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Vidya Pogula Sanjay
M.Sc. Scholar Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj, Uttar Pradesh, India

Vijay Bahadur
Associate Professor Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj, Uttar Pradesh, India

Samir E Topno
Assistant Professor Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj, Uttar Pradesh, India

Corresponding Author:
Vidya Pogula Sanjay
M.Sc. Scholar Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj, Uttar Pradesh, India

Effect of organic and inorganic manures on growth, yield, and quality of tomato (*Solanum lycopersicon* L.) C.v. Ns4266 under naturally ventilated polyhouse condition

Vidya Pogula Sanjay, Vijay Bahadur and Samir E Topno

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Abstract
This study evaluates the effects of organic and inorganic manures on the growth, yield, and quality of tomato cv. NS4266 under naturally ventilated polyhouse conditions. Conducted in SHUATS college Research fields of Horticulture Department at PRAYAGRAJ Agro climatic conditions. The experiment included 11 treatments, each with varying combinations of organic and inorganic manures. Above all 11 treatments, Treatment 3 (75% RDF + 25% FYM) proved the lowest performance in terms of growth, yield, and quality, writing down insufficient nutrient provision or suboptimal nutrient ratios. In contrast, Treatment 9 (25% RDF + 75% FYM), which likely included a balanced mix of organic and inorganic manures, exhibited superior results, highlighting significant improvements in plant Vigor, fruit production, and quality attributes. These findings underscore the importance of perfecting manure composition to enhance tomato cultivation under controlled environment conditions. The research offers valuable insights for horticulturists aiming to maximize productivity and fruit quality in polyhouse tomato farming within the specific agroclimatic context of Prayag- raj. Further studies are recommended to refine manure combinations for sustainable and efficient tomato production.

Keywords: FYM, manure, sustainable, efficient, RDF

Introduction
Tomato production, a major horticultural crop in the world, is always changing as a result of creative research that aims to maximize sustainability, quality, and yield. To investigate the effects of different treatments on tomato production, the Horticulture Research Farms at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS) have initiated an extensive experimental investigation. The goal of this research, dubbed the "Tomato Trail," is to evaluate how eleven different treatments affect tomato plant growth, yield, and general health. The goal of the study is to give farmers and horticulturists useful insights into tomato crop best practices by analyzing various treatments in a controlled environment.
Solanum lycopersicum, or tomatoes, are an important crop in agricultural economics and a staple in diets all over the world. However, there are many obstacles to tomato production, such as environmental stressors, problems managing nutrients, and pest and disease pressures. The Tomato Trail at SHUATS looks into different agronomic techniques and inputs to see whether they may improve tomato growth and production in order to address these issues. This study is important because it advances the larger objective of sustainable agriculture, which is to maximize environmental impact while meeting rising tomato demand.
Eleven treatments make up the experimental setup at SHUATS, and each one's dosage has been carefully calibrated to assess its impact on tomato plants. Combinations of organic and inorganic fertilizers, biostimulants, insecticides, and irrigation techniques are some of these therapies. Every treatment plan is created to test a particular hypothesis regarding the possible advantages or disadvantages of the treatment, enabling researchers to make thorough findings about the practical uses of the treatments.
Finding the best treatments to improve tomato quality and productivity in the particular soil and

climate conditions at SHUATS is the main goal of the Tomato Trail. The goal of the study is to determine how various treatments interact with one another and what effect they have on tomato plants as a whole by methodically changing the inputs. The results of this study will be essential in creating integrated crop management strategies that maximize resource utilization, enhance plant health, and boost output. This study is significant to more people than just scholars and researchers. The findings will offer practical suggestions for bettering tomato cultivation techniques that can be adopted by nearby farmers and the larger agricultural industry. Considering the economic value of tomatoes and their contribution to food security, this is very noteworthy.

Higher yields, better-quality products, and more financial success for farmers are all possible outcomes of improved tomato production techniques. Every treatment is administered at precise dosages that have been meticulously calculated based on early research and the body of available literature. For example, the inorganic fertilizer treatment employs a balanced NPK (nitrogen, phosphorus, potassium) fertilizer at specified rates, whereas the organic fertilizer treatment applies 5 tons of well-decomposed compost per hectare. Foliar sprays, microbial inoculants, and biostimulants are administered in accordance with product instructions, taking local conditions into consideration.

Materials and Methods

Experimental Site

The experiment was conducted at the Horticulture Research Farms of SHUATS (Sam Higginbottom University of Agriculture, Technology &Sciences), located in Prayagraj, Uttar Pradesh, India. The region falls under the sub-tropical Agro climatic conditions with typical weather patterns that include hot summers, mild winters, and a monsoon seasons.

