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Nitrogen and Sulphur Supplementation through Organic Sources on Nutrients Content and their Uptake of Tomato Crop

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ABSTRACT

The integrated application of mineral fertilizers and organic materials is widely recognized as an effective and eco-friendly strategy for achieving sustainable crop production. To evaluate the impact of nitrogen and sulphur supplementation through organic sources on nutrient content and uptake in tomato (Solanum lycopersicum), a field experiment was conducted during the Rabi season of 2019–20 at the Nursery Area Organic Farm, Karguwan Ji, Bundelkhand University, Jhansi, Uttar Pradesh. The study employed a Randomized Block Design (RBD) with nine treatment combinations and three replications. The findings revealed that the combined use of organic amendments significantly enhanced the nutrient content and uptake in tomato plants, underscoring the potential of organic nutrient sources in improving soil fertility and crop nutritional status under sustainable farming systems. The highest contents (N,P,K,S) were reported in T_8 (50 % VC+50% FYM + 30 kg/ha S) with value of (2.63 %, 0.24 %, 2.16 %, 0.23 %) and least was reported in T_4 N (1.20 %), T_0 P (0.11 %), T_3 K (1.43 %), T_2 S (0.18 %). Highest uptakes (N,P,K,S) was reported in T8 (119.32 kg/ha, 11.89 Kg/ha, 103.03 kg/ha, 11.34 kg/ha) and least was reported in T_4 N (42.50 kg/ha), T_0 P (5.04 kg/ha), T3 K (58.13 kg/ha), T_2 S (7.02 kg/ha).

Keywords: *Tomato, Nitrogen, content, uptake organic sources.*

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important and widely cultivated vegetable crops, belonging to the family Solanaceae—commonly known as the nightshade family—which also includes economically significant crops such as potato, eggplant, chilli, and tobacco. Known colloquially as "Wolf Apple", "Love Apple", or "Vilayati Baingan", tomato is not only valued for its culinary versatility but also for its rich nutritional profile.

Globally, tomato cultivation occupies a significant place in vegetable production. As of 2017–18, the estimated global production stood at approximately 127.92 million tonnes, covering an area of around 47.19 lakh hectares. China leads global production with 33.64 million tonnes, followed by the United States. In India, during 2018–19, tomato was cultivated over an area of about 7.78 lakh hectares, yielding approximately 19.39 million tonnes. Major tomato-producing states include Uttar Pradesh, Karnataka, Maharashtra, Haryana, Punjab, and Bihar.

Tomato is often referred to as the "Poor Man's Orange" due to its affordability and its high vitamin C content, making it accessible and beneficial across socio-economic groups. The fruit's vibrant red color and pleasant taste make it a staple in both raw and cooked forms. It is consumed fresh in salads and sandwiches or processed into products such as ketchup, puree, sauces, pickles, and tomato powder. Nutritionally, tomatoes are rich in vitamins A and C, B-complex vitamins, essential amino acids, and minerals like calcium (48 mg/100g), sodium (12.9 mg), and copper (0.19 mg). They also contain beneficial organic acids such as citric, formic, and acetic acids. Notably, tomatoes are a primary source of lycopene, a powerful antioxidant associated with reduced risk of certain cancers and other chronic diseases [1], their nutritional and economic value, tomato cultivation in India is challenged by low productivity, declining farm profitability, and limited awareness among growers regarding improved agronomic practices and quality management [2]. Addressing these challenges is essential to enhance yield, nutritional quality, and the livelihoods of smallholder farmers.

The beneficial effects of farmyard manure (FYM) and vermicompost on crop yield and soil productivity are largely attributed to their role as reservoirs of essential plant nutrients [3]. These organic amendments enhance soil physical properties by improving aeration, promoting root development, and stimulating microbial and biological activity in the rhizosphere, which collectively contribute to better nutrient cycling and plant health.

