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NUTRITION AND BIOMASS ALLOCATION OF TOMATO (*SOLANUM LYCOPERSICUM* L.) PLANT INFLUENCED BY MULCHING AND ORGANIC FERTILIZERS

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Keywords: biomass, nutrition, organic mulch, root-shoot ratio, sustainable agriculture

Abstract

Global demand for vegetable crops has surged in this era of globalization and increased health awareness. Due to its rich nutritional and chemical composition, tomato (*Solanum lycopersicum* L.) has become one of the most popular and widely consumed vegetables worldwide. In response, a field experiment was conducted in net house at the Department of Soil, Water, and Environment, University of Dhaka, Bangladesh, to evaluate the effects of organic fertilizers, both alone and in combination with mulching, on the nutrient content and biomass allocation of tomato plants. The results indicated that the application of organic fertilizers such as mustard oil cake (MOC), poultry manure (PM), and vermicompost (V) at higher rates (8 t ha^{-1}) significantly increased the nutrient contents (N, P, K, S, Ca, and Mg) in the leaves, stems, and roots of tomato plants in absence of mulching. However, applying these fertilizers at lower rates (4 t ha^{-1}) in combination with mulching also effectively enhanced nutrient content. Regarding biomass allocation, particularly the root-to-shoot ratio, a slight anomaly was observed. The highest root-to-shoot ratio was recorded in the control plot, suggesting that factors other than nutrient supply, such as root penetration depth, distribution in the soil, response to transient drought, initial root growth and also environmental or physiological conditions, might have influenced root weight. Therefore, variations in root-to-shoot ratios could be misleading from a physiological perspective. To meet the growing demand for high-yielding, fertilizer-responsive crops, there has been significant reliance on synthetic inputs, raising concerns about the long-term sustainability of agricultural systems. Thus, environmentally friendly farming methods are urgently needed to ensure sustainable food production. The combination of mulching and organic fertilizers presents an effective strategy for improving crop growth conditions, increasing yield, and enhancing product quality by mitigating unfavorable environmental conditions.

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Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular and nutritious vegetables globally[1]. Its rich nutritional and chemical composition makes it a unique vegetable, containing essential components such as vitamin C, vitamin A (in the form of carotenoids), fiber, potassium, and the antioxidant lycopene. Consequently, the consumption of tomatoes and tomato-based products has been shown to have significant health benefits[2].

According to the Food and Agriculture Organization (FAO), annual global tomato production is estimated at approximately 123 million tons and covering an area of cultivation about 4.5 million hectares[3]. In Bangladesh, tomatoes account for 6.81% of the total cultivated area, with an average yield of 5,451 kg/acre and a total production of 368,000 tons(4). This yield is significantly lower compared to countries such as India (15.67 t/ha), Japan (52.82 t/ha), the USA (65.22 t/ha), China (30.39 t/ha), Egypt (34.00 t/ha), and Turkey (41.77 t/ha)(5). The low yield in Bangladesh is attributed to factors such as the unavailability of quality seeds of improved varieties, improper fertilizer management, inadequate irrigation, insufficient disease control, and lack of suitable pruning practices and quality of soil as well. Furthermore, excessive use of chemical fertilizers and low content of organic matter have deteriorated soil characteristics and fertility over time, and leading to increase soil acidity resulted high accumulation of heavy metals in plant tissues, which compromises the nutritional value and quality of the produce[6].