Experimental Design

The experiment was laid out in a randomized complete block design (RBD) with 11 treatments and 3 replications each.

Treatments

The treatments included various combinations of organic and inorganic manures. The details of the treatments are as follows:

Table 1: Details of treatments comprising organic and inorganic manures

S. No.	Treatment Notation	Treatment Details
1.	T_0	Control
2.	T_1	RDF 100% (150:100:50 NPK Kg/ha)
3.	T_2	Organic Manures 100% (33%FYM + 33%Vermicompost + 33% Poultry Manure)
4.	T_3	75% RDF + 25% FYM
5.	T_4	75% RDF + 25% Poultry Manure
6.	T_5	75%RDF + 25%Vermicompost
7.	T_6	50%RDF + 50%FYM
8.	T_7	50%RDF + 50% Vermi Compost
9.	T_8	50%RDF + 50%Poultry Manure
10.	T_9	25%RDF + 75% FYM
11.	T_{10}	25% RDF + 75% Vermicompost
12.	T_{11}	25% RDF + 75% Poultry manure

Crop and Variety

The Tomato Variety used in the study was NS4266. Seeds were procured from a certified source and were sown in a seedbed. Healthy seedlings of 25-30 days old were transplanted into the polyhouse.

Polyhouse condition

A naturally ventilated polyhouse was used for the experiment. The polyhouse conditions were monitored to maintain optimum temperature, humidity, and ventilation suitable for tomato cultivation.

Soil Preparation and Planting

The soil was prepared by ploughing, harrowing and levelling. Raised beds were formed with dimensions of 1 meter in width and 15 cm in height. Manures as per the treatment combinations were thoroughly mixed into the soil before transplanting.

Irrigation

Channel type irrigation was used to provide water supply to the plants. The irrigation schedule was maintained to meet the crop water requirements throughout the growing period.

Data Collection: The following parameters were recorded during the study are discussed in table no 1 mentioned below:

Statistical Analysis: The data collected were subjected to analysis of variance (ANOVA) using proper statistical formulas. Mean comparisons were done using the least significant Difference test @ 5% level of significance.

Results and Discussions

The experiment was conducted to study the effect of organic and inorganic manures on the growth, yield, and quality of tomato (NS4266) under naturally ventilated polyhouse conditions at SHUATS college Horticulture Research farm in prayagraj.

The results of the experiment are summarized below.

Growth Parameters

Plant Height

The maximum significant plant height at 120 DAS (153.59) cm was recorded in T_9 (25%RDF + 75% FYM) followed by T_8 (50% RDF + 50% Poultry Manure) with (146.65 cm) plant height and minimum plant height (129.40 cm) was recorded in Treatment 3 (T_3) (75%RDF + 25% FYM).

The variability in plant height due to the sustainability of treatments in climatic condition of prayagraj and growth characters of treatments of tomato.

No of Branches

The maximum significant Number of Branches, at 30, 60, 90 and 120 days after transplanting (8.72, 10.89, 21.17 and 23.07) was found in treatment 9 (25%RDF + 75% FYM), followed by treatment 1 (RDF100% [150:100:50 NPK Kg/ha]) with (7.00, 8.34, 20.19, 22.09) number of branches/plant and minimum Number of branches/plant (4.99, 7.54, 17.82, 19.15) was recorded in Treatment 3 (T_3) (75%RDF + 25% FYM). Variability in number of branches in tomato plants is due to the suitability of treatments in agro climatic conditions and high growth characters of treatments, similar findings also reported by Alam *et al*., (2010) [1] from 4.3 to 6.7, Singh *et al*., (2013) [12] from 15.29 to 24.2 and Shankar *et al*., (2013) [10] from 5.33 to 10.60.

Days to First Flowering

The minimum Days to first flowering (29.11days) was found in treatment 9 (25%RDF + 75% FYM), followed by treatment 5 (75% RDF + 25% Poultry Manure) with (29.01 days) and maximum days to first flowering (30.73 days) was recorded in treatment 10 (25%RDF + 75%FYM). Variability in days to first flowering is due to the earliness of the tomato Treatments; similar findings also reported by Ali *et al*., (2012) [2] from 42.00 to 56.00 DAS, Shankar *et al*., (2013) [10] from 28.00 to 37.00 DAT, Singh *et al*., (2013) [12] from 49.88 to 53.92 DAS and Said *et al*., (2014) [7] from 29 to 41 DAS in tomato.

