Plant Archives Vol. 24, No. 2, 2024 pp. 659-669 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.092

COMPARATIVE STUDIES ON APPLICATION OF ORGANIC AND INORGANIC NUTRIENTS ON PERFORMANCE OF TOMATO (*SOLANUM LYCOPERSICUM* L.) IN NORTH WESTERN HIMALAYAS

Manish Chauhan[1]*, Shilpa[2], Rekha Dhanai[3], Mohd. Kamran[4], Shikha Bhagta[5], Reena Kumari[6] and Komal Sharma[1]

[1]Department of Vegetable Science, School of Agriculture, Abhilashi University, Mandi - 175 028, Himachal Pradesh, India.
[2]Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalya, Palampur-176 062, Kangra, Himachal Pradesh, India
[3]Tula's Institute, Dehradun - 248 011, Uttarakhand, India.
[4]Department of Food Technology, School of Applied and Life Sciences (SALS), Uttaranchal University, Dehradun - 248 007 Uttarakhand, India.
[5]Department of Tree Improvement and Genetic Resources, College of Horticulture and Forestry, Thunag - 175 048, Mandi, Himachal Pradesh, India.
[6]Dr. YSP UHF Nauni, Solan - 173 230, H.P., India.
*Corresponding author E-mail : manishchauhanvsc@gmail.com
(Date of Receiving-24-03-2024; Date of Acceptance-14-06-2024)

ABSTRACT

Tomato (*Solanum lycopersicum* L.) is a popular warm season vegetable grown throughout the world under tropical and subtropical conditions. The use of synthetic fertilizers for tomato production over an extended time period can improve the productivity but consequently deteriorates soil health. Therefore, with the hypothesis that for an extensive evaluation of different nutrient sources, its influence on the soil health, growth, yield and biochemical traits of crop. A comprehensive study was carried out on tomato cv. Heem sohna in a randomized block design with three replication during *rabi* seasons of 2017-18 and 2018-2019. The experiment comprised twelve treatments of different nutrient sources including organic manure and in conjugation with the inorganic fertilizers. Application of 80% NPK + PM (T_{10}) produced higher yield (451.38 q) over control *i.e.*, T_{12} and registered the highest available soil NPK content (369.04, 71.49 and 264.59 kg ha^{-1}, respectively). The results revealed maximum plant height (99.23 cm), number of branches per plant (16.14), days to 50% flowering (35.87), number of fruits per plant (25.38), fruit weight (58.47 g) was recorded under T_{10} as well as highest TSS (4.63^{0}B), Ascorbic acid (26.08 mg^{-1} 100g) and dry matter content. From the present investigation, it can be concluded that 80 % NPK + PM can be recommended to farmers for maintaining soil fertility and obtaining higher yields. It could be a cost-effective nutrient management module on a sustainable basis.

Key words : Inorganic fertilizers, Organic manures, Soil fertility, Yield, Tomato.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of India's most important fruit vegetables, belonging to the Solanaceae family (Shilpa *et al*., 2021). It covers 789 thousand hectares and produces 19759 thousand metric tonnes per year, with a productivity of 25.0 metric tonnes per hectare (Anonymous, 2018). The global tomato production till 2020 is 41.52 million tonnes and is expecting to increase about 51.93 million tonnes in 2026 according to the universal scenario (Shilpa *et al*., 2022). Tomato in general responds well to both manures and fertilizers. However, haphazard use of synthetic fertilizer for an extremely long time can deteriorates the fertility status of soil. Thus, there is urgency in the need for research to determine the efficient and judicious utilization of available nutrient sources to increase the production, productivity, and profitability per unit area to meet the food and other demands of an increasing population (Sahu *et al*., 2020). The maintenance of soil health as well as the resolution of issues with sustainable crop productivity is made possible by effective nutrient management. Additionally, it facilitates in detecting any emerging nutrient deficiencies in plants (Chauhan *et al*., 2020). Globally, there is an increased interest in employing organic manures to recoup the decrease in soil fertility (Sharma *et al*., 2020).

Organic agriculture is a holistic production management system, which promotes and enhances agro-ecosystem, soil health, including biodiversity, biological cycles and soil biological activity, but the lack of studies scrutinizing the soil health responses to organic nutrient management highlights a research gap not sufficiently addressed by researchers, even though it is a topic of great concern to many organic farmers (Osterholz *et al*., 2021; Chauhan *et al*., 2022). Native farm products like Farmyard manure (FYM), Vermicompost (VC), poultry manure and neem cake supplement the soil fertility by enhancing mineralization rate of soil nutrients (Amalraj *et al*., 2013). Vermicompost provides macro and micronutrients while also improving the soil's physical, chemical and biological properties (Chatterjee and Bandyopadhyay, 2014). In addition, vermicompost improves soil structure, porosity, aeration, drainage and water retention, while also helping to prevent soil degradation (Sharma *et al*., 2022). Organic manures such as cow dung, poultry manure, crop residues and vermicompost were used as substitutes for inorganic fertilizers, but no conclusive results were obtained to determine which of these organic sources of nutrition produced the highest tomato yield (Ali *et al*., 2014). As a result, it is important to investigate the impact of applying recommended and reduced doses of inorganic nutrient sources in various combinations with organic amendments such as farm yard manure (FYM), vermicompost, neem cake and poultry manure on soil properties, tomato growth, yield and quality.

Integrated nutrient management (INM) is a strategy that uses both the sources *i.e.*, organic and inorganic, for enhancing soil health and providing balanced nutrition to crops (Singh and Sadawarti, 2021). Combined application of organic manures and inorganic fertilizers leads to improvement in yield with controlled release of nutrients in the soil through slow mineralization of organic manures (Negi *et al*., 2021; Chauhan *et al*., 2023).