Vegetable crops, including tomatoes, require optimal growing conditions to achieve their maximum yield, and adequate fertilizer application is a key factor[7]. For decades, chemical fertilizers have been the primary means of enhancing plant productivity. However, their environmental consequences necessitate a shift towards sustainable agricultural practices that minimize their use[8]. Climate change has further compelled farmers to reconsider and improve their production systems, often in alignment with government programs targeting the Millennium Development Goals and Sustainable Development Goals[9]. Sustainable agricultural practices play a crucial role in addressing food insecurity in the context of climate change[10]. However, limited access to efficient inputs remains a significant challenge for the agricultural sector in many countries[11]. The use of organic fertilizers is increasingly being recognized as a sustainable alternative to chemical fertilizers. Organic fertilizers not only supply essential nutrients to plants but also enhance soil microbial activity and overall soil health[12]. Organic matter, rich in nitrogen (N), phosphorus (P), and potassium (K), persists longer in the soil compared to mineral fertilizers, providing sustained nutrient release. Studies have shown that optimized use of organic fertilizers contributes significantly to sustainable agriculture[13]. Key sources of organic fertilizers include composted livestock manure, plant residues[14], and industrial by-products. It is well-documented that the growth and quality of crops are influenced by a wide range of organic, inorganic, and bio-fertilizers. Farmyard manure (FYM) is one of the most widely used organic fertilizers in vegetable cultivation. The application of organic manure like FYM and vermicompost, alone or in combination with N, P, and S, has been reported to decrease soil bulk density, increase soil porosity, and enhance water-holding capacity[15]. Vermicompost, in particular, has gained popularity in integrated nutrient management due to its slow nutrient release and ability to recycle organic wastes like animal manure and poultry waste into plant-available nutrients. It provides eleven out of seventeen essential elements to the plants and microbes increase humic acid content and reducing the carbon-to-nitrogen ratio. Additionally, vermicompost contains biologically active substances, including plant growth regulators(16).

Mulching, derived from the German word *molsch* meaning 'easy to decay', has been widely practiced in vegetable cultivation since ancient times(17). Mulching involves covering the soil surface with various materials to reduce moisture loss, suppress weed growth, and improve crop yield(18). Organic mulches, such as plant residues, straw, and manure, are cost-effective and environmentally friendly options specially for vegetable production(19). Proper use of organic mulches not only enhances soil conditions but also improves crop yield and quality by mitigating unfavorable environmental factors. The utilization of organic fertilizers and mulching has been shown to increase the productivity of vegetables, including tomatoes(20). According to Naznin *et al*.(21), organic fertilizers sustain higher food quality while minimizing environmental pollution. Mulching with organic materials maintains favorable soil physical conditions, which are crucial for realizing the genetic yield potential of crops. This study aims to explore the combined effects of organic fertilizers, poultry manure, mustard oil cake, and Vermicompost with rice straw as organic mulch on the nutrient content and biomass allocation of tomato plants.

Materials and Methods

Setup of experiment: A field experiment was conducted at the net house premises of the Department of Soil, Water, and Environment, University of Dhaka, Dhaka, Bangladesh to assess the impacts of organic fertilizers alone and in combination with mulching on the nutrition and biomass allocation of Tomato plant. Soil sample was collected from a medium-high land agricultural field of Barisal series in Rahmatpur Union, Babuganj Upazila, Barishal district (Map 1), located between N 22^{o}42′ and E 90^{o}23′, within AEZ-13 named the Ganges Tidal Floodplain. The collected soil sample was placed onto the designated plot and the plot was prepared by plowing and cross-plowing and subdivided into 9 sub-plots measuring 50 × 30 cm each. The experiment was designed in a completely randomized manner, with three replications within the sub-plots.

Map 1. Location map of the sampling site at Babuganj upazila of Barishal district[22].

Two different doses of mustard oil cake (MOC), poultry manure (PM), and vermicompost (V) were applied, both individually and in combination with mulching (Mu). The treatments number and their denotations for the field experiment are described as following-

T_1 (Absolute C) = Absolute Control;

T_2 (C) = Control;

T_3 (Mu) = Mulching;

T_4 (MOC_4Mu) = Mustard oil cake @ 4 t ha^{-1} with Mulching;

T_5 (PM_4Mu) = Poultry manure @ 4 t ha^{-1} with Mulching;

T_6 (V_4Mu) = Vermicompost @ 4 t ha^{-1} with Mulching;

T_7 (MOC_8Mu_0) = Mustard oil cake @ 8 t ha^{-1} without Mulching;

T_8 (PM_8Mu_0) = Poultry manure @ 8 t ha^{-1} without Mulching;

T_9 (V_8Mu_0) = Vermicompost @ 8 t ha^{-1} without Mulching.

Transplantation: Basal doses of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) from Urea, TSP, and MoP fertilizers were applied at the rates of 80, 24, and 50 kg ha^{-1} considering soil amendments and initial nutrient contents. All organic fertilizers, phosphorus, potassium and half of nitrogen fertilizers were incorporated during final land preparation. The remaining nitrogen fertilizer were applied in two equal splits at 15 and 35 days after transplantation followed by irrigation.