50% Flowering

The minimum Days to 50% flowering (52.54 days) was found in Treatment 2 (Organic manures 100% [33%FYM + 33% Vermicompost + 33% Poultry Manure]) followedby T_{10}(25%RDF + 75% FYM) with (56.50 days) and maximum days to 50% flowering (69.89 days) was recorded in T_1 (RDF100% [150:100:50 NPK Kg/ha]) Variability in days to 50% flowering is due to the earliness of the tomato treatment; similar findings previously also reported by Ali *et al*., (2012) [2] from 42.00 to 56.00 DAS, Shankar *et al*., (2013) [10] from 28.00 to 37.00 DAT, Singh *et al*., (2013) [12] from 49.88 to 53.92 DAS and Said *et al*., (2014) [7] from 29 to 41 DAS in tomato.

Yield Parameters

Fruit Diameter

The maximum Fruit diameter (15.49 cm) was found in treatment 9 (25%RDF + 75% FYM), followed by T_6 (50% RDF + 50% FYM) with (14.73 cm) and minimum fruit diameter (10.62 cm) was recorded in Treatment 3 (T_3) (75%RDF + 25% FYM). Variability in fruit length, width and diameter of tomato hybrids is due to the different shapes and sizes of tomato hybrids; similar findings previously also reported by Ali *et al*., (2012) [2] from 5.50 cm to 7.80 cm, Saleem *et al*., (2013) [8] from 4.04 cm to 6.75 cm, Shankar *et al*., (2013) [10] from 3.00 cm to 6.10 cm and Said *et al*., (2014) [7] from 3.9 cm to 6.5 cm.

No of Fruits/cluster

The maximum Number of Fruits/Cluster (7.92) was found in treatment 9 (25%RDF + 75% FYM), followed by treatment 10 (25%RDF + 75%FYM) with (7.05) and minimum fruit/cluster (5.67) was recorded in Treatment 3 (T_3) (75%RDF + 25% FYM). Variability in number of fruit/cluster of Tomato hybrids is due to the maximum number of fruit set/plant in a particular tomato treatments similar findings previously also reported by Kurain *et al*., (2001) [6] from 2.4 to 5.0, Sekhar *et al*., (2009) [9] from 2.70 to 4.00, Shankar *et al*., (2013) [10] from 2.33 to 6.50 and Cheema *et al*., (2013) [3] from 2.00 to 4.50 in tomato.

No of Flowers/cluster

The maximum Number of Flowers/Cluster (6.52) was found in treatment 9 (25%RDF + 75% FYM) followed by T_1 (RDF100% [150:100:50 NPK Kg/ha]) with (5.89) and minimum flowers/cluster (4.56) was recorded in Treatment 3 (T_3) (75%RDF + 25% FYM).Variability in Number of fruits/plant of tomato hybrids is due to the maximum fruit set%/plant of a particular tomato treatments and minimum fruit drop percent in different treatments; similar findings previously also reported by Sekhar *et al*., (2009) [9] who noted variability in number of flowers per clusters from 27.00 to 73.53, Singh *et al*., (2013) [12] from 20.89 to 22.50, Saleem *et al*., (2013) [8] from 48 to 95 and Cheema *et al*., (2013) [3] from 7.50 to 32.00 in tomato hybrids and/or genotypes.

Average Fruit Weight

The maximum Average fruit weight (111.82 g) was found in treatment 9 (25%RDF + 75% FYM), followed by T_1 (RDF100% [150:100:50 NPK Kg/ha]) with (89.41g) and minimum average fruit weight (51.18 g) was recorded in Treatment 3 (75%RDF + 25% FYM).Variability in average fruit weight is due to the different fruit size of tomato treatments; similar findings previously also reported by Sekhar *et al*., (2009) [9] from 38.86 g to 67.14 g, Sharma *et al*., (2013) [11] from 30.77 g to 77.80 g, Singh *et al*., (2013) [12] from 65.00 g to 72.27 g, Cheema *et al*., (2013) [3] from 30.00 g to 52.50 g, and Degade *et al*., (2015) [4] from 16.80 g to 24.69 g in tomato hybrids. Said *et al*., (2014) [7] from 23.0 g to 69.8 g in open pollinated tomato.

Yield/Plant: The maximum Yield/plant (3.010 kg) was found in treatment 9 (25%RDF + 75% FYM), followed by T_1 (RDF100% [150:100:50 NPK Kg/ha]) with (2.817 Kg) and minimum Yield/plant (1.417 kg) was recorded in Treatment 3 (75%RDF + 25% FYM). Variability in fruit yield per plant in tomato hybrids is due to the maximum number fruit/plant and maximum average fruit weight of Tomato hybrids; similar findings previously also reported by Sharma *et al*., (2013) [11] from 681.00 g to 1278.19 g, Singh *et al*., (2013) [12] from 1000.36 g to 1000.63 g, Saleem *et al*., (2013) [8] from 1000.93 g to 3000.72 g, Shankar *et al*., (2013) [10] from 1000 g to 3000.90 g.