The nutrient sources adopted for the cultivation of a crop is likely to impact not only the yield of the crop but also the quality of soil and the overall profits to the farmer. Efficient use of various inputs in crop production helps to achieve maximum production and productivity of crops and contributes to profitability and sustainability for rural livelihoods (Batabyal *et al*., 2016). Hence, we hypothesized that in order to thoroughly evaluate various nutrient sources, its effect on the soil health, crop economics and yield need to be critically quantified. Adopting best nutrient management practices can effectively address the current concept of "farming for health," the sustainability of the natural resource base, particularly soil and ultimately the livelihood for the farming community (Kakar *et al*., 2020). The following study was conducted with a motive to find the best combination of nutrient sources for the growth, yield, biochemical traits and soil properties for tomato. The objectives behind this investigation were (i) To ascertain the effect of organic and inorganic sources of nutrient on growth and yield of tomato (ii) to find out the effect of organic and inorganic sources of nutrient on physio-chemical properties of tomato.

Materials and Methods

Experimental site

The experiment was conducted in Research and Extension Center, Veer Chandra Singh Garhwali Uttrakhand University of Horticulture and Forestry, Selaqui, Dehradun (U.K.) during 2018-2019 with a view to ascertain the most suitable organic manure combining with the recommended NPK fertilizer dose for winter tomato under agro-climatic and soil conditions of northern Dehradun. It is located at 30.31° N, longitude 78.03° and a altitude of 650 metres above sea level. The average rainfall in this area is 2073 mm, with the majority of it falling between June and September. However, both winter and summer rains are common, with the heaviest rainfall falling between June and September. Before laying out the experiment, random soil samples were taken from the experimental field at a depth of 0-15 cm and analyzed for various chemical properties of the soil. The suggested methods for physico-chemical properties were used and the results are listed in Table 1.

Treatments and experimental details

With three replications, the experiment was set up in a Randomized Block Design (RBD). Different organic and inorganic fertilizer levels were used in each of the 12 treatments as mentioned in Table 2. The tomato variety "Heem sohna" was used as a plant material. Recommended dose of fertilizers for tomato is N 120, P 60 and K 50 kg ha^{-1}. Nitrogen, Phosphorus and Potassium were used as inorganic fertilizers in the form of urea, single superphosphate (SSP) and murate of potash

Table 1 : Chemical properties of soil before sowing of crop.

Properties	Values	Method employed
pH (1:2)	6.72	1:2 Soil: water suspension, measured with digital pH meter (Jackson,1973)
Electrical conductivity (dS m^{-1})	0.28	1:2 Soil: water suspension, measured with digital ECmeter (Jackson,1973)
Organic carbon (g kg^{-1})	9.43	Wet digestion (Walkley and Black,1934)
Available N (kg ha^{-1})	285.41	Alkaline potassium permanganate (Subbiah and Asija,1956)
Available P (kg ha^{-1})	45.12	Sodium bicarbonate extraction (Olsen *etal*.,1954)
Available K (kg ha^{-1})	234.17	Ammonium acetate (Merwin and Peach, 1951)

Table 2 : Details of the treatments.

Treatment code	Treatment Details
T_1	60 % NPK(72:36:30)
T_2	60 % NPK + VC
T_3	60 % NPK + NC
T_4	60 % NPK + FYM
T_5	60 % NPK + PM
T_6	80 % NPK (96:48:40)
T_7	80 % NPK + VC
T_8	80% NPK +NC
T_9	80% NPK +FYM
T_{10}	80% NPK +PM
T_{11}	100% NPK (120:60:50)
T_{12}	Absolute control

❖ VC: Vermicompost (5 t/ha)
❖ NC: Neem cake (2.5 t/ha)
❖ PM: Polutry manure (2.5 t/ha)
❖ FYM: Farm yard manure (20 t/ha)

(MOP), respectively. Nitrogen was applied in three split doses: the first during field preparation, the second after one month of transplanting, and the third during the fruit initiation stage. The full doses of FYM, SSP, MOP, Vermicompost, poultry manureand Neem cake were applied as per the treatments.

The decomposed mixture of dung and urine of farm animals, as well as their litter and leftover material from roughages or fodder fed to cattle, is referred to as farmyard manure. The use of this type of organic manure improves the soil's physical, chemical and biological conditions. FYM (0.5% N, P_2O_5 0.2% and K_2O 0.5%) can provide all of the nutrients that the plant requires, but only in low quantity. The vermicompost (1.75% N, P_2O_5 1.5% and K_2O 1.2%) was obtained from the Research and Extension Center, Veer Chandra Singh Garhwali Uttrakhand University of Horticulture and Forestry, Selaqui, Dehradun. It's a nutrient-dense organic amendment which is microbiologically active. Poultry manure (3.03% N, P_2O_5 2.63% and K_2O 1.6%) is organic waste from poultry that consists primarily of chicken faeces and urine, as well as spilled feed, feathers and bedding materials such as wood shavings or sawdust. Poultry litter is a type of organic manure that is high in major plant nutrients like N, P and K, as well as trace elements like Zn and Cu. This manure was obtained from a Selaqui poultry farm (UK). Neem cake (5.2% N, 1.0 % P_2O_5 and 1.4% K_2O) is a by-product of the solvent extraction process for neem oil cake and the cold pressing of neem tree fruits and kernels.

Growth and yield attributes

For growth, yield and biochemical parameters, observations were taken on five plants from each replication in each treatment combination. Plant height (cm), number of branches per plant, days to 50% flowering, number of fruits per plant, fruit weight (g), Fruit yield per hectare (q). The total weight of fruits per plant was calculated and expressed in grams using the weight of fruits from previously randomly tagged plants (g). Fruit yield per hectare was calculated using the weight of marketable fruits harvested at various times from each plot. Fruit yields per plot were converted to q/ha.

Biochemical traits

Total soluble solids (TSS) were determined using a Hand Refractrometer and expressed as a percentage of fruit weight after the fruits were crushed and juice passed through a double layer of fine mesh cheese cloth. Ascorbic acid was measured and expressed as mg 100 g^{-1} of sample using the 2, 6-dichlorophenol dye, as suggested by Ranganna (1986). The dry matter content of tomato fruits was determined using a hot air oven by keeping them at 60°C for 48 hours under each treatment and calculating the average.

