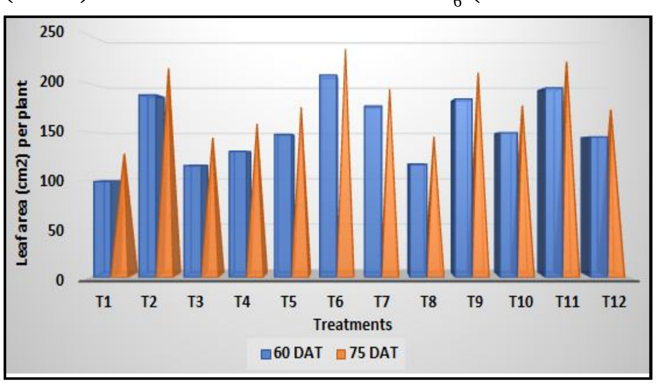

Fig. 2: Effect of different treatments on leaf area 60 and 75 DAT per plant of tomato.

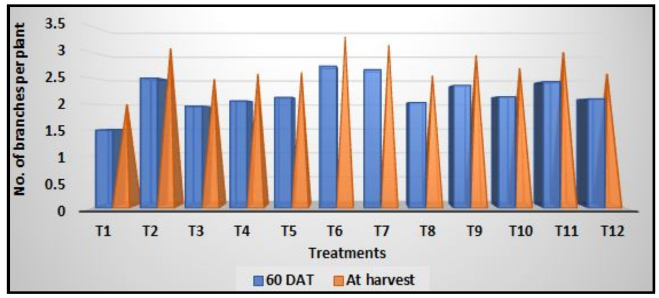

Fig. 3: Effect of different treatments on no of branches per plant at 60 DAT and at harvest.

foliar spray of 0.4% nano urea). This might be due to the reason that nano urea promotes the plant to absorb the water and nutrients from soil, then the photosynthesis is improved (Wu, 2013). Further, nano urea is considered the biological pump for the plants to absorb nutrients and water. Liu and Liao (2008) reported increased water uptake due to application of nano materials which increased the N, P and K uptake and resulted in increased biomass production. Nearly similar results were found by Mishra *et al.*, (2020).

10-Fruit weight (g)

The higher 10-fruit weight of tomato (676.66 g) was observed with the treatment T_6 (75% RDN + 2 foliar spray of 0.4% nano urea). The observed increase in fruit weight may be attributed to the foliar application of nano fertilizers, which enhanced photosynthetic efficiency, promoted dry matter accumulation, and facilitated the effective translocation of photosynthates from source to sink. This enhancement is likely due to the nano fertilizers' ability to penetrate plant tissues efficiently, ensuring timely nutrient delivery and boosting fruit weight. Consequently, this process may have led to a higher accumulation of carbohydrates in storage organs, resulting in increased fruit weight. These results are in accordance to Marzouk *et al.*, (2019) in an experiment on snap bean, Merghany *et al.*, (2019) in cucumber, Mishra *et al.*, (2020) and Panda *et al.*, (2020) in tomato.

Fruit length (cm)

The results indicate that highest length of fruit was

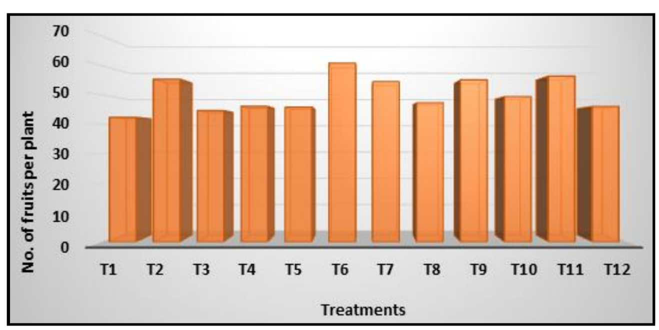

Fig. 4: Effect of different treatments on no. of fruits per plant of tomato.

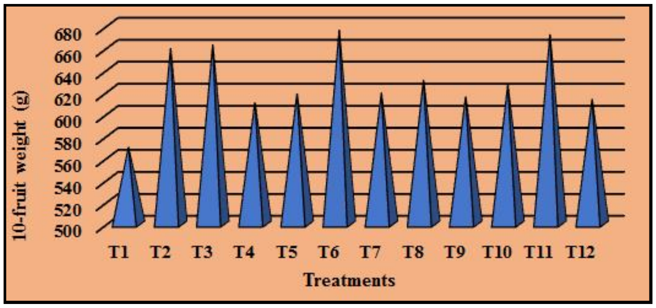

Fig. 5: Effect of different treatments on 10-fruit (g) weight of tomato.

observed under the treatment T_6 (75% RDN + 2 foliar spray of 0.4% nano urea). The substantial increase in fruit length can be attributed to an accelerated growth rate and enhanced photosynthetic efficiency, resulting from improved nutrient availability and translocation. This facilitated a more significant allocation of photosynthates from source to sink, promoting increased cell division and the accumulation of these assimilates within the fruit. Consequently, the augmented cell number and expansion contributed to the observed elongation of the fruit. Such results are in conformity with Alasvand and Shokuhfar (2017) in cowpea, Elizabath *et al*., (2017) in carrot and Mishra *et al*., (2020) in tomato.