Yield/Plot: The maximum Yield/plot (14.02 kg) was found in treatment 9 (25%RDF + 75% FYM), followed by T_1 (RDF100% [150:100:50 NPK Kg/ha]) with (13.95 Kg) and minimum Yield/plot (8.80kg) was recorded in Treatment 3 (75%RDF + 25% FYM). Variability in fruit yield per plot of tomato hybrids is due to the maximum fruit yield per plant of Tomato hybrid; similar findings previously also reported by Sharma *et al*., (2013) [11] from 681.00 g to 1278.19 g, Singh *et al*., (2013) [12] from 1000.36 g to 1000.63 g, Saleem *et al*., (2013) [8] from 1000.93 g to 3000.72 g, Shankar *et al*., (2013) [10] from 1000 g to 3000.90 g.

Yield Tonnes/Hectare: The maximum Yield t/ha (56.98 tonnes) was found in treatment 9 (25%RDF + 75% FYM), followed by T_1 (RDF100% [150:100:50 NPK Kg/ha]) with (52.16 tonnes) and minimum Yield/ha (27.13 tonnes) was recorded in Treatment 3 (75%RDF + 25% FYM). Variability in fruit yield/ha in tomato hybrids is due to the maximum yield of tomato per plant and per hectare; similar findings previously also reported by Sharma *et al*., (2013) [11] from 681.00 g to 1278.19 g, Singh *et al*., (2013) [12] from 1000.36 g to 1000.63 g, Saleem *et al*., (2013) [8] from 1000.93 g to 3000.72 g, Shankar *et al*., (2013) [10] from 1000 g to 3000.90 g.

Quality Traits

The maximum Total Soluble Solids (∘Brix) (6.53 ∘Brix) was found in treatment 9 (25%RDF + 75% FYM), followed by T_1

(RDF100% [150:100:50 NPK Kg/ha]) with (5.96◦Brix) and minimum Total Soluble Solids (3.91 ◦Brix) was recorded in Treatment 3 (75%RDF + 25% FYM). Variability in Total Soluble Solids in different hybrids of tomato is previously also reported by Singh *et al*., (2014). The maximum Ascorbic acid (mg/100 g) (27.34 mg/100g) was found in treatment 9 (25%RDF + 75% FYM, followed by T_1 (RDF100% [150:100:50 NPK Kg/ha]) with (26.37 mg) and minimum Ascorbic acid (21.09 mg) was recorded in Treatment 3 (75%RDF + 25% FYM).

Economics

In terms of economics maximum Gross Return Rs. 481920.00, Net Return Rs. 390410.00 and Cost Benefit Ratio 1:5.55 was recorded in treatment 9 (25%RDF + 75% FYM) Followed by T_1 (RDF100% [150:100:50 NPK Kg/ha]) with Gross Return Rs. 455896.00, Net Return Rs. 361386.00 And Cost Benefit Ratio 1:4.82 And Minimum Gross Return Rs. 282344.00, Net Return Rs. 190034.00 and Cost Benefit Ratio 1:2.39 was recorded in Treatment 3 (75%RDF + 25% FYM).

Table 2: Effect of Organic and In Organic Manures On Plant Height And No Of Branches Of Tomato

S. No.	Treatment Notation	Plant Height (cm)				No Of Branches			
		30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
1.	T_0	39.13	59.71	105.13	144.18	6.47	8.69	17.88	20.66
2.	T_1	40.47	51.36	103.43	136.54	7.00	8.34	20.19	22.09
3.	T_2	37.94	60.33	104.63	148.30	7.18	10.16	19.68	20.24
4.	T_3	34.77	39.36	98.88	129.40	4.99	7.54	17.82	19.15
5.	T_4	37.47	53.67	107.68	143.96	7.92	9.98	19.60	21.47
6.	T_5	38.77	52.16	109.66	140.74	7.22	8.14	19.76	21.09
7.	T_6	35.79	51.03	102.76	144.87	6.56	8.17	19.56	21.90
8.	T_7	37.21	45.63	103.29	139.56	7.74	9.13	19.96	20.96
9.	T_8	36.74	52.92	106.84	146.65	6.60	8.16	19.60	21.68
10.	T_9	41.28	61.07	118.81	153.59	8.72	10.89	21.17	23.07
11.	T_{10}	40.96	58.09	104.54	145.07	7.31	9.96	18.85	20.21
12.	T_{11}	36.74	41.37	99.93	131.20	5.74	8.67	19.71	21.81
F Test		S	S	S	S	S	S	S	S
SE(d)±		1.56	5.64	3.06	5.30	0.86	0.73	0.65	0.74
CD @5%		5.00	13.03	3.53	4.54	14.64	9.99	4.11	4.25
CV		315%	1139%	618%	1071%	174%	148%	132%	149%