Among essential nutrients, nitrogen (N) plays a pivotal role in plant metabolism, directly influencing vegetative growth, enzymatic activity, and protein synthesis. Nitrogen is often considered the most critical nutrient for improving both crop yield and produce quality, thus dominating the field of plant nutrition. Understanding nitrogen's interaction with other nutrients is of fundamental importance, as increased nitrogen availability not only promotes growth but also elevates the demand for other macro- and micronutrients. Depending on their availability in the root zone, this heightened demand may lead to nutrient imbalances, either in the form of deficiencies or toxicities [4], nitrogen, phosphorus (P) and potassium (K) are well-recognized for their role in crop development. More recently, sulphur (S) has been acknowledged as the fourth major nutrient essential for optimal plant growth. Over the past two to three decades, sulphur deficiencies have become increasingly prevalent, adversely affecting crop productivity, nutrient balance, and overall soil health [5-6]. Sulphur is now considered a vital component of balanced fertilization strategies, particularly in sulphur-deficient regions. Sulphur contributes significantly to both yield enhancement and quality improvement. It improves nitrogen use efficiency, supports amino acid and protein synthesis, and plays a crucial role in the development of seed oils—especially in oilseed crops. Numerous studies across India and globally have demonstrated that sulphur supplementation leads to improved crop yields, enhanced nutrient uptake, and sustained soil fertility.

Material and Methods

Experimental site and location

The experiment was conducted during the Rabi season of 2019–20 at the Nursery Area Organic Farm, Karguwan Ji, Bundelkhand University, Jhansi, Uttar Pradesh. Geographically, Jhansi is located in the southern part of Uttar Pradesh, situated between the rivers Pahuj and Betwa, at an average elevation of 225 meters above mean sea level (MSL). The precise geographical coordinates of the site are 25°26′55″N latitude and 78°34′11″E longitude. The region falls under Agro-Climatic Zone VI (Central Plateau and Hills Region), characterized by semi-arid conditions, with variable rainfall and distinct seasonal variations, making it a representative location for studying sustainable agricultural practices in the Bundelkhand region. The meteorological data recorded during the experimentation periods (2019-2020) based on observations made at the metrological observation of the IGFRI, Jhansi are depicted in figure. During Experimental period, a total rainfall of 8.20mm was received. Maximum temperature being 31.6^{0}C was recorded in October. While the lowest temperature recorded in December was 4.2^{0}C. The mean relative humidity ranged from to 86% in 22 October to December, respectively.

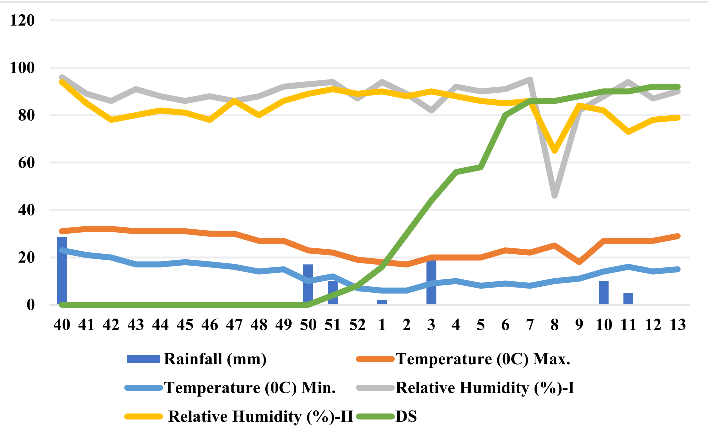

Figure 1: meteorological observations during the crop growth period.

Experimental details

Treatments consists of T0: RDF 100:75:55 (Through chemical fertilizer), T1: 100% N from FYM, T2: 100% N from V.C., T3: 100% N from FYM+20kg/ha sulphur through gypsum, T4: 100% N from FYM+30kg/ha sulphur through gypsum, T5: 100% N From V.C+20 kg/ha sulphur through gypsum, T6: 100% N From V.C+30 kg/ha From sulphur through gypsum, T7: 50% N From FYM+50%N From VC+20kg/ha sulphur through gypsum, T8: 50% N From FYM+50% from VC+30 kg/ha sulphur through gypsum. The crop opted for the experiment was tomato with variety Uday and a spacing of 60 x 45 cm during *Rabi* 2019 – 2020.

The experiment consists of nine treatments and three replications. The design used was Randomized Block Design (RBD).

