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Effect of Organic and Inorganic Fertilizers on Growth, Yield and Quality Tomato (Lycopersicon esculentum Mill.)

Nirmala Sharma[1*], Kailash Agrawal[2] , Ishwar Patil[3]

[1*,2]Department of Life Sciences, Vivekananda Global University, Jaipur
[3]COCSIT College, Latur

Abstract
This two-year field study (2021–22 and 2022–23), looked at how organic and inorganic fertilizers affect tomato plants. The goal was to see how these fertilizers impact growth, yield, quality, and economic feasibility. Sixteen combinations of fertilizers were tested, including inorganic fertilizers at different rates (0%, 50%, 75%, and 100% recommended dose) and organic fertilizers like Panchgavya, Jeevamrutha, and a plant growth-promoting spray (PGPOS). Higher levels of inorganic fertilizers improved plant growth, while PGPOS gave the best results among the organic fertilizers. Both fertilizers increased fruit weight and yield. Quality measures like vitamin C, chlorophyll, and lycopene also improved with more fertilizer. The highest economic return came from the 100% RDF with PGPOS. Overall, proper fertilizer use can significantly improve tomato production and quality. However, no significant interaction was observed between the types of inorganic and organic fertilizers. From an economic perspective, the highest benefit-cost ratio (B) was achieved with the 100% RDF and PGPOS treatments, proving their economic feasibility. This study emphasizes the advantages of proper fertilizer application in improving tomato production and quality.

Keywords: Tomato, Organic, Inorganic, Yield, Quality, Economics

Introduction

Tomato (Lycopersicon esculentum Mill.), a member of the Solanaceae family, is one of the most commonly cultivated vegetables with significant economic value. It is a day-neutral plant that primarily self-pollinates, although some cross-pollination can occur. Tomato is the second most important vegetable crop globally, after potato, and holds the top spot among processed vegetables. In India, tomato farming covers 840,000 hectares, producing about 20,331 thousand tons of tomatoes, with an average yield of 24.20 tons per hectare (Anonymous, 2022).

Tomatoes are widely consumed in raw, cooked, and processed forms, including sauces, chutneys, ketchup, juices, purees, and powders. Due to the continuous growth of tomato plants and their potential for high fruit production, they require a substantial amount of nutrients. Inorganic fertilizers provide essential nutrients and are important for intensive farming. However, overuse of inorganic fertilizers can lead to problems like nutrient imbalances, nitrogen deficiencies, and deterioration of soil health (Kakar et al., 2020). These issues can negatively impact fruit yield and quality. Nitrogen plays a crucial role in the photosynthesis process and protein formation, while phosphorus helps convert solar energy into chemical energy. Potassium aids in carbohydrate transportation and is needed in large amounts for crop species (Mandal & Dutta, 2020).

Organic fertilizers, such as Panchgavya and Jeevamrutha, have gained importance in organic farming. Panchgavya is a traditional organic mixture made from cow products, known for its nutrient and biopesticide properties (Kumar et al., 2020). Jeevamrutha is another organic fertilizer made from cow dung and urine, along with other ingredients like jaggery and pulses, which help boost crop growth and control pests. Given the importance of the tomato crop and its response to both organic and inorganic fertilizers, this study was conducted to evaluate the impact of these fertilizers on tomato growth, yield, quality, and economic feasibility.

Materials and Methods

This two-year field experiment was conducted during the Rabi seasons of 2021–22 and 2022–23, on sandy clay soil. The objective was to study the impact of organic and inorganic fertilizers on the growth, fruit yield, quality, and economic performance of tomato cultivar 'Heemsohna' under irrigated conditions. The experiment followed a factorial randomized block design with sixteen treatment combinations replicated three times. The treatment combinations consisted of four levels of inorganic fertilizer (Control, 50%, 75%, and 100% of the recommended dose) and four types of organic fertilizers (Control, Panchgavya, Jeevamrutha, and Plant Growth Promoting Organic Spray - PGPOS).

Table 1: Treatments these were applied during the experimentation.