Table 3: Effect of Organic and In Organic Manures on First Flower Initiation Etc, on Tomato

S. No.	Treatment Notation	Days To First Flower Initiation	Days to 50% Flower Initiation	Fruits / Cluster	Flowers/ Cluster	Clusters Per Plant	Days To First Fruit Setting	No of Fruits /Plant	Fruits Per Plot	Fruit Yield / Plot (Kg)
1.	T_0	30.67	53.92	5.64	3.56	4.56	62.48	28.05	128.05	10.53
2.	T_1	30.28	69.89	6.23	3.89	5.68	60.48	27.30	127.30	10.65
3.	T_2	30.04	52.54	5.63	2.66	3.26	62.07	29.11	129.11	11.92
4.	T_3	18.85	63.20	5.67	4.56	4.65	79.87	21.90	101.90	8.80
5.	T_4	30.70	58.22	6.93	4.78	4.89	65.76	28.74	128.74	10.78
6.	T_5	29.01	62.12	5.85	5.62	5.04	60.04	34.89	134.89	11.78
7.	T_6	26.07	65.72	4.68	3.28	5.29	65.97	42.47	142.47	13.92
8.	T_7	30.01	61.42	4.23	4.57	4.87	67.14	31.96	131.96	12.68
9.	T_8	31.23	65.96	7.92	5.62	6.36	62.25	31.44	131.44	12.90
10.	T_9	29.11	58.43	7.05	6.52	5.28	58.54	45.30	159.30	14.02
11.	T_{10}	30.73	56.50	6.05	5.25	5.98	66.53	35.41	135.41	13.87
12.	T_{11}	29.83	61.75	5.73	4.29	5.23	64.57	30.96	130.96	10.65
F Test		S	S	S	S	S	S	S	S	S
SE(d)±		3.16	4.96	0.86	0.65	0.48	0.51	2.22	2.28	1.42
CD @5%		13.40	10.00	14.61	4.11	17.09	9.93	4.49	4.49	2.86
CV		638%	1003%	174%	132%	97%	98%	866%	866%	1461%

Table 4: Effect Of Organic And In Organic Manures On Fruit Weight,Fruit Diametre, On Tomato

S. No.	Treatment Notation	Average Fruit weight (g)	Fruit Diameter	Ascorbic Acid (mg/100g)	TSS (◦Brix)	Fruit Yield Per Hectare (tonnes)
1.	T_0	63.77	13.40	22.88	5.30	42.13
2.	T_1	89.41	13.99	24.44	4.87	42.16
3.	T_2	79.15	11.33	24.92	5.24	42.70
4.	T_3	51.18	10.62	21.09	3.91	37.13
5.	T_4	53.34	12.97	25.33	5.56	42.99
6.	T_5	77.10	13.09	26.37	4.90	47.08
7.	T_6	88.20	14.73	24.84	5.23	57.29
8.	T_7	71.93	12.89	25.26	5.60	50.74
9.	T_8	66.83	12.70	25.68	4.97	51.62
10.	T_9	90.82	15.49	27.34	6.53	59.98
11.	T_{10}	62.75	11.91	24.97	4.78	49.48
12.	T_{11}	82.27	13.05	25.71	5.96	42.62
F Test		S	S	NS	S	S
SE(d)±		10.89	0.95	1.15	0.37	5.69
CD @5%		21.96	1.93	2.33	0.74	14.62
CV		1769%	880%	56%	85%	1148%

Conclusion

The experiment investigating the effects of organic and inorganic manures on the growth, yield, and quality of tomato cultivar NS4266 under naturally ventilated polyhouse conditions at SHUATS College Horticulture Research Farms in Prayagraj demonstrated significant variability among the 11 treatments. Treatment 9 emerged as the most effective, resulting in superior growth, yield, and quality of tomatoes. Conversely, Treatment 3 exhibited the poorest performance across these parameters.

These findings suggest that the specific composition and application of manures can profoundly influence tomato cultivation outcomes, highlighting the importance of selecting appropriate fertilization strategies to optimize production in similar agro-climatic conditions. Further research may explore the underlying mechanisms and long-term impacts of these treatments to develop more refined guidelines for tomato growers.

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