Soil analysis

Soil samples were taken from each plot of all three replicates after the tomato crop was harvested and analysed for various physico-chemical properties of soil. By using a 1:25 soil water suspension and an electrical digital pH metre, the pH of the soil was determined (Jackson, 1973). Using a conductivity metre, the electrical conductivity (dSm^{-1}) of a suspension mixture was determined (Jackson, 1973). The organic carbon (%) was determined by dichromate oxidation and titration with ferrous ammonium sulfate method of Walkley and Black (1934). Available N(kg/ha) was determined by alkaline potassium permanganate method of Subbiah and Asija (1956). For extraction of available P (kg/ha) 0.5 N $NaHCO_3$ at 8.5 pH was used (Olsen *et al*., 1954), which was measured spectrophotometrically. The amount of available K was determined using a flame photometer and normal neutral ammonium acetate (Merwin and Peech, 1951). For the isolation and identification of viable bacteria, actinomycetes and fungi populations, the serial dilution and plating technique suggested by Rao (1999) was used. The media were prepared to support the microflora that was desired. The medium was autoclaved and cooled to 450°C before being poured into sterile plates and allowed to solidify. In a 9 ml sterile water blank, one gram of sieved (2 mm) soil was added and shaken for 15-20 minutes. 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} and 10^{-8} serial dilutions were prepared and 0.1 ml of aliquots of different dilutions were added over cooled and solidified medium in petriplates. The plates were rotated to ensure that the bacterial cells and fungal spores in the aliquot under the media were distributed uniformly, then allowed to solidify. The plates were inverted and incubated at 28°C for 3-4 days after the media had solidified. Colonies appeared on the surface of the medium in the plates, which was observed. Using the dilution plate technique, bacteria, fungi and actinomycetes were counted using nutrient agar (NA), potato dextrose agar medium (PDA), and Kenknight's agar media, respectively (Table 3).

Statistical analysis

MS-Excel and OPSTAT were used to statistically analyse the data collected. The mean values of the data were subjected to analysis of variance using Randomized Block Design, as described by Panse and Sukhatme (2000).

Table 3 : The composition of different types of media used for microbiological studies.

	Composition	Quantity
Media Nutrient agar media (NA)(Bacteria)	Beef extract	3g
	Peptone	5g
	NaCl	5g
	Agar-agar	20g
	Distilled water	1litre
Potato dextrose agar media(PDA) (Fungi)	Potatoes	250 g
	Dextrose	20 g
	Agar-agar	20 g
	Distilled water	1litre
Kenknight media (Actinomycetes)	K_2HPO_4	1 g
	$NaNO_3$	0.1 g
	KCl	0.1 g
	$MgSO_4.7H_2O$	0.1 g
	Glucose	1.0 g
	Agar-agar	20 g
	Distilled water	1 litre

Results and Discussion

All growth, yield contributing, and yield parameters, including biochemical traits, significantly differed in both organic and inorganic fertilizer applications.

Growth attributes

To consider crop yield, plant height is a key factor. Taller plants are regarded as more desirable because they have more foliage for photosynthesis and carbohydrate accumulation, resulting in higher yield and productivity. The availability of nutrients and cultivar both have an impact on plant height, which is a genetically determined trait (Sonet *et al*., 2020). An appraisal of data in Table 4 showed that maximum (99.23 cm) plant height was recorded in T_{10} (80% NPK +PM), which was followed by the treatment T_{11} *i.e.* 100% NPK ($N_{120}P_{60}K_{50}$). Maximum number of branches per plant (16.14) was recorded in T_{10}, which was statistically at par with T_7 (80% NPK + VC). The number of leaves was affected by the study years and "treatment × year" interactions. In the treatment T_{10} maximum (35.87) days to 50% flowering was observed.

According to Manohar and Paliwal (2016), inorganic fertilizers supply nutrients to the crop during the early stages of growth and organic manures later. As a result, plants receive a balanced diet throughout the growing season, which helps strengthen the height of the plant.

An increase in plant height may be the result of the plant assimilating more nutrients that fertilization made available. Increasing in number of branches might be due to application of poultry manure as soil amendment provided macro and micronutrients essentially required by tomato. The results are in accordance with Makinde and Bello (2009). The enhanced growth characteristics carried along by the increased supply of multi-nutrients may be attributed to the fact that these applied nutrients in large quantities exerted their combined functions by improving the physico-chemical and biological conditions of soils and promoting plant growth by ensuring a higher number of greener levels within increased photosynthesis due to increased metabolism of the absorbed nutrients, profuse root development efficient utilization of plant nutrients accompanied by the increased supply of multi-nutrients. Similar results have been reported by Gowda *et al*. (2002), Kadam and Sahane (2002) and Krishnappa (2002).

Yield contributing and yield attributes

In this study, appraisal of data in Table 4 represented maximum number of fruits per plant (25.38) and fruit weight (58.47 g) in the treatment consisting of 80% NPK + PM. Accordingly, integrated module; T_{10} also exhibited significantly maximum yield per hectare (451.38 q). The "treatment x year" interactions also showed significant influence whereas, maximum number of fruits per plant 26.14 g were recorded by T_{10} during 2018-2019, the minimum (10.13 g) were recorded in the same year through module T_{12}. However, "treatment x year" interactions were found to be significant and maximum fruit weight (62.13 g) was recorded in T_{10} in 2018-2019 and minimum in T_{12} (40.13 g) during 2018-19. Interaction effect (years × treatments) revealed significant results shown in Table 4, maximum yield per hectare was recorded in T_{10} (453.15 q/ha) in the year 2018-19 whereas, minimum bulb yield was recorded in T_{12} (401.18 q/ha) in the year 2018-19.

Increased nutrient availability from the soil to plants and subsequent higher plant uptake of those nutrients may be the cause of increasing fruit weight. In comparison to other tomato crop treatments, it was observed that combining organic manures with inorganic fertilizers significantly improved the fruit weight. These findings concur with those made by Singh *et al*. (2015), Manoj (2014), Meena *et al*. (2014) and Pandey and Chandra (2013). NPK and PM applied together have an incremental impact on yield. Noticeably, the highest fruit yield was found in treatment T_{10} (80% NPK + PM), which may be attributed to favourable soil physical conditions, adequate nutrient availability and higher uptake. Results for the tomato crop have been reported by Tesfay *et al*. (2018). The combined application of inorganic and organic nutrient sources increased the nutrient uptake and fruit yield of hybrid tomatoes, according to Sridharan *et al*. (2017). Brar *et al*. (2015), Islam *et al*. (2017), Singh *et al*. (2017), Kumar *et al*. (2017) and Kumari and Tripathi (2018) all reported comparable result in tomato. The increased growth and flower characteristics, which in turn increased photosynthesis and dry matter production, may be the cause of the increased tomato yield (Laxmi *et al*., 2015). Minimum yield and fruit yield in T_{12}.