Four-weeks-old healthy Tomato seedlings, measuring 15-20 cm tall with 3-5 true leaves, were transplanted into the field. Rice straw were used as mulching material, applied two weeks after planting, involved uniform spreading at 2 t ha^{-1} (300 g/subplot) of rice straw manually as soil surface cover with a thickness of approximately 3-4 cm. Calculated amounts of water were applied daily, and intercultural operations were performed as necessary. Weeds were removed manually as per requirement.

Nutrition and Biomass allocation: Primary (N, P, K) and secondary (S, Ca, Mg) nutrient contents of leaf, stem and root of Tomato plants at harvesting stage along with biomass allocation were studied. The matured plants were harvested at 90 days after transplantation (DAT), and the leaf, stem and root of the harvested plants were separated according to the individual treatments for the study. Then the samples were sun dried, cut into small pieces, oven dried, crumbed by pestles into powders and analyzed.

Nitrogen in leaf, stem and root samples were determined by micro-Kjejdhal method following H_2SO_4 acid digestion and steam distillation with NaOH. Ammonia thus collected in H_3BO_3 was determined titrimetrically(23). Powered samples were digested by means of HNO_3-$HClO_4$ acid (2:1) extracts as described by Jackson (1973)(23). The digests were cooled, filtered, dilute to 100 ml and kept in dry plastic bottles as stock solution for the determination of P, K, S, Ca and Mg. Total P content of the studied parts were determined colorimetrically by a HACH spectrophotometer at 490 nm wave lengths after developing yellow color from digest with vanadomolybdate(23). Sulfur contents were determined by the turbidity created by suspended $BaSO_4$ using Tween-80 stabilizer and the turbidity was measured by HACH spectrophotometer at 420 nm wavelength(24). The concentrations of K were recorded by flame photometer and, Ca and Mg by atomic absorption spectrophotometer (Model No. Varian-AA240).

Biomass allocation is the end result of a number of processes which take place in the plant. It starts with the way how sugars are allocated over the different organ after having been fixed by leaves in process of photosynthesis (sugar allocation)(25).

Abbreviations with a definition and the units applied here are presented below:

Abbreviation	Variables	Definition	Units
LMF	Leaf mass fraction	Leaf dry mass/total plant dry mass	$g\ g^{-1}$
RMF	Root mass fraction	Root dry mass/total plant dry mass	$g\ g^{-1}$
SMF	Stem mass fraction	Stem dry mass/total plant dry mass	$g\ g^{-1}$
R/S ratio	Shoot to root ratio	root dry mass /(leaf + stem dry mass)	$g\ g^{-1}$

Statistical Analyses

Data were analyzed using Analysis of Variance (ANOVA) and least significant differences (LSD) at a 5% significance level, steered using Microsoft Excel and Stata-14.

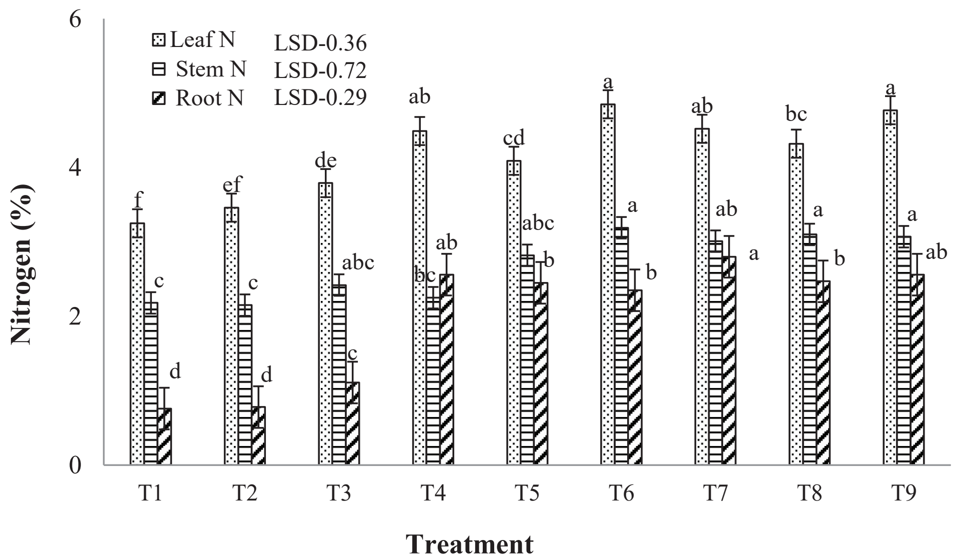
Results and Discussion

Nutrition of Tomato plant

Nitrogen: Nitrogen (N) is a major part of all amino-acids, which are the building blocks of all proteins. A good supply of N stimulates root growth and development, as well as the uptake of other nutrients[26].