Plant analysis

Plant samples were dried in oven at 50^{0} C until constant dry weight obtained. The plant samples were grinded and used for following chemical analysis. Nitrogen content was determined by Micro-Kjeldahal method [3]. Phosphorus content in plant was determined by photo colorimetric method [4]. Potassium content plant was determined by flame-photometer method, using di-acid digestion system respectively by [5]. The sulphur content, By Turbid Metric Methods.

Statistical Analysis

The data recorded during the course of investigation were subjected to analysis statistically using analysis of variance techniques (ANOVA) for randomized block design as prescribed by [6]. Standard error of mean in each case and the critical difference only for significant cases were computed at 5% levels of probability as under.

Results and Discussion

Nitrogen content in Tomato

Effect of organic sources of nitrogen and sulphur application on nutrient concentration in tomato fruit was significantly influence nitrogen content in tomato and the mean date is presented in (Table 1).The maximum values (2.63%) recorded in respect to nitrogen content under T_8 followed by T_1 and control and lowest value was recorded in T_4(1.20 %) treatment combination which was inferior to treatment combination, the incensement in nitrogen concentration may be due to organic sources fertilizers are enhanced the mineralization of nitrogen. Our findings are partially agreed with the results of [6-7]. Nitrogen and K accumulation was greater in fruit than leaves. The rate of tomato growth and N uptake peak during fruit setting and slow after fruit ripening begins, thus, N applications should coincide with peak requirements to prevent excessive application and leaching [8-10].

Phosphorus content by Tomato

Effect of organic source of fertilizers on phosphorous concentration in tomato fruit was significantly influence during the crop period and the mean date is presented in (Table 1). The maximum values (0.24%) recorded in respect to nitrogen content under T_8 followed by T_7 and T_5. The lowest value was recorded in to (0.11 %). The organic fertilization increases the availability of phosphorous. Our finding is partially agreed with the result of [7] Mukta *et al.* (2015) phosphorus content in tomato plant increased significantly due to the application of integrated applications of vermicompost and chemical fertilizers. It has already been shown that phosphorus availability in andosols was improved with organic manure [9]. It is also known that the organic phosphorus from poultry manure strongly integrates the pool of the soil steady organic matter [10-11] and organic colloids prevent soluble phosphates from linking with soluble iron and aluminium in acidic soils. Improved phosphorus concentration tended to be higher with balanced mineral fertilization than with local farmers fertilization even if the amount of applied phosphorus is very similar in the two treatments.

Potassium content in tomato

Effect of organic source of fertilizers on potassium content in tomato fruit was significantly influence during the crop period and the mean date is presented in (Table 1). The maximum content in tomato crop (2.16%) recorded in T_8 and T_4 followed by T_6 2.13 %, the lowest value was recorded in T_3 (1.43%). The organic fertilization increases the mineralization of potassium, insoluble to soluble forms. Nitrogen and K accumulation was greater in fruit than leaves. According to [8-12], the rate of tomato growth and N uptake peak during fruit setting and slow after fruit ripening begins, thus, N applications should coincide with peak requirements to prevent excessive application and leaching.

Sulphur content in plant

The effect of nitrogen and sulphur application on nutrient content in tomato crop was significantly influence and mean data showed in Table 1. The mean values of sulphur content was found under different treatments *i.e.* T_0 (0.22), T_1 (0.22), T_2 (0.18), T_3 (0.18), T_4 (0.23), T_5 (0.23), T_6 (0.21), T_7 (0.21), T_8 (0.23). The maximum values were recorded under T_8 and lowest in T_2 and T_3.