Fresh fruit yield (t/ha)

Significantly the higher fresh fruit yield (40.06 t/ha) was observed under the treatment T_6 (75% RDN + 2 foliar spray of 0.4% nano urea). The observed increase in fresh fruit yield may be attributed to the role of nitrogen in activating several enzymes, such as catalase and tryptophan synthetase, which are essential for chlorophyll synthesis and various physiological activities that promote plant growth and development. Foliar application of nano nitrogen fertilizers has been shown to alleviate chlorosis and produce healthy green leaves, leading to higher assimilate synthesis. This enhanced nutrient availability and translocation likely contributed to increased fruit production and consequently, higher fruit yield. These results are in conformity with the findings of by Merghany *et al*., (2019), Mishra *et al*., (2020) and Panda *et al*., (2020). This is also in agreement with the findings of Sheykhbaglou *et al*., (2010), Jafarzadeh *et al*., (2013), Kumar *et al*., (2014), Abdel-Aziz *et al*., (2016), Kumar *et al*., (2020) and Ojha *et al*., (2022).

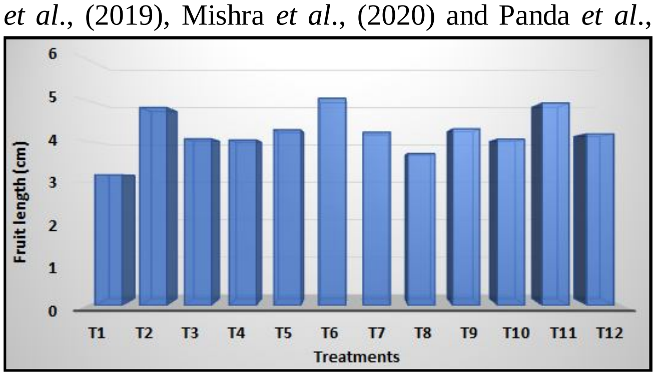

Fig. 6: Effect of different treatment on fruit length (cm) of tomato.

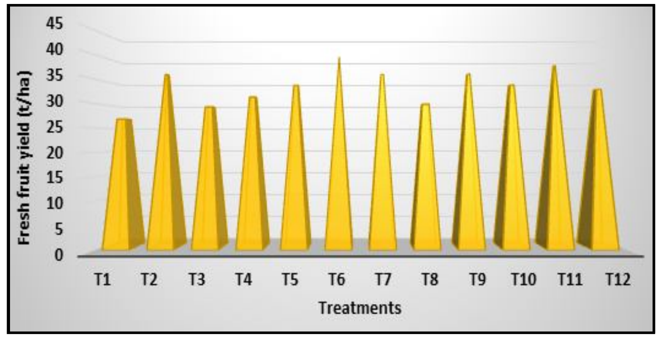

Fig. 7: Effect of different treatment on fresh fruit yield (t/ha) of tomato.

Economics

Gross return

The increased gross return could be explained on the basis of increased fresh fruit yield under T_6 (75% RDN + 2 foliar spray of 0.4% nano urea) which was higher than rest of the treatments. These results are in close proximity with the findings of Mishra *et al*., (2020), Panda *et al*., (2020), Singh *et al*., (2023) and Subramani *et al*., (2023).

Net return

A substantially higher net return found with T_6 (75% RDN + 2 foliar spray of 0.4% nano urea) due to higher fresh fruit yield was observed and also due to lower treatment cost than T_{11} (75% RDN + 3 foliar spray of 0.4% nano urea). These findings are in the line with those reported by Mishra *et al*., (2020), Panda *et al*., (2020), Singh *et al*., (2023) and Subramani *et al*., (2023).

Benefit: cost ratio

Highest B: C ratio of 4.99 in T_6 (75% RDN + 2 foliar spray of 0.4% nano urea) found due to high fresh fruit yield. These findings are in accordance with those reported by Mishra *et al*., (2020), Panda *et al*., (2020), Singh *et al*., (2023) and Subramani *et al*., (2023).

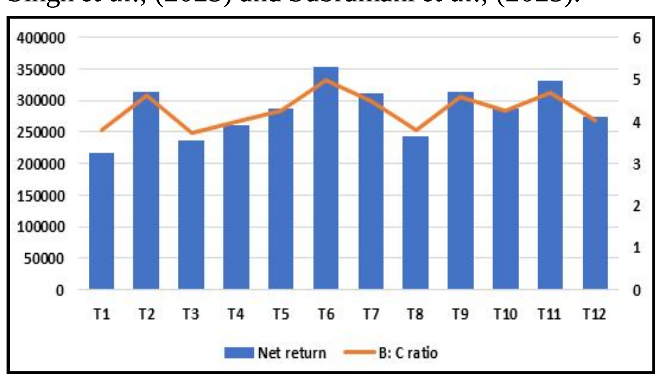

Fig. 8: Effect of different treatments on economics of tomato.

Conclusion

Based on one year experimentation, it can be concluded that in South Saurashtra Agro-climatic zone higher growth, yield attributes and fresh fruit yield of tomato (*cv*. Gujarat tomato 6) with higher net returns can be obtained with the application of 75% RDN + 2 foliar spray of 0.4% nano urea.

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