

Effect of Silkworm Pupa Compost on Growth, Yield and Nutrient Content in Maize (*Zea mays* L.)

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ABSTRACT

A pilot study entitled 'Effect of Silkworm pupa compost on Growth, Yield and nutrient content in Maize (*Zea mays* L.)' productivity was conducted to evaluate the potential of silkworm pupa, a byproduct of sericulture, as a sustainable organic fertilizer. Five different silkworm pupa compost was applied at 10 t/ha along with 100 and 75 per cent of the recommended fertilizer dose and its impact on maize growth, yield and nutrient content was analyzed. The experiment consisted of 12 treatments, which were replicated thrice. The results revealed that silkworm pupa compost significantly enhanced maize growth, yield and nutrient content (nitrogen, phosphorus and potassium). The highest increase in yield was observed in the T₁₁ (100% RDF + C5 @ 10t/ha) compost treatment, with a notable improvement in plant height (226.82 cm), number of leaves (12.45), dry matter accumulation (164.84 g plant⁻¹) and leaf area (6719.43 cm²). Similar results were noticed with respect to yield parameters of maize such as cob length (22.57cm), cob girth (21.06 cm), number of kernel rows per cob (17.02), number of kernels per row (35.59), test weight (36.10 g), kernel yield (84.15 q ha⁻¹), stover yield (92.81 q ha⁻¹). Nutrient analysis revealed that maize plants receiving 100% RDF + C5 @ 10t/ha (T₁₁) exhibited higher N (1.27 and 0.87%), P (0.25 and 0.21%) and K (1.20 and 1.38%) content in both the kernel and stover of maize. These findings suggest that silkworm pupa compost not only improves maize growth and productivity but also provides a nutrient-rich alternative to conventional chemical fertilizers.

Keywords : Growth, Yield, Nutrient content, Organic fertilizer, Sustainable agriculture

THE increasing demand for sustainable agricultural practices has led to the exploration of organic fertilizers as alternatives to synthetic inputs. Among these, silkworm pupa compost (SPC) has gained attention due to its nutrient-rich composition and potential to improve crop growth and yield. Silkworm pupae, a by-product of the sericulture industry, are typically discarded or used for limited purposes such as animal feed. However, converting these pupae into compost provides an opportunity to recycle waste

while offering a valuable organic amendment for soil (Saha and Bandyopadhyay, 2014).

SPC is rich in essential macro and micronutrients such as nitrogen (N), phosphorus (P), potassium (K) and trace elements like zinc, iron and calcium, all of which are crucial for plant growth (Liu *et al.*, 2021). Organic fertilizers like SPC improve soil fertility by increasing organic matter content, enhancing soil structure and promoting microbial activity. This makes SPC an ideal

candidate for improving the growth and yield of crops, particularly maize (*Zea mays*), a staple food crop widely grown around the world.

Maize is a highly nutrient-demanding crop and its productivity is often limited by nutrient deficiencies, particularly in soils with low organic matter content. The application of organic amendments, such as SPC, has shown to enhance maize growth, increase nutrient uptake and improve yield potential. Research has indicated that silkworm pupa compost could enhance the root development, plant height and overall vigor of maize plants by providing a balanced supply of nutrients (Saha *et al.*, 2016). Additionally, SPC may improve the nutritional quality of maize, addressing concerns related to micronutrient deficiencies in maize grains, which is a common issue in many developing regions (Khair *et al.*, 2022).

Several studies have demonstrated the positive effects of organic fertilizers on maize growth, but there is limited research on the specific impact of silkworm pupa compost on maize productivity and nutrient content. This gap in the literature highlights the need for studies focused on the application of SPC in maize cultivation (Singh *et al.*, 2020a). By investigating the impact of SPC on maize growth, yield and nutrient content, this research aims to provide insights into the potential benefits of SPC as a sustainable, organic fertilizer. The findings could help farmers to improve maize production while promoting environmental friendly agricultural practices.

MATERIAL AND METHODS

Details of Silkworm Pupa Compost

The composts in the field had been produced at the College of Agriculture, V.C Farm, Mandya. The experiment was conducted over the course of 90 days, from February 2023 to May 2023.