S. No.	Treatments	Symbols
Factor A	**Inorganic fertilizer**	
(a)	Control	F_0
(b)	50% RDF	F_1
(c)	75% RDF	F_2

(d)	100% RDF	F_3
Factor B	**Organic fertilizer**	
(a)	Control	O_0
(b)	Panchgavya	O_1
(c)	Jeevamrutha	O_2
(d)	Plant growth promoting organic spray	O_3

The tomato variety 'Heemsohna', developed by Syngenta India Pvt. Ltd., was used. The seed rate was 150–200 g per hectare, with a planting distance of 60.0 × 45.0 cm. Organic fertilizers such as Panchgavya, Jeevamrutha, and PGPOS were prepared as per the treatment guidelines. Well-decomposed farmyard manure (FYM) was applied at a rate of 25 tons per hectare three weeks before sowing, mixed thoroughly with the soil. The treatments were applied according to the experimental design, and all standard practices for tomato cultivation were followed.
The number of branches per plant and leaf area were measured 45 days after transplanting and at the harvest stage. Fruit yield per hectare was calculated based on the weight of fruits from randomly selected plants. Ascorbic acid, chlorophyll, and lycopene contents were analyzed using standard methods (Ranganna, 1986; Hiscox & Israelstam, 1979; Sharma & Le Maquer, 1996). The benefit-cost ratio (B) was calculated by dividing the total return by the cultivation cost.

Results

Growth attributes

The application of inorganic fertilizers significantly increased the number of branches per plant. The control group (F0) had the lowest number of branches (8.95), while the 100% RDF treatment (F3) showed the highest (12.23). Among organic fertilizers, PGPOS (O3) resulted in the highest number of branches (11.71), while the control group (O0) had the lowest (9.24). No significant interaction was found between inorganic and organic fertilizers for the number of branches.
Leaf area also increased significantly with higher levels of inorganic fertilizers. The control group (F0) had the smallest leaf area (41.41 cm²), while the 100% RDF treatment (F3) had the largest (46.55 cm²). The application of PGPOS (O3) resulted in the largest leaf area among organic fertilizers (45.77 cm²), while the control group (O0) had the smallest leaf area (41.79 cm²). Again, no significant interaction was observed between inorganic and organic fertilizers.

Table 1. Effect of organic and inorganic fertilizers on number of branches in tomato.

Treatments	**Number of branches per plant**		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	8.89	9.02	8.95
F_1-50% RDF	10.68	10.89	10.78
F_2-75% RDF	11.33	11.66	11.50
F_3-100% RDF	12.14	12.33	12.23
F – test	S	S	S
SEm±	0.17	0.14	0.15
CD at 5 %	0.50	0.42	0.43
(B) Factor B (Organic fertilizer)			
O_0-Control	9.17	9.32	9.24
O_1-Panchgavya	11.25	11.47	11.36
O_2-Jeevamrutha	11.03	11.28	11.15
O_3-PGPOS	11.59	11.83	11.71
F – test	S	S	S
SEm±	0.17	0.14	0.15
CD at 5 %	0.50	0.42	0.43
Interaction A × B			
F – test	NS	NS	NS
SEm±	0.35	0.29	0.30
CD at 5 %	NS	NS	NS

Table 2. Effect of organic and inorganic fertilizers on leaf area in tomato.

Treatments	**Leaf area (cm^2)**		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	41.40	41.42	41.41
F_1-50% RDF	43.33	44.13	43.73
F_2-75% RDF	44.92	45.60	45.26

F_3-100% RDF	46.11	47.00	46.55
F – test	S	S	S
SEm±	0.69	0.58	0.61
CD at 5 %	2.00	1.68	1.75
(B) Factor B (Organic fertilizer)			
O_0-Control	41.53	42.05	41.79
O_1-Panchgavya	44.55	45.27	44.91
O_2-Jeevamrutha	44.20	44.76	44.48
O_3-PGPOS	45.48	46.07	45.77
F – test	S	S	S
SEm±	0.69	0.58	0.61
CD at 5 %	2.00	1.68	1.75
Interaction A × B			
F – test	NS	NS	NS
SEm±	1.38	1.16	1.22
CD at 5 %	NS	NS	NS