Biochemical traits

One of the most essential components of tomato is total soluble solids, which is affected by different nutrients and soil characteristics. Table 5 clearly illustrates that different treatments have a significant impact on total soluble solids. The treatment T_{10} (80% NPK + PM) had the highest TSS (4.63 Brix), which was followed by the treatment T_7 (80% NPK + VC) with the lowest TSS (3.77 Brix) in T_{12}. The combined effect of the optimal nitrogen application received by the plants and the application of (80% NPK + PM) under T_{10} treatment may be the cause of the higher TSS. As a significant component of endogenous factors influencing the quality of fruit, nitrogen absorption may have played a controlling role. Fruits heavily rely on the carbohydrate reserves of the roots and stems as they ripen, which may have led to higher TSS in fruits. Ahmadi *et al*. (2017) also reported similar results for the tomato crop. Bhardwaj *et al*. (2010), Gosavi *et al*. (2010) and Chumyani *et al*. (2012) noted comparable outcomes. The evidence about ascorbic acid content in tomato fruits and how it is affected by various treatments is listed in Table 5. The data demonstrates that T_{12} had the highest ascorbic acid content, which was analysed at 26.08 mg 100 g^{-1}. However, in both study years, the lowest (17.96 mg 100 g^{-1}) was found with treatment T_{12}. Increased availability of macronutrients, particularly nitrogen and potassium, which are important for enhancing tomato's fruit vitamin C content, was the cause of the tomato's significantly higher ascorbic acid content. The highest ascorbic acid content was seen after the application of NPK and organic manure. These findings concur with those of Khan *et al*. (2017). One of the most essential factors for determining yield is the tomato's dry matter content. Carbohydrates, fats, proteins, vitamins, minerals and antioxidants are all indications of "dry matter," which is the substance that is left over after water has been removed. The outcomes showed that T_{10} had the highest dry matter content (6.78%) and T_{11} was the next-highest treatment. The availability of major

Table 4 : Effect of different nutrient sources on growth parameters and yield of tomato.

	Plant height (cm)			**Number of branches**			**Days to 50% flowering per plant**			**Number of fruits**			**Fruit weight (g) per plant**			**Fruit yield per hectare (q)**		
T.C	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**
T_1	73.23	75.62	74.42	11.89	12.17	12.03	33.50	35.23	34.36	14.00	16.23	15.11	48.62	49.12	48.87	419.84	423.63	421.73
T_2	77.14	80.21	78.67	13.88	14.70	14.29	33.37	34.21	33.79	18.60	20.11	19.35	51.10	53.21	52.15	434.22	437.88	436.05
T_3	73.91	77.32	75.61	12.04	12.57	12.30	34.12	35.85	34.98	15.37	17.76	16.56	45.8	50.21	48.00	423.73	426.19	424.96
T_4	75.21	78.62	76.90	12.92	13.30	13.11	33.47	34.50	33.98	15.77	18.52	17.14	45.48	51.23	48.35	428.91	430.35	429.63
T_5	80.27	84.42	82.34	13.02	13.97	13.49	34.40	34.41	34.40	18.60	20.76	19.68	50.77	52.78	51.77	438.92	440.86	439.89
T_6	83.71	85.14	84.42	12.29	12.87	12.58	33.47	33.03	33.25	16.50	19.04	17.77	47.66	53.12	50.39	436.78	440.73	438.75
T_7	86.41	90.12	88.26	15.41	16.00	15.70	35.32	35.02	35.17	22.71	24.78	23.74	51.77	59.24	55.50	446.23	446.85	446.54
T_8	84.23	87.26	85.74	12.96	12.33	12.64	34.40	34.92	34.66	15.60	21.62	18.61	50.03	54.36	52.19	440.94	442.28	441.61
T_9	85.46	89.12	87.29	13.20	14.33	13.76	34.50	34.98	34.74	16.17	23.41	19.79	47.38	57.28	52.33	444.94	444.83	444.89
T_{10}	97.24	101.23	99.23	15.96	16.33	16.14	35.63	36.11	35.87	24.62	26.14	25.38	54.82	62.13	58.47	449.61	453.15	451.38
T_{11}	90.17	96.14	93.15	14.24	15.30	14.77	35.03	35.00	35.01	19.20	29.49	24.34	51.47	58.91	55.19	440.46	441.24	440.85
T_{12}	70.04	72.13	71.08	9.13	9.33	9.23	32.17	32.54	32.35	11.06	10.13	10.59	42.77	40.13	41.45	404.59	401.18	402.89
Mean	**81.41**	**84.77**	**83.09**	**13.07**	**13.60**	**13.33**	**34.11**	**34.65**	**34.38**	**17.35**	**19.07**	**19.00**	**48.97**	**53.47**	**51.22**	**434.09**	**435.76**	**434.93**
$CD_{0.05}$	**3.61**	**3.08**		**0.55**	**0.61**		**1.64**	**1.43**								**1.96**	**1.32**	
		$CD_{0.05}$			**$CD_{0.05}$**			**$CD_{0.05}$**			**$CD_{0.05}$**			**$CD_{0.05}$**			**$CD_{0.05}$**	
		Treat-ment:	**2.31**		**Treat-ment:**	**0.73**		**Treat-ment:**	**1.06**		**Treat-**	**4.73 ment:**		**Treat-**	**5.47**		**Treat-ment:**	**3.28**
		Year	**0.94**		**Year**	**0.16**		**Year**	**0.43**		**Year**	**0.27**		**Year**	**0.64**		**Year**	**0.47**
		Treat-ment × Year	**NS**		**Treat-ment × Year**	**0.57**		**Treat-ment ×Year**	**NS**		**Treat-ment ×Year**	**0.94**		**Treat-ment ×Year**	**2.25**		**Treat-ment ×Year**	**1.62**

Table 5 : Effect of different sources of nutrients on biochemical traits of tomato and microbiological properties in soil.