Materials used in Composting

The main raw materials used in the preparation of composts were FYM (farm yard manure), silkworm pupae, waste decomposer and cow dung slurry.

Silkworm pupae were obtained from a reeling unit, Ramanagara district. Waste decomposer, Farm yard manure and Cow dung was obtained from the field unit, Department of Agronomy, COA, V C. Farm, Mandya. Slurry was prepared by adding 100 g of cow dung/ 1 liter of water. Compost was prepared in compost pits of size 7 m X 4 m X 3 m (length X breadth X height). The experiment was done during the period from Feb 2023 to May 2023 (90 days).

Requirements for Silkworm Pupa Compost Preparation

Silkworm pupae waste	1 Part
Partially decomposed farm waste	4 Part, 2 Part
Cow dung slurry	@ 10 % w/w
Waste decomposer	@ 5kg/t, 10kg/t of farm waste

Treatments Details for Silkworm Pupa Composting

- C1 - Partially decomposed farm waste + silkworm pupae (4:1) + cow dung slurry
- C2 - Partially decomposed farm waste + silkworm pupae (4:1) + cow dung slurry + waste decomposer (5kg/t)
- C3 - Partially decomposed farm waste + silkworm pupae (2:1) + cow dung slurry + waste decomposer (5kg/t)
- C4 - Partially decomposed farm waste + silkworm pupae (4:1) + cow dung slurry + waste decomposer (10 kg/t)
- C5 - Partially decomposed farm waste + silkworm pupae (2:1) + cow dung slurry + waste decomposer (10 kg/t)

Four pits were used to replicate the composting process, which lasted three months. Once every 30 days, the decomposing materials were turned. Throughout the entire composting process, turnings were made. By the 90th day, the compost was ready, and it was used for field evaluation by using Maize as a test crop.

Evaluation of Silkworm Pupa Composts in the Field

The experiment was carried out in the *kharif* 2023 at COA, V. C. Farm, Mandya, which is located at 12°34' North latitude and 76° 49' East longitude with an altitude of 695 meters above mean sea level in the southern Dry Zone of Karnataka. The texture of the soil at the experimental site was Red Loamy sand. The investigation was conducted in RCBD with 12 treatments that were replicated three times (Table 3). The individual gross plot size was 3 X 4 m.

Maize (*Zea mays*) was utilised as the test crop; the variety used here is 'MAH14-05' with a spacing of

60 X 20 cm. For optimal crop nutrition, integrate 10 t/ha of silkworm pupa compost and 10 t/ha of FYM along with chemical fertilizer supplying 150 kg N, 75 kg P₂O₅ and 40 kg K₂O per hectare. Timely required cultural practices like weeding and irrigation were given as crop maintenance. The NPK content of FYM was 0.5, 0.19 and 0.48 per cent.

Observation Recorded

At 30, 60, 90 DAS and at harvest, morphological observations such as plant height (cm), number of leaves, leaf area and total dry matter production (g plant⁻¹) were noted. Based on the yield from each net plot, the amount of grain and straw was estimated and expressed as q ha⁻¹. Following the suggested set

TABLE 1
Initial physico-chemical properties of experimental site

Parameter	Value	Analytical method
<i>Physical properties</i>		
Sand (%)	84.75	International pipette method
Silt (%)	5.72	
Clay (%)	9.53	
Textural class	Red Loamy sand	
<i>Chemical properties</i>		
pH (1:2.5)	7.21	Potentiometric method Jackson (1973)
EC (dSm ⁻¹)	0.21	Conductometric method Jackson (1973)
Organic carbon (g kg ⁻¹)	4.98	Wet oxidation method (Walkley and Black, 1934)
Available N (kg ha ⁻¹)	295	Kjeldahl nitrogen method (Subbiah and Asija 1956).
Available P ₂ O ₅ (kg ha ⁻¹)	23.82	Olsen's extractant method, Colorimetry using ascorbic acid reagent (Olsen <i>et al.</i> , 1954)
Available K ₂ O (kg ha ⁻¹)	186	Ammonium acetate extractant method, Flame photometry (Jackson, 1973)
Exchangeable Ca (cmol (p ⁺) kg ⁻¹)	5.9	
Exchangeable Mg (cmol (p ⁺) kg ⁻¹)	4.21	
Available S (mg kg ⁻¹)	14.54	0.15 % CaCl ₂ extractable method (Williams and Steinberg, 1959)
DTPA Fe (mg kg ⁻¹)	15.16	Atomic absorption spectrophotometry (Lindsay and Norvell, 1978)
DTPA Zn (mg kg ⁻¹)	0.65	
DTPA Mn (mg kg ⁻¹)	8.4	
DTPA Cu (mg kg ⁻¹)	0.69	
B (mg kg ⁻¹)	0.17	Azomethine-H reagent (John <i>et al.</i> , 1975)