Yield attributes

The fruit weight increased with the higher application of inorganic fertilizers. The 100% RDF treatment (F3) produced the heaviest fruits (65.78 grams pooled over two years), while the control (F0) had the lightest (60.08 grams). Among the organic fertilizers, PGPOS (O3) led to the highest fruit weight (64.85 grams pooled), while the control (O0) had the lowest (60.37 grams). No significant interaction was observed between inorganic and organic fertilizers in terms of fruit weight. Similarly, yield per hectare increased with higher levels of inorganic fertilizers. The control treatment (F0) resulted in the lowest yield (39.47 tons per hectare pooled over two years), whereas the 100% RDF treatment (F3) showed the highest yield (54.05 tons per hectare). Among organic fertilizers, the highest yield was recorded in the PGPOS treatment (O3) with 51.04 tons per hectare, while the control (O0) showed the lowest yield (40.38 tons per hectare). No significant interaction was observed between inorganic and organic fertilizers for yield per hectare.

Table 3. Effect of organic and inorganic fertilizers on weight of fruit in tomato.

Treatments	**Weight of fruit (g)**		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	58.12	62.05	60.08
F_1-50% RDF	61.09	64.83	62.96
F_2-75% RDF	62.49	66.44	64.46
F_3-100% RDF	63.55	68.01	65.78
F – test	S	S	S
SEm±	0.78	1.00	0.52
CD at 5 %	2.26	2.88	1.49
(B) Factor B (Organic fertilizer)			
O_0-Control	58.36	62.38	60.37
O_1-Panchgavya	62.38	66.25	64.32
O_2-Jeevamrutha	61.71	65.78	63.74
O_3-PGPOS	62.79	66.90	64.85
F – test	S	S	S
SEm±	0.78	1.00	0.52
CD at 5 %	2.26	2.88	1.49
Interaction A × B			
F – test	NS	NS	NS
SEm±	1.56	1.99	1.03
CD at 5 %	NS	NS	NS

Table 4. Effect of organic and inorganic fertilizers on yield per hectare in tomato.

Treatments	**Yield per hectare (t)**		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	36.19	42.75	39.47
F_1-50% RDF	41.53	49.53	45.53
F_2-75% RDF	45.50	54.32	49.91

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F_3-100% RDF	49.67	58.43	54.05
F – test	S	S	S
SEm±	1.02	1.20	0.78
CD at 5 %	2.96	3.48	2.24
(B) Factor B (Organic fertilizer)			
O_0-Control	36.92	43.83	40.38
O_1-Panchgavya	45.35	53.55	49.45
O_2-Jeevamrutha	43.92	52.27	48.10
O_3-PGPOS	46.71	55.38	51.04
F – test	S	S	S
SEm±	1.02	1.20	0.78
CD at 5 %	2.96	3.48	2.24
Interaction A × B			
F – test	NS	NS	NS
SEm±	2.05	2.41	1.55
CD at 5 %	NS	NS	NS

Quality parameters

The application of both organic and inorganic fertilizers significantly influenced the quality attributes of the tomatoes, such as vitamin C (ascorbic acid), chlorophyll, and lycopene content. For inorganic fertilizers, the ascorbic acid content increased progressively with higher levels of RDF. The 100% RDF treatment (F3) produced the highest ascorbic acid content (26.68 mg/100g), which was significantly higher than the control (23.82 mg/100g). Among organic fertilizers, PGPOS (O3) also led to the highest ascorbic acid content (25.90 mg/100g), while the control (O0) showed the lowest (23.94 mg/100g). No significant interaction effects were observed between inorganic and organic fertilizers for ascorbic acid content.

Total chlorophyll content in tomatoes was similarly affected. The highest total chlorophyll content was observed in the 100% RDF treatment (149.88 mg/100g), significantly higher than the control (130.05 mg/100g). Among organic fertilizers, PGPOS (O3) led to the highest chlorophyll content (145.49 mg/100g), while the control (O0) had the lowest (132.02 mg/100g). No interaction was observed between the types of fertilizers.