	TSS (°B)			Ascorbic acid (mg^{-1} 100g)			Dry matter content (%)			Soil microbial count: Bacteria ($\times 10^4$ cfug^{-1}soil)			Soil microbial count: Fungi ($\times 10^3$cfu g^{-1} soil)			Soil microbial count: Actinomycetes ($\times 10^2$cfug^{-1}soil)		
T.C	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**
T_1	3.80	3.87	3.83	19.82	19.97	19.89	6.22	6.27	6.24	146.21	154.68	150.44	2.96	2.98	2.97	2.61	2.68	2.64
T_2	4.12	4.20	4.16	20.82	21.89	21.35	6.13	6.21	6.17	196.24	204.06	200.15	4.29	4.35	4.32	3.56	3.59	3.57
T_3	4.23	4.28	4.25	20.00	21.45	20.72	6.30	6.35	6.32	160.14	174.14	167.14	3.29	3.32	3.30	3.27	3.31	3.29
T_4	3.87	3.94	3.90	20.30	21.69	20.99	6.10	6.23	6.16	186.54	194.78	190.66	4.06	4.17	4.11	3.51	3.54	3.52
T_5	4.33	4.41	4.37	21.40	22.45	21.92	6.23	6.39	6.31	166.24	178.64	172.44	3.26	3.30	3.28	3.34	3.36	3.35
T_6	3.94	4.12	4.03	19.93	20.12	20.02	5.95	6.04	5.99	138.26	144.35	141.30	2.91	2.96	2.93	2.37	2.42	2.39
T_7	4.50	4.63	4.56	23.60	24.94	24.27	6.37	6.42	6.39	174.21	186.50	180.35	3.81	3.94	3.87	3.41	3.44	3.42
T_8	4.19	4.25	4.22	20.37	20.87	20.62	5.82	5.98	5.90	154.23	159.37	156.80	3.12	3.17	3.14	2.75	2.79	2.77
T_9	3.98	4.29	4.13	20.03	21.14	20.58	5.65	5.74	5.69	165.64	170.28	167.96	3.61	3.74	3.67	3.12	3.17	3.14
T_{10}	4.61	4.66	4.63	25.82	26.34	26.08	6.73	6.84	6.78	158.47	164.19	161.33	3.19	3.25	3.22	2.84	2.88	2.86
T_{11}	4.29	4.35	4.32	20.83	21.96	21.39	6.32	6.39	6.35	132.17	138.62	135.39	2.80	2.87	2.83	2.11	2.16	2.13
T_{12}	3.76	3.79	3.77	17.84	18.08	17.96	5.54	5.58	5.56	124.12	128.43	126.27	2.52	2.57	2.54	2.08	2.14	2.11
Mean	**4.13**	**4.23**	**4.18**	**20.89**	**21.74**	**21.31**	**6.11**	**6.20**	**6.15**	**158.53**	**166.50**	**162.52**	**3.31**	**3.38**	**3.35**	**2.91**	**2.95**	**2.93**
$CD_{0.05}$	**0.13**	**0.22**		**0.77**	**1.30**		**0.25**	**0.25**		**7.76**	**4.83**		**0.15**	**0.14**		**0.16**	**0.12**	
		$CD_{0.05}$			**$CD_{0.05}$**			**$CD_{0.05}$**			**$CD_{0.05}$**			**$CD_{0.05}$**			**$CD_{0.05}$**	
		Treatment:	**0.12**		**Treatment:**	**0.73**		**Treatment:**	**0.17**		**Treatment:**	**4.44**		**Treatment:**	**0.10**		**Treatment:**	**0.09**
		Year	**0.05**		**Year**	**0.30**		**Year**	**0.07**		**Year**	**1.81**		**Year**	**0.04**		**Year**	**0.04**
		Treatment × Year	**NS**		**Treatment × Year**	**NS**		**Treatment × Year**	**NS**		**Treatment × Year**	**NS**		**Treatment × Year**	**NS**		**Treatment × Year**	**NS**

Table 6 : Effect of different nutrient sources on available nitrogen, phosphorus and potassium content in tomato.

	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
T.C	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1	294.21	304.16	299.18	50.45	54.24	52.34	232.14	234.45	233.29
T_2	326.45	334.74	330.59	62.73	64.36	63.54	242.34	247.13	244.73
T_3	309.62	316.84	313.23	57.14	58.62	57.88	233.58	236.29	234.93
T_4	321.21	330.58	325.89	60.12	62.21	61.16	239.42	241.56	240.49
T_5	342.14	348.22	345.18	65.76	66.04	65.90	249.16	249.92	249.54
T_6	338.41	345.26	341.83	64.47	65.93	65.20	246.74	248.42	247.58
T_7	354.39	364.14	359.26	66.11	66.84	66.47	252.34	253.79	253.06
T_8	340.64	346.29	343.46	65.24	66.08	65.66	248.21	250.83	249.52
T_9	346.84	351.59	349.21	65.52	65.84	65.68	247.49	247.98	247.73
T_{10}	365.17	372.92	369.04	71.12	71.87	71.49	262.78	266.41	264.59
T_{11}	359.21	364.64	361.92	68.24	69.81	69.02	259.40	262.24	260.82
T_{12}	264.23	272.41	268.32	38.21	41.74	39.97	221.43	228.15	224.79
Mean	**330.21**	**337.64**	**333.92**	**61.25**	**62.79**	**62.02**	**244.58**	**247.26**	**245.92**
$CD_{0.05}$									
		$CD_{0.05}$			$CD_{0.05}$			$CD_{0.05}$	
		Treatment:	**9.92**		**Treatment:**	**1.79**		**Treatment:**	**6.35**
		Year	**4.05**		**Year**	**0.73**		**Year**	**2.59**
		Treatment × Year	**NS**		**Treatment × Year**	**NS**		**Treatment × Year**	**NS**

and minor nutrients, particularly nitrogen and potassium, which are essential for improving fruit quality, may have increased, while the availability of sufficient nutrients may have decreased. Singh *et al*. (2010) reported similar results.