Table 1: Effect of organic sources of N and S application on nutrients content by tomato

Treatments	Nitrogen	Phosphorus	Potassium	Sulphur
T_0 (RDF)	1.84	0.11	1.80	0.22
T_1 (100 % FYM)	2.27	0.15	1.95	0.22
T_2 (100 % V.C)	1.52	0.16	2.08	0.18
T_3 (100 % FYM+20 kg/ha S)	1.24	0.18	1.43	0.18
T_4 (100 % FYM+30 kg/ha S)	1.20	0.19	2.16	0.23
T_5 (100 %V.C+20kg/ha S)	1.74	0.21	2.10	0.23
T_6 (100 % V.C+30 kg/ha S)	1.56	0.19	2.13	0.21
T_7 (50 % V.C+50% FYM+20 kg/ha S)	1.45	0.22	2.04	0.21
T_8 (50 % V.C+50% FYM+30kg/ha S)	2.63	0.24	2.16	0.23
SEm (±)	**0.22**	**0.01**	**0.10**	**0.44**
CD $_{(5\%)}$	**0.65**	**0.04**	**0.31**	**1.32**

Sulphur content in fruit

The effect of nitrogen and sulphur application on nutrient content in tomato fruit was significantly influence and mean data showed in (Fig. 2). The mean values of sulphur content was observed in treatments T_0 (237.67), T_1 (180), T_2 (208), T_3 (463), T_4 (283), T_5 (278), T_6 (245), T_7 (253), T_8 (340). The maximum values recorded in respect to sulphur concentration and uptake from T_3 and lowest content was recorded in T_1 treatment combinations.

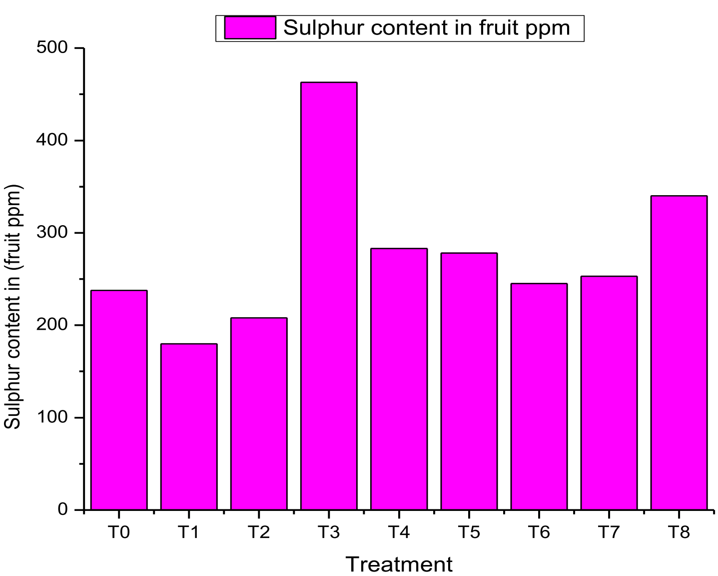

Figure 2: showing Effect of organic sources of N and S application on sulphur content in fruit in tomato

Nitrogen uptake by tomato

The effect of nitrogen and sulphur application on nitrogen uptake by tomato plants was significantly influence and mean data showed in (Table 2). The mean values of nitrogen content was observed in treatments from T_0 (84.08 kg/ha), T_1 (112.84 kg/ha), T_2 (62.07 kg/ha), T_3 (48.90 kg/ha), T_4 (42.50 kg/ha), T_5 (64.94 kg/ha), T_6 (63.74 kg/ha), T_7 (56.14 kg/ha), T_8 (119.32 kg/ha). The maximum values recorded in respect to sulphur concentration and uptake from T_8 and lowest content was recorded in T_4 treatment combinations.

Phosphorus uptake by tomato

The effect of nitrogen and sulphur application on phosphorous uptake by tomato plants was significantly influence and mean data showed in (Table 2). The mean values of phosphorous content was observed in treatments from T_0 (5.04 kg/ha), T_1 (6.78 kg/ha), T_2 (6.42 kg/ha), T_3 (7.30 kg/ha), T_4 (6.88 kg/ha), T_5 (7.97 kg/ha), T_6 (7.86 kg/ha), T_7 (8.36 kg/ha), T_8 (11.89 kg/ha). The maximum values recorded in respect to sulphur concentration and uptake from T_8 and lowest content was recorded under control (T_0).