Lycopene content, another important quality measure, increased significantly with higher levels of inorganic fertilizers. The 100% RDF treatment (F3) recorded the highest lycopene content (2.44 mg/100g), which was significantly greater than the control (2.22 mg/100g). Among organic fertilizers, PGPOS (O3) led to the highest lycopene content (2.40 mg/100g), while the control (O0) showed the lowest (2.24 mg/100g). No significant interaction was found between inorganic and organic fertilizers for lycopene content.

Table 5. Effect of organic and inorganic fertilizers on ascorbic acid in tomato.

Treatments	**Ascorbic acid (mg/100g)**		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	23.57	24.07	23.82
F_1-50% RDF	24.42	25.03	24.72
F_2-75% RDF	25.19	25.74	25.46
F_3-100% RDF	26.40	26.96	26.68
F – test	S	S	S
SEm±	0.23	0.21	0.16
CD at 5 %	0.65	0.61	0.47
(B) Factor B (Organic fertilizer)			
O_0-Control	23.67	24.22	23.94
O_1-Panchgavya	25.21	25.72	25.46
O_2-Jeevamrutha	25.08	25.68	25.38
O_3-PGPOS	25.62	26.18	25.90
F – test	S	S	S
SEm±	0.23	0.21	0.16
CD at 5 %	0.65	0.61	0.47
Interaction A × B			
F – test	NS	NS	NS
SEm±	0.45	0.42	0.32
CD at 5 %	NS	NS	NS

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Table 6. Effect of organic and inorganic fertilizers on total chlorophyll content in tomato.

Treatments	Total chlorophyll content (mg per 100g)		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	129.32	130.79	130.05
F_1-50% RDF	137.65	140.16	138.90
F_2-75% RDF	143.33	145.85	144.59
F_3-100% RDF	148.92	150.84	149.88
F – test	S	S	S
SEm±	0.98	1.09	0.76
CD at 5 %	2.83	3.16	2.21
(B) Factor B (Organic fertilizer)			
O_0-Control	130.90	133.15	132.02
O_1-Panchgavya	142.74	144.47	143.61
O_2-Jeevamrutha	141.27	143.34	142.31
O_3-PGPOS	144.31	146.67	145.49
F – test	S	S	S
SEm±	0.98	1.09	0.76
CD at 5 %	2.83	3.16	2.21
Interaction A × B			
F – test	NS	NS	NS
SEm±	1.96	2.18	1.53
CD at 5 %	NS	NS	NS

Table 7. Effect of organic and inorganic fertilizers on lycopene content in tomato.

Treatments	Lycopene content (mg/100g)		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	2.20	2.24	2.22
F_1-50% RDF	2.30	2.33	2.32
F_2-75% RDF	2.37	2.40	2.39
F_3-100% RDF	2.43	2.45	2.44
F – test	S	S	S
SEm±	0.02	0.02	0.01
CD at 5 %	0.05	0.05	0.04
(B) Factor B (Organic fertilizer)			
O_0-Control	2.23	2.26	2.24
O_1-Panchgavya	2.36	2.38	2.37
O_2-Jeevamrutha	2.34	2.37	2.35
O_3-PGPOS	2.38	2.41	2.40
F – test	S	S	S
SEm±	0.02	0.02	0.01
CD at 5 %	0.05	0.05	0.04
Interaction A × B			
F – test	NS	NS	NS
SEm±	0.04	0.04	0.03
CD at 5 %	NS	NS	NS

Economic feasibility

The benefit-cost (B) ratio for different fertilizer treatments was calculated to evaluate their economic feasibility. The 100% RDF treatment (F3) provided the highest B
ratio (4.48 pooled over two years), followed by the 75% RDF treatment (F2) with a B
ratio of 4.23. Among organic fertilizers, PGPOS (O3) gave the highest B
ratio (4.57 pooled over two years), while the control (O0) had the lowest (3.42 pooled over two years). No significant interaction was observed between organic and inorganic fertilizers for the B
ratio.

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Table 8. Effect of organic and inorganic fertilizers on Benefit: Cost ratio in tomato cultivation.