Microbiological properties

The data in the Table 5 reveal that treatment T_2 (60 percent NPK + VC) recorded the highest Bacteria, Fungi and Actinomycetes count, at 200.15 × 10^4 cfu g^{-1}, 4.32 × 10^3 cfu g^{-1} and 3.57 × 10^2 cfu g^{-1} soil, closely followed by treatment T_4 (60 percent NPK + FYM). In the treatment T_{12} (Absolute control), the minimum count was recorded as 126.27 × 10^4 cfu g^{-1}, 2.54 × 10^3 cfu g^{-1} and 2.11 × 10^2 cfu g^{-1}. Similar findings were reported by Arbad and Ismail (2012), who came to the conclusion that treatment plots receiving 60% NPK+ VC had the highest populations of bacteria, actinomycetes, and fungi. The density of the microbial population increased in the vermicompost-applied plot (Ammaan and Subramaniam, 2017). The loss of organic matter in conventional farming, according to Singh *et al*. (2017), makes it difficult to maintain the microbial load in soil. When organic manures like vermicompost and FYM were applied, microbes multiplied exponentially. They held the opinion that microbe activity increased in soils devoid of chemical fertilizers.

Soil analysis

To ascertain the effect of organic and inorganic sources of nutrients on soil nutrition, the nutrient status of the soil was analysed. Table 6 clearly shows that the integrated use of fertilizers from inorganic and organic sources resulted in a significant increase in the amount of nitrogen that was readily available in the soil. The available nitrogen was significantly higher under T_{10} (369.04 kg ha^{-1}), followed by T_{11} (361.92 kg ha^{-1}) and the lowest was under T_{12} (268.32 kg ha^{-1}). The direct application of sufficient amounts of inorganic nitrogenous fertilizers and the quick release of nitrogen in the soil may be responsible for the increase in the soil's nitrogen availability (Katkar *et al*., 2011). Combining nitrogen fertilizer and organic manures may have increased the amount of available nitrogen by increasing soil nitrogen mineralization and reducing nitrogen losses (Meena *et al*., 2018). The mean phosphorus content of T_{10} was the highest of all the modules, at 71.87 kg/ha. The highest amount of potassium that was readily available was found in treatment T_{10} (80 percent NPK + PM), which was followed by treatment T_{11} (264.59 kg/ha). The significant increase in available P in the treatments receiving NPK+PM may be attributable to decreased water soluble P fixation, increased organic P mineralization due to microbial action, and soil P solubilization by organic acids produced during organic matter decomposition. Varalakshmi *et al*. (2005) and Chandel *et al*. (2017) both reported results along similar lines (2017). The increased potassium availability in treatment T_{10} can be attributed to the direct addition of potassium to the soil's potassium pool by inorganic NPK fertilizers, the reduction of K fixation, and the release of K as a result of the interaction of organic matter and clay upon the addition of organic manures. Choudhary *et al*. (2004) reported outcomes that were comparable.

Conclusion

The integrated application of organic manures and inorganic fertilizers in the current study revealed significant variations for all tomato growth, yield and yield-attributing traits as well as biochemical attributes. The recommended dose of fertilizers (80%) and poultry manure (2.5 t/ha) in treatment T_{10} were appraised to be the best treatment for yield and its component traits. Our findings may help to clarify the significance of combining organic manure with inorganic fertilizers to improve growth quality and increase tomato yield.

Disclosure statement

No potential conflict of interest was reported by the author(s)

Author contributions

MC and RB envisaged and designed the experiment; MC and RB performed the experiments and laboratory analysis; S, P and PS analyzed the data; PB and RB supervised the experimental work; MC assisted in the experimental work; S and PS reviewed the design and performed language editing and critical reading of the manuscript. All the authors have read the manuscript and agreed to submit it in its current form for publication in the Journal.

References

Ahmadi, E., Honnabyraiah M.K., Alur A.S., Adiga J.D. and Rao V. (2017). Impact of integrated nutrient management on yield and quality parameters of strawberry. *Int. J. Curr. Microbiol. App. Sci*., **6**, 3481-3487.

Ali, M.B., Lakun H.I., Abubakar W. and Mohammed Y.S. (2014). Performance of tomato as influenced by organic manure and sowing date in Samaru, Zaria. *Int. J. Agron. Agri. Res*., **5**, 104-110.

Amalraj, E.L.D., Kumar G.P., Ahmed R. Abdul and Kishore N. (2013). Microbiological analysis of panchgavya, vermicompost and FYM and their effect on plant growth promotion of pigeon pea (*Cajanus cajan* L.) in India. *Organic Agri*., **3**, 23-29.

Ammaan, M. and Subramaniam S. (2017). Efficacy of organic manures and biofertilizers on soil microbial count and yield of Blacknight shade (*Solanum nigrum* L.). *Int. J. Curr. Microbiol. App. Sci*., **6**, 1780-1786.

Anonymous (2018). *Indian Horticulture Database*. National Horticulture Board, Gurgaon.

Arbad, B.K. and Ismail S. (2012). Effect of continuous use of chemical fertilizers and manures on soil biological and chemical properties in soyabean-sunflower system. *J. Soils Crops*, **21**, 109-114.

Barrios-Masias, F.H., Cantwell M.I. and Jackson L.E. (2011). Cultivar mixtures of processing tomato in an organic agroecosystem. *Organic Agri*., **1**, 17-30.

Batabyal, K.B., Mandal D., Sarkar S., Murmua A., Tamang T., Das G.C., Hazra and Chattopadhyay P.S. (2016). Comprehensive assessment of nutrient management technologies for cauliflower production under subtropical conditions. *Europ. J. Agron*., **79**, 1-13.

Bhardwaj, S.K., Sharma I.P. and Sharma S.D. (2010). Effect of integrated nutrient management on soil fertility, yield and quality of tomato and French bean crops in the Mid Himalayas. *J. Ind. Soc. Soil Sci.*, **58**, 464-466.