The data on N contents in leaf, stem and root of Tomato plants revealed that there were significant differences (5%) among the treatments (Fig. 1). In leaf the maximum amount of N (4.77%) was found in treatment T_9 which received vermicompost at the rate of 8 t ha^{-1} without mulching whereas, in stem and root the highest values (3.10 and 2.80%) of N contents were observed in T_8 (PM_8Mu_0) and T_7 (MOC_8Mu_0), respectively. So the presented results stated that without mulching, the application of organic fertilizers i.e. mustard oil cake (MOC), poultry manure (PM) and vermicompost (V) at their higher rates significantly increase the N contents in the plant parts of Tomato although the applied fertilizers at their lower rates in combination with mulching also increased N content significantly (Fig. 1).

The least amounts (3.25% in leaf, 2.15% in stem and 0.76% in root) of N in all three parts of Tomato plants were found in the T_1 (absolute control) treatment followed by T_2 (control), respectively.



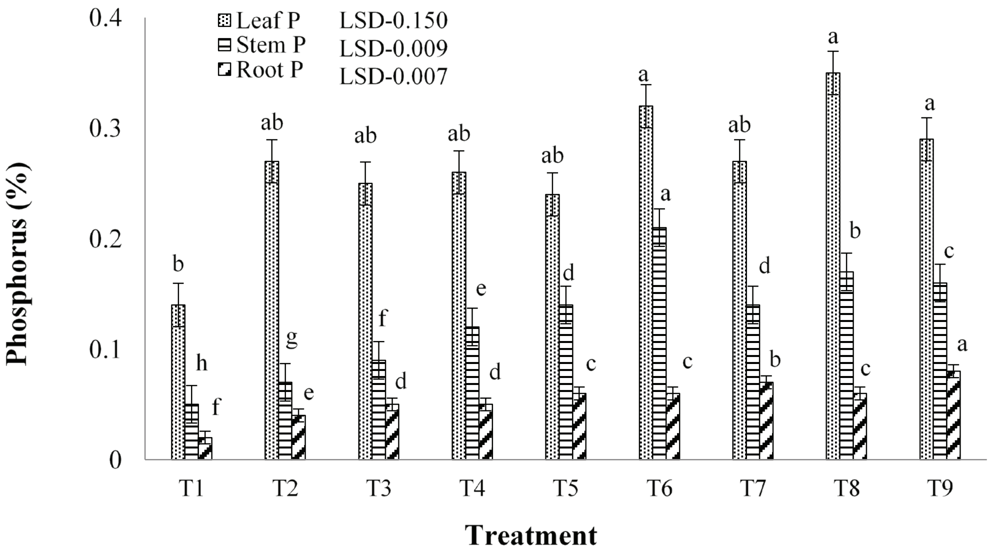
In a bar, means followed by a common letter are not significantly different at 5% level by The Duncan's New Multiple Range Test.

Fig. 1. Effects of organic fertilizers and mulching on nitrogen content (%) of Tomato plant.

Phosphorus: Adequate phosphorus nutrition enhances many aspects of plant physiology, including photosynthesis, nitrogen fixation, flowering, fruiting and maturation. Root growth is encouraged by phosphorus[27]. Significant positive (5% level) influences of the treatments on phosphorus content in different parts (leaf, stem and root) of the plant were observed in this study (Fig. 2). Among the tested parts of Tomato plant, the highest amount of P uptake was found in leaf and lowest in the roots for all the treatments.