Treatments	**Benefit: Cost ratio**		
	2021	**2022**	**Pooled**
(A) Factor A (Inorganic fertilizer)			
F_0-Control	3.21	3.98	3.60
F_1-50% RDF	3.50	4.37	3.94
F_2-75% RDF	3.77	4.69	4.23
F_3-100% RDF	4.04	4.92	4.48
F – test	S	S	S
SEm±	0.09	0.12	0.07
CD at 5 %	0.25	0.34	0.21
(B) Factor B (Organic fertilizer)			
O_0-Control	3.04	3.79	3.42
O_1-Panchgavya	3.87	4.75	4.31
O_2-Jeevamrutha	3.52	4.38	3.95
O_3-PGPOS	4.09	5.04	4.57
F – test	S	S	S
SEm±	0.09	0.12	0.07
CD at 5 %	0.25	0.34	0.21
Interaction A × B			
F – test	NS	NS	NS
SEm±	0.17	0.24	0.14
CD at 5 %	NS	NS	NS

Discussion

These findings underscore the crucial role of inorganic fertilizers in stimulating vegetative growth and overall plant vigor. The diminished plant heights in the absence of fertilizer application further emphasize the necessity of proper nutrient supplementation for optimal crop development and yield. The observed variations in plant height among different fertilizer treatments can be attributed to the varying nutrient compositions and concentrations provided by each treatment. Inorganic fertilizers contribute essential macronutrients and micronutrients crucial for plant growth, including nitrogen, phosphorus, and potassium, among others (Sinha and Tandon, 2020). The results of this study reveal a notable impact of organic fertilizers on the number of branches and leaf area of tomato plants. The pooled data from both years consistently demonstrated that the O_3-Plant growth promoting organic fertilizer treatment exhibited the maximum vegetative growth. This finding suggests that the application of O_3 fertilizer positively contributed to the robust growth of tomato plants, potentially through the provision of essential nutrients and growth-promoting substances. Similar results were reported by Hernandez et al. (2021), Adekiya et al. (2022) and Antal-Tremurici et al. (2022) in tomato.

The findings of this study emphasize the positive impact of inorganic fertilizers, especially the 100% RDF treatment, on the growth, yield, and quality of tomato plants. Inorganic fertilizers provided essential nutrients that significantly boosted plant vegetative growth, as seen in the higher number of branches and leaf area. This is consistent with the results of previous studies, where nutrient-rich inorganic fertilizers improved plant vigor and productivity (Sinha & Tandon, 2020). The study also demonstrated that organic fertilizers like PGPOS and Panchgavya can enhance tomato growth and yield. Although inorganic fertilizers generally had a more pronounced effect, PGPOS significantly increased branch number, leaf area, fruit weight, and quality attributes like ascorbic acid, chlorophyll, and lycopene content. The results suggest that PGPOS can be a valuable alternative for improving tomato production, especially in organic farming systems (Verdi et al., 2022).

In terms of economic feasibility, the highest B ratio was recorded with the 100% RDF and PGPOS treatments, confirming their potential for sustainable and profitable tomato cultivation. Both fertilizers provide significant returns on investment, making them suitable for farmers looking to maximize productivity while maintaining soil health.
This highlights the potential of organic fertilizers in enhancing economic returns in tomato cultivation, possibly due to their slow-release nature and additional benefits to soil health. It's evident that both organic and inorganic fertilizers play significant roles in determining economic outcomes (Wang et al., 2018). However, the superior performance of organic fertilizers in terms of B:C ratio suggests their potential for sustainable and profitable agriculture, aligning with the growing interest in organic farming practices (Alexoaei et al., 2022). Despite the individual effects of organic and inorganic fertilizers on economic parameters, the interaction between these factors did not yield significant results at different crop growth stages. Similar results were reported by Mohit et al. (2019), Hernandez et al. (2021) and Adekiya et al. (2022) in tomato.

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Conclusion

The study concludes that both inorganic and organic fertilizers can significantly enhance the growth, yield, and quality of tomatoes. Inorganic fertilizers, especially at 100% RDF, provided the best results in terms of growth parameters, yield, and quality. Among organic fertilizers, PGPOS showed the greatest potential for improving tomato production. Both types of fertilizers also demonstrated good economic feasibility, with the highest benefit-cost ratios observed in the 100% RDF and PGPOS treatments. These findings suggest that a balanced and optimal use of fertilizers can improve tomato production while ensuring economic sustainability.

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