Brar, N.S., Thakur K.S., Kumar R., Mehta D.K., Sharma N., Kumar D. and Kumar S. (2015). Effect of organic manures and bio fertilizers on fruit yield and contributing traits of tomato (*Solanum lycopersicum* L.). *Ecol., Environ. Conserv*., **21**, 1783-1787.

Chandel, A.S., Gabhane V.V., Nagdeve M.B., Turkhede A.B. and Patode R.S. (2017). Effect of INM on soil fertility, productivity and economics of cotton + green gram intercropping system in vertisols. *Int. J. Curr. Micro. Appl. Sci.*, **6**, 3738-3743.

Chatterjee, R. and Bandyopadhyay S. (2014). Studies on effect of organic, inorganic and biofertilizers on plant nutrient status and availability of major nutrients in tomato. *Int. J. Bio-res. Stress Manag*., **5**, 93-97.

Chauhan, M., Shilpa, Bijalwan P., Sharma H.R. and Shukla Y.R. (2022). Influence of organic and inorganic nutrients on horticultural and biochemical traits of garlic (*Allium sativum* L.). *Int. J. Environ. Clim. Change*, **12**, 1095-1099.

Chauhan, M., Sharma H.R., Shukla Y.R. and Shilpa (2022). Performance of garlic in North Western Himalyas: Comparative assessment to Integrated nutrient management practices. *Environ. Ecol*., **40**, 2277-2281.

Chauhan, M., Shilpa, Kaur R., Bijalwan P., Negi S. and Bhagta S. (2023). Biochemical analysis of garlic (*Allium sativum* L.) under integrated nutrient management in North Western Himalayas. *Ann. Phytomed. : An Int. J*., **12**, 1-7.

Choudhury, M.R., Saikia A. and Talukdar N.C. (2004). Response of cauliflower to integrated nutrient management practices. *Bioved*., **15**, 83-87.

Chumyani, Kanaujia S.P., Singh V.B. and Singh A.K. (2012). Effect of integrated nutrient management on growth, yield and quality of tomato (*Solanum lycopersicum* L.). *J. Soils Crops*, **21**, 65-71.

Gosavi, P.U., Kamble A.B. and Pandure B.S. (2010). Effect of organic manures and biofertilizers on quality of tomato fruits. *The Asian J. Hort.*, **5**, 376-378.

Gowda, M.C.B., Krishnappa K.S., Gowda M.C. and Puttaraju T.B. (2002). Effect of NPK levels on dry matter nutrient accumulation and uptake of nutrients in okra. *South Ind. Hort.*, **50**, 543-549.

Islam, A.M., Islam S., Akter A., Rahman H.M. and Nandwani D. (2017). Effect of organic and inorganic fertilizers on soil properties and the growth, yield and quality of tomato in Bangladesh. *Agri.,* **18**, 7-8.

Jackson, M.L. (1973). *Soil Chemical Analysis*. Printice Hall, India Pvt. Ltd., New Delhi.

Kadam, J.R. and Sahane J.S. (2002). Chemical composition and dry matter yield of tomato as influenced by NPK fertilizer briquette. *J. Maharashtra-Agri. Univ.,* **27**, 4-6.

Kakar, R., Sharma J.C., Mogta A., Guleria A. and Thakur J. (2020). Assessment of various nutrient management technologies for quality, fertilizer use efficiency, and economics of ginger production under subtropical to sub-temperate conditions. *Commun. Soil Sci. Plant Anal.*, **51**, 2805-2820.

Katkar, R.N., Sonune B.A. and Kadu P.R. (2011). Long term effect of fertilization on soil chemical and biological characteristics under sorghum-wheat system in vertisol. *Indian J. Agri. Sci*., **81**, 734-739.

Khan, A.A., Bibi H., Ali Z., Sharif M., Shah S.A., Ibadullah H., Khan K., Azeem I and S. Ali (2017). Effect of compost and inorganic fertilizers on yield and quality of tomato. *Acad. J. Agri. Res*., **5**, 287-293.

Krishnappa, K.S. (2002). Growth and yield of tomato cv. vihash in relation to inorganic fertilizer and organic manures. *South Indian Hort*., **50**, 335-341.

Kumar, R., Kumar S., Meena R.K., Kumar P. and Rawat R. (2017). Effect of integrated nutrient management on growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Pusa Ruby. *Plant Archieves*, **17**, 1197-1200.

Kumari, M. and Tripathi D. (2018). Influence of integrated nutrient management on yield and uptake of tomato (*Solanum lycopersicum* L.) and availability of nutrients in soil under mid hill conditions of Himachal Pradesh. *The Pharm. Innov. J.*, **7**, 561-564.

Kumari, M. (2017). Influence of integrated nutrient management on yield and soil properties in pea-tomato cropping sequence (*Ph.D. Thesis*). Dr YS Parmar University of Horticulture and Forestry Nauni, Solan (HP), India.

Laxmi, P.R., Saravanan S. and Naik M.L. (2015). Effect of organic manures and inorganic fertilizers on plant growth, yield, fruit quality and shelf life of tomato (*Solanum lycopersicon* L.). *Int. J. Agri. Sci. Res.,* **5**, 7-11.

Makinde, A.A. and Bello N.J. (2009). Effects of soil temperature pattern on the performance of cucumber intercrop with maize in a tropical wet-and-dry climate of Nigeria. *Researcher*, **1**, 24-36.

Manohar, S.V.S. and Paliwal R. (2016). Interactive effect of FYM and inorganic fertilizers on performance of tomato. *Ann. Arid Zone*, **55**, 47-49.

Manoj, K. (2014). Impact of front line demonstration of INM on yield in tomato. *Hort. Flora Res. Spect*., **3**, 295-297.

Meena, K.B., Alam M.S., Singh H., Bhat M.A., Singh A.K., Mishra A.K. and Thomas T. (2018). Influence of farmyard manure and fertilizers on soil properties and yield and nutrient uptake of wheat. *Int. J. Chem. Stud*., **6**, 386-390.

Meena, R.K., Kumar S., Maji S., Kumar D. and Kumar M. (2014). Effect of organic manures and biofertilizers on growth, flowering, yield and quality of tomato. *Int. J. Agri. Sci*., **10**, 329-332.