TABLE 2
Chemical properties of the mature SPC

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)
C1	1.41	0.69	1.25	2.16	1.18	0.60	468.06	147.00	116.94	43.04
C2	1.48	0.79	1.37	2.21	1.23	0.68	475.11	151.32	120.22	44.57
C3	1.87	0.94	1.48	2.31	1.27	0.75	492.57	161.96	150.72	49.19
C4	1.52	0.84	1.39	2.24	1.25	0.70	482.37	153.36	134.06	47.24
C5	1.90	0.96	1.51	2.32	1.29	0.76	493.90	162.82	169.55	52.46

of practices allowed the crop to be maintained and plant samples were obtained at random to assess the crop's nutrient content at harvest. Then randomly selected destructive plant samples were taken to determine the nutrient content of crop at harvest, washed and rinsed with distilled water and dried in an oven at 60 °C to constant weight. Further nutritional analysis was carried out using the same samples.

Nutrient Analysis of Kernal and Stover of Maize

Both the kernal and stover of maize were examined for major (N, P, K, Ca, Mg and S) and micronutrients (Fe, Mn, Zn and Cu). A modified micro Kjeldahl method and a Vanadomolybdate yellow colour method, respectively, were used to evaluate the

nitrogen (N) and phosphorus (P) contents of straw and grain (Jackson, 1973). Potassium (K) content of grain and straw was estimated by flame photometric method and the titration method was adopted for the estimation of calcium (Ca) and magnesium (Mg). The turbidimetric approach was used to estimate the sulphur (S) content (Bradsley and Lancaster, 1965). Micronutrient samples (Fe, Mn, Zn and Cu) were measured using an atomic absorption spectrophotometer (AAS) after being initially digested using a di-acid mixture containing HClO₄ and HNO₃ in 9:4 ratio (Lindsay and Norwell, 1978) and same analytical methods were used for FYM and SPC (Table 2). The data was statistically analysed using Gomez and Gomez's (1984) methodology.

TABLE 3
Treatment details for maize

T ₁	:	100 % RDF + FYM @ (10t/ha)
T ₂	:	75 % RDF + FYM @ (10t/ha)
T ₃	:	100 % RDF + C1 @ (10t/ha)
T ₄	:	75 % RDF + C1 @ (10t/ha)
T ₅	:	100 % RDF + C2 @ (10t/ha)
T ₆	:	75 % RDF + C2 @ (10t/ha)
T ₇	:	100 % RDF + C3 @ (10t/ha)
T ₈	:	75 % RDF + C3 @ (10t/ha)
T ₉	:	100 % RDF + C4 @ (10t/ha)
T ₁₀	:	75 % RDF + C4 @ (10t/ha)
T ₁₁	:	100 % RDF + C5 @ (10t/ha)
T ₁₂	:	75 % RDF + C5 @ (10t/ha)

*RDF : Recommended dose of fertilizers
(150: 75: 40 N : P₂O₅ : K₂O kg/ha)

RESULTS AND DISCUSSION

Effect of Silkworm Pupa Compost on Growth and Yield of Maize

Growth Parameters of Maize

Plant Height (cm)

The plant height at different growth stages of maize as influenced by SPC is presented in Fig. 1. Plant height of maize varied significantly at 30, 60, 90 DAS and at harvest as influenced by different rates of RDF and SPC. Application of 100% RDF + C5 @ 10 t ha⁻¹ (C5 which received PD-FYM + silkworm pupae (2:1) + cow dung slurry + waste decomposer @ 10 kg/t) recorded significantly