According to the results it can be indicated that treatment T_8 (PM_8Mu_0) provided the highest P content (0.35%) in leaf part of Tomato where the statistically lowest P content (0.14%) was found in T_1 (absolute control) treatment. The maximum quantity (0.21%) of P in stem of Tomato was recorded from T_6 (V_4Mu) while T_1 (no fertilizer application) provided the lowest amount (0.05%) of phosphorus. The second lowest amount (0.07%) was found in T_2 treatment. In root the highest content (0.08%) of phosphorus was gained from T_9 (VC_8Mu_0) and the next best quantity (0.07%) was obtained for treatment T_7 (MOC_8Mu_0). The least amount of phosphorus (0.02%) was recorded in T_1 treatment.

Potassium: Of all the essential elements, potassium is the third most likely, after nitrogen and phosphorus, to limit plant productivity. For this reason, it is applied to the soils as fertilizer.



In a bar, means followed by a common letter are not significantly different at 5% level by The Duncan's New Multiple Range Test.

Fig. 2. Effects of organic fertilizers and mulching on phosphorus content (%) of Tomato plant.

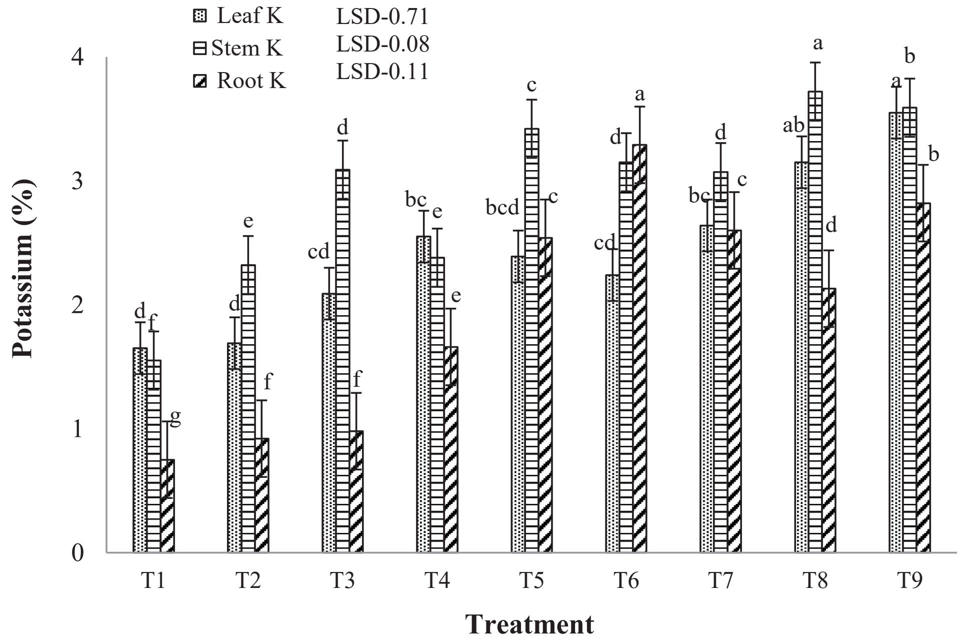
Data of potassium concentration in different parts of Tomato plant tissue as influenced by different treatments are presented in figure 3 which revealed that the stem part contain the maximum amount of K than leaf and root of the tested variety of Tomato plant.

In the portion of leaf, the highest average potassium content (3.55%) was recorded in treatment T_9 (VC_8Mu_0) and the lowest amount of potassium (1.65%) was recorded in treatment T_1 (absolute control) and next least amount (1.69%) was found in T_2 (control) treatment, respectively.

In stem part of the plant, treatment T_8 (PM_8Mu_0) exhibited the maximum K content (3.72%) and the next highest amount of K (3.59%) was observed in T_9 (VC_8Mu_0) while T_1 (absolute control) produced the least amount (1.55%) of total potassium followed by T_2 (1.59%).

Potassium contents in roots varied significantly due to the application of the treatments. The best value (3.29% K) was found from T_6 (V_4Mu) and the least value (0.75% K) of total potassium content was gained from T_1 treatment which received no doses and types of fertilizers.

Sulfur: Sulfur moves in soil and plant mostly in anionic form. The vitamins biotin, thiamine, and B_1 contain sulfur, as do many protein enzymes regulate photosynthesis and nitrogen fixation[28].



In a bar, means followed by a common letter are not significantly different at 5% level by The Duncan's New Multiple Range Test.

Fig. 3. Effects of organic fertilizers and mulching on potassium content (%) of Tomato plant.

There was statistically significant difference (5%) in sulfur content of Tomato leaf due to different treatments (Table 1). Maximum quantity (0.27% S) was recorded in treatment T_9 and the second highest value (0.23% S) was recorded in treatments T_6 and T_7. The lowest sulfur (0.13%) was recorded in treatment T_1 receiving no fertilizer. The highest sulfur content (0.24%) in stem was observed in treatment $T_{6,}$ which received 4 t ha^{-1} vermicompost with mulching. Second highest value (0.15%) was recorded in treatment T_5 (MOC_4Mu). The least sulfur content (0.10%) was found in treatment T_1 with no fertilizer addition.

Table 1. Effects of organic fertilizers and mulching on sulfur content (%) in leaf, stem and root of Tomato plant

Treatment		Sulfur content (%)					
No.	Denotation	Leaf	IOC (%)	Stem	IOC (%)	Root	IOC (%)
T_1	Absolute C	0.13 e		0.10 b		0.18 d	
T_2	Control (C)	0.16 de	0	0.11 b	0	0.31 cd	0
T_3	Mu	0.16 de	0	0.14 b	27	0.29 cd	-6
T_4	MOC_4Mu	0.18 cd	13	0.12 b	9	0.49 ab	58
T_5	PM_4Mu	0.23 ab	44	0.15 b	36	0.49 ab	58
T_6	VC_4Mu	0.23 ab	44	0.24 a	118	0.42 bc	35
T_7	MOC_8Mu_0	0.22 bc	38	0.21 a	91	0.51 ab	65
T_8	PM_8Mu_0	0.21 ab	31	0.21 a	91	0.57 a	84
T_9	VC_8Mu_0	0.27 a	69	0.23 a	109	0.61 a	97
LSD (5%)		**0.039**	-	**0.046**	-	**0.13**	-

In a bar, means followed by a common letter are not significantly different at 5% level by The Duncan's New Multiple Range Test.

In root part of Tomato significant difference was in the sulfur amount due to different treatments. The maximum average sulfur (0.61%) was registered in treatments T_9 followed by T_7 (0.51% S). The minimum sulfur (0.18%) was registered in treatments T_1, the second lowest amount (0.29% S) was found in treatment T_3 (Mulching).

Calcium: Calcium is responsible for holding together the cell walls of plant. Calcium plays an important role in plant growth and nutrition. The data on calcium content of Tomato plant exhibited that there was significant difference (5%) among the treatments (Table 2).

Table 2. Effects of organic fertilizers and mulching on calcium content (%) in leaf, stem and root of Tomato plant

Treatment		Calcium content (%)					
No.	Denotation	Leaf	IOC (%)	Stem	IOC (%)	Root	IOC (%)
T_1	Absolute C	0.48 g		0.26 i		0.20 i	
T_2	Control (C)	0.61 f	0	0.38 h	0	0.27 g	0
T_3	Mu	0.56 f	-8	0.76 g	100	0.25 h	-7
T_4	MOC_4Mu	0.84 e	38	0.88 f	132	0.56 e	107
T_5	PM_4Mu	0.86 e	41	0.97 d	155	0.49 f	81
T_6	VC_4Mu	1.61 c	164	0.93 e	145	1.02 b	278
T_7	MOC_8Mu_0	1.28 d	110	1.04 b	174	0.60 d	122
T_8	PM_8Mu_0	1.68 b	175	1.06 a	179	0.92 c	241
T_9	VC_8Mu_0	1.89 a	210	1.00 c	163	1.10 a	307
LSD (5%)		**0.065**	-	**0.007**	-	**0.017**	-

In a bar, means followed by a common letter are not significantly different at 5% level by The Duncan's New Multiple Range Test.

In leaf the maximum amount (1.89%) of Ca was found in treatment T_9. In stem the highest value (1.06%) was observed in T_8 whereas in root best quantity (1.10%) was found in T_9. The least amount (0.84%) of calcium in leaf of Tomato was obtained from treatment T_1. The lowest value (0.26 and 0.20 %) of Ca in stem and in root was also found in the treatment T_1 (absolute control).

Magnesium: The most important role of magnesium is as the central atom in the chlorophyll molecule. Chlorophyll is the pigment that gives the plants their green color and carries out the process of photosynthesis. With respect to different treatments, magnesium content of leaf was significantly higher (1.00%) in treatment T_8 (PM_8Mu_0) followed by treatment T_6 (VC_4Mu) while the lowest magnesium content (0.32%) was recorded in treatment T_1 (Table 3).

In stem the maximum quantity (0.76%) of magnesium was recorded in treatment T_8 (PM_8Mu_0) followed by treatments T_9 (VC_8Mu_0). The lowest (0.16%) magnesium in Tomato stem was recorded in absolute control treatment. In the roots of Tomato the total magnesium content was significantly different due to different treatments. The maximum (0.54%) magnesium was recorded in treatments T_8 (PM_8Mu_0), the second best value (0.52%) was found in treatment T_9 (VC_8Mu_0) while the lowest amount (0.14%) was recorded in control plot (Table 3). In all the parts of Tomato plant, the treatment poultry manure at the rate of 8 t ha^{-1} exerted the highest results, where magnesium contents increased 186, 300 and 286 % in leaf, stem and root, respectively as compared to the control treatment.

Table 3. Effects of organic fertilizer and mulching on magnesium content (%) in leaf, stem and root of Tomato plant

Treatment		Magnesium content (%)					
No.	Denotation	Leaf	IOC (%)	Stem	IOC (%)	Root	IOC (%)
T_1	Absolute C	0.32 i		0.16 e		0.15 g	
T_2	Control (C)	0.35 h	0	0.19 e	0	0.14 g	0
T_3	Mu	0.41 g	17	0.26 d	37	0.19 f	36
T_4	MOC_4Mu	0.54 f	54	0.30 d	58	0.33 d	136
T_5	PM_4Mu	0.61 e	74	0.31 d	63	0.25 e	79
T_6	VC_4Mu	0.97 b	177	0.54 c	184	0.40 b	186
T_7	MOC_8Mu_0	0.66 d	89	0.62 b	226	0.37 c	164
T_8	PM_8Mu_0	1.00 a	186	0.76 a	300	0.54 a	286
T_9	VC_8Mu_0	0.88 c	151	0.71 a	274	0.52 a	271
LSD (5%)		**0.012**	**-**	**0.07**	**-**	**0.022**	**-**

In a bar, means followed by a common letter are not significantly different at 5% level by The Duncan's New Multiple Range Test.

Biomass allocation: The fraction of whole-plant mass represented by leaves increases most strongly with nutrients and decreases mostly with light. The data on leaf mass fraction

(LMF) of Tomato plants are presented in table 5 which reveals that LMF was maximum (0.55 g g^{-1}) in treatment T_5 (PM_4M_u)) and the opposite (0.24 g g^{-1}) was in treatment T_1.

The main function of stem is to support and transport resources. The values of stem mass fraction (SMF) are presented in table 4. The maximum stem mass fraction (0.57 g g^{-1}) was detected in Tomato plant receiving treatment T_1 (absolute control) followed by treatment T_4 (MOC_4Mu). The minimum value (0.31 g g^{-1}) was found in treatment T_5 (PM_4Mu).

Table 4. Effects of organic fertilizers and mulching on LMF, SMF, RMF and R/S ratio (g g-1) of Tomato plant

Treatment		#LMF	SMF	RMF	R/S ratio
No.	Denotation	(g g^{-1})	(g g^{-1})	(g g^{-1})	(g g^{-1})
T_1	Absolute C	0.24 f	0.57 a	0.19 b	0.23 b
T_2	Control (C)	0.36 e	0.42 cd	0.21 a	0.27 a
T_3	Mu	0.47 bcd	0.44 c	0.08 f	0.09 e
T_4	MOC_4Mu	0.42 cde	0.51 b	0.07 g	0.07 f
T_5	PM_4Mu	0.55 a	0.31 e	0.13 e	0.15 d
T_6	VC_4Mu	0.49 abc	0.38 d	0.13 e	0.15 d
T_7	MOC_8Mu_0	0.41 de	0.43 c	0.16 c	0.19 c
T_8	PM_8Mu_0	0.37 e	0.49 b	0.14 d	0.16 d
T_9	VC_8Mu_0	0.51 ab	0.40 cd	0.08 f	0.09 e
LSD (5%)		**0.23**	**0.04**	**.003**	**0.01**

#LMF = Leaf Mass Fraction; SMF = Stem Mass Fraction; RMF = Root Mass Fraction; R/S = Root/Shoot

In a bar, means followed by a common letter are not significantly different at 5% level by The Duncan's New Multiple Range Test.

The main function of root is to uptake nutrient and water and anchoring. In the studied Tomato plant root mass fraction (RMF) was maximum (0.21 g g^{-1}) in treatment T_2 (control)) and the minimum value (0.07 g g^{-1}) was recorded from treatment T_3 (Table 4) which contained the sole application of mulching.

Root-shoot is the part of plant tissues that have supportive functions to the amount of those that have growth functions. The root-shoot ratio of Tomato plants was significantly different (5% level) due to the application of organic fertilizers and mulching. The maximum (0.27 g g^{-1}) root-shoot ratio was obtained from treatment T_2 (control) and the minimum (0.07 g g^{-1}) root-shoot ratio was obtained from treatment T_4 (MOC_4Mu).

The partitioning of photo assimilate between roots and shoots has frequently been analyzed as a balance between roots and shoot activity(29). There is an interdependence of shoot and root for growth and development. The shoot relies on the root for water and nutrients, while the roots depend on the shoot for carbohydrates(30). Root growth is closely related to the whole plant growth. This relationship is called "allometry" or relative growth[31]. Growth rates of roots and shoots during vegetation period continually adjust to environmental conditions and "genetic program" of plant growth and development. In case of the high value of this ratio, there is with large probability a possibility to absorb more nutrients from the soil and this will help in increasing above-ground biomass and probably also increases resistance to the stresses[32]. But plenty of concurrently evaluated other features are important, depth of root penetration and their distribution into the soil, the reaction to transient drought, root initial growth, etc. In many plant species increasing nutrient supplies in the soil may also decrease root length but increase root weight in a quadratic fashion. The bigger plant will have a different root: shoot ratio than a smaller plant. Thus differences in root: shoot ratios might be from the physiological view deceiving[33,34].

Having much importance of vegetables as economic, nutritional, medicinal and industrial, and also employment opportunities, their production is a costly enterprise as it requires heavy cultural practices such as irrigation, weeding, fertilizers and protection from biotic and abiotic stresses. To improve the productivity of vegetables by reducing number of irrigation and chemical inputs for weed control, mulch may be a good alternative of conventional cultivation practice[35]. Tomatoes are a globally cultivated and popular vegetable. In accordance with mulching the output and quality of tomatoes were significantly influenced by the use of organic fertilizers in greenhouse production[36]. An experimental data revealed that significant increase in growth; yield and TSS on BARI hybrid tomato 8 were observed due to foliar application of vermicompost and mustard oil cake[37]. Organic mulches such as compost, sawdust, grass clippings, straw, and newspaper play significant roles in soil temperature regulation, moisture conservation, soil structure improvement, erosion prevention, and crop nutrition enhancement. Understanding the types, application depths, and precautions associated with organic mulches aids in optimizing agricultural productivity and sustainability[38]. Therefore, the impacts of low-cost, eco-friendly, and biodegradable mulching materials on soil microbes, nutrient balance, plant growth, and soil erosion should be explored in the future[39].

Conclusion

New environmentally friendly farming methods are essential for producing food sustainably. The combination of mulching and organic fertilizers has proven to be an effective strategy for optimizing the crop-growing environment. This approach increases yield and enhances product quality by controlling weed growth, regulating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure, and increasing organic matter content. The present study demonstrated that the application of organic fertilizers, viz. poultry manure, mustard oil cake, and Vermicompost alone and in combination with straw as organic mulch significantly influenced the primary and secondary nutrient content and biomass allocation of the studied tomato variety. The highest doses of organic fertilizers without mulching produced comparatively better results for the nutrient content (N, P, K, S, Ca and Mg) in the leaf, stem, and root of tomato plants. Beyond the nutrient supply from the treatments, other factors such as root penetration depth, distribution in the soil, response to transient drought, and initial root growth also played crucial roles in influencing root weight. Thus, while root-to-shoot ratios are useful, they should be considered alongside other physiological and environmental factors to provide a comprehensive understanding of plant growth dynamics.

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