Merwin, H.D. and Peech M. (1951). Exchangeability of soils potassium in the silt and clay fractions as influenced by the nature of the complimentary exchangeable cations. *Soil Sci. Soci. Amer. Proceed.*, **15**, 125-128.

Negi, M., Sharma J.C., Shukla Y.R., Chauhan A., Sharma S. and Sharma K. (2021). Comparative assessment of different nutrient sources on growth, yield and nutrient uptake by onion (*Allium cepa* L.). *J. Plant Nutr.,* **45**, 1516-1522.

Olsen, S.R., Cole C.V., Watanable F.S. and Dean L.A. (1954). Estimation of available phosphorous in soil by extraction with sodium bicarbonate. *USDA Circular*, **939**, 1-19.

Osterholz, W.R., Culman S.W., Herms C., Oliveira F.R., Robinson A. and Doohan D. (2021). Knowledge gaps inorganic research: Understanding interactions of cover crops and tillage for weed control and soil health. *Organic Agri*., **11**, 13-25.

Pal, A., Majhi S., Govind, Kumawat R., Kumar S. and Meena D. (2015). Efficacy of various sources of nutrients on growth, flowering, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Azad T-6. *Bioscan*., **10**, 473-477.

Pandey, S.K. and Chandra K.K. (2013). Impact of integrated nutrient management on tomato yield under farmer field conditions. *J. Environ. Biol*., **34**, 1047-1051.

Raiola, A., Rigano M.M., Calafiore R., Frusciante L. and Barone A. (2014). Enhancing the health-promoting effects of tomato fruit for biofortified food. *Mediators Inflamm*., 139873 p.

Ranganna, S. (1986). *Hand book of Anaylsis and Quality Control for Fruits and Vegetable products*. 2nd ed. Hill Publishing Company Limited, New Delhi. 105 p.

Sahu, P., Tripathy P.R., Sahu G.S., Dash S.K., Pattanayak S.K., Sarkar S., Tripathy B., Nayak N.J. and Mishra S. (2020). Effect of integrated nutrient management on growth and fruit yield of cucumber (*Cucumis sativus* L.). *J. Crop Weed*, **16**, 254-257.

Sharma, S., Shilpa, Kaur M., Sharma A.K. and Sharma P. (2022). Influence of different organic manures, biofertilizers and inorganic nutrients on performance of pea (*Pisum sativum* L.) in North Western Himalayas. *J. Plant Nutr*., **46**, 600-617.

Shilpa, Bijalwan P., Shukla Y.R., Kansal S.K. and Thakur K.S. (2021). Effects of planting methods, mulches, training systems on flowering, fruiting, yield and disease incidence of tomato (*Solanum lycopersicum* L.) under open field conditions of Himalayan region. *Environ. Ecol.,* **39**, 854-867.

Shilpa, Sharma P., Thakur V., Sharma A., Rana R.S. and Kumar P. (2022). A status-quo review on management of root knot nematode in tomato. *The J. Hort. Sci. Biotech.*, **97**, 403-416.

Singh, A., Jain P.K., Sharma H.L. and Singh Y. (2015). Effect of planting date and integrated nutrient management on the production potential of tomato (*Solanum lycopersicum* L.) under polyhouse condition. *J. Crop Weed.*, **11**, 28-33.

Singh, B.K., Pathak K.A., Boopathi T. and Deka B.C. (2010). Vermicompost and NPK fertilizer effects on morpho-physiological traits of plants, yield and quality of Tomato fruits. *Veg. Crops Res. Bull.,* **73**, 77-86.

Singh, L. and Sadawarti R.K. (2021). Effect of INM (Integrated nutrient management) on plant growth, yield and quality of strawberry (*Fragaria ananassa* Duch.). *The Pharm. Innov. J.*, **10**, 244-247.

Singh, R., Sharma R.R. and Singh D.B. (2010). Effect of vermicompost on plant growth, fruit yield and quality of strawberries in irrigated arid region of northern plains. *Indian J. Hort.*, **67**, 318-321.

Singh, S.K., Yadav R.B., Singh J. and Singh B. (2017). Organic Farming in Vegetables. *IIVR Technical bulletin no. 77*, ICAR-IIVR, Varanasi. 47p.

Sonet, R.A., Ali M.H., Amin A.K., Haque M.N. and Masum S.M. (2020). Influence of phosphorus levels on growth and yield of four lentil varieties. *Bangladesh Agron. J.*, **23**, 29-36.

Sridharan, S., Mariappan S. and Arumugam T. (2017). Influence of organic and inorganic nutrients in tomato (*Solanum lycopersicum* L.) for nutrient uptake and yield under shadenet condition. *Int. J. Curr. Microbiol. Appl. Sci*., **6**, 2904-2908.

Subbiah, B.V. and Asija G.L. (1956). Rapid method for estimation of available nitrogen in soils. *Curr. Sci*., **25**, 259-260.

Tesfay, T., Gebremariam M., Gebretsadik K., Hagazi M. and Girmay S. (2018). Tomato yield and economic performance under vermicompost and mineral fertilizer applications. *The Open Agri. J*., **12**, 262-269.

Thakur, J. (2016). Studies on conjoint application of nutrient sources and PGPR on soil properties, growth and yield of cauliflower (*Brassica oleraceae* var. *botrytis* L.) cv. Pusa Snowball K-1(*MSc Thesis*). Dr YS Parmar University of Horticulture and Forestry Nauni, Solan (HP), India.

Usha, P., Tembhre D., Das M.P. and Pradhan J. (2019). Effect of integrated nutrient management on growth development and yield traits of tomato (*Solanum lycopersicon* L.). *J. Pharmacog. Phytochem.,* **8**, 2764-2768.

Varalakshmi, L.R., Srinivasmurthy C.A. and Bhaskar S. (2005). Effect of integrated use of organic manures and inorganic fertilizers on organic carbon, available N, P and K in sustaining productivity of groundnut-finger millet cropping system. *J. Indian Soc. Soil Sci.,* **53**, 315-318.

Walkley, A.J. and Black C.A. (1934). Estimation soil organic carbon by the chromic acid titration method. *Soil Sci*., **37**, 259-260.