Potassium uptake by tomato

The effect of nitrogen and sulphur application on potassium uptake by tomato plants was significantly influence and mean data showed in (Table 2). The mean values of potassium content was observed in treatments from T_0 (82.33 kg/ha), T_1 (88.47 kg/ha), T_2 (86.60 kg/ha), T_3 (58.13 kg/ha), T_4 (76.87 kg/ha), T_5 (78.37 kg/ha), T_6 (86.17 kg/ha), T_7 (77.20 kg/ha), T_8 (103.03 kg/ha). Earlier reported that the maximum uptake values of N, P and K were recorded with higher dose of nitrogen application [11-14].

Table 2: Effect of organic sources of N and S application on nutrients uptake by tomato crop

Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
T_0 (RDF)	84.08	5.04	82.33
T_1 100% FYM)	112.64	6.78	88.47
T_2 100% V.C	62.07	6.42	86.60
T_3 100% FYM+20kg/ha S	48.09	7.30	58.13
T_4 100% FYM+30 kg/ha S	42.50	6.88	76.87
T_5 100% V.C+20kg/ha S	64.94	7.97	78.37
T_6 100% V.C+30 kg/ha S	63.76	7.86	86.17
T_7 50% FYM+50%V.C+20kg/ha S	56.14	8.36	77.20
T_8 50% FYM+50%V.C+30 kg/ha S	119.32	11.89	103.03
SE m (±)	11.58	0.58	4.05
CD ($_{5\%}$)	35.01	1.75	12.26

Sulphur uptake by tomato plant

The effect of nitrogen and sulphur application on sulphur uptake by tomato plants was significantly influence and mean data showed in (Table-3). The mean values of sulphur content was observed in treatments T_0 (9.84), T_1 (10.07), T_2 (7.34), T_3 (7.34), T_4 (8.11), T_5 (8.59), T_6 (7.39), T_7 (8.07), T_8 (11.34). The maximum values recorded in respect to sulphur concentration and uptake from T_8 and lowest content was recorded under treatments T_2.

Sulphur uptake in tomato fruit

The effect of nitrogen and sulphur application on sulphur uptake by tomato fruits was significantly influence and mean data showed in (Table-3). The mean values of sulphur content in fruits was observed in treatments T_0 (3.65), T_1(2.38), T_2(2.), T_3 (6.37), T_4(3.70), T_5 (3.23), T_6 (3.25), T_7 (2.83), T_8 (4.06). The maximum values recorded in respect to sulphur concentration and uptake from T_3 and lowest content was recorded under treatments T_2.

Conclusion

Organic fertilizers like Farm Yard manure, Vermicompost significantly improved the nutrient contents and uptakes. The highest contents (N, P, K, S) were reported in T_8 (50 % V.C+50% FYM+30 kg/ha S) with value of (2.63 %, 0.24 %, 2.16 %, 0.23 %) and least was reported in T_4 N (1.20 %), T_0 P (0.11 %), T_3 K (1.43 %), T_2 S (0.18 %). Highest uptakes (N, P, K, S) was reported in T8- (50 % V.C+50% FYM+30 kg/ha S) (119.32 kg/ha, 11.89 kg/ha, 103.03 kg/ha, 11.34 kg/ha) and least was reported in T_4 N (42.50 kg/ha), T_0 P (5.04 kg/ha), T3 K (58.13 kg/ha), T_2 S (7.02 kg/ha).

Table 3. Effect of organic sources of N and S application on sulphur uptake by tomato plant and fruit

Treatment	Sulphur uptake by plant	Sulphur uptake by fruit
T_0 (RDF)	9.84	3.65
T_1 (100 % FYM)	10.07	2.38
T_2 (100 % V.C)	7.02	2.19
T_3 (100 % FYM+20 kg/ha S)	7.34	6.37
T_4 (100 % FYM+30 kg/ha S)	8.11	3.70
T_5 (100 %V.C+20kg/ha S)	8.59	3.23
T_6 (100 % V.C+30 kg/ha S)	7.39	3.25
T_7 (50 % V.C+50% FYM+20 kg/ha S)	8.07	2.83
T_8 (50 % V.C+50% FYM+30 kg/ha S)	11.34	4.06
SEm (±)	**0.44**	0.69
CD($_{5\%}$)	**1.32**	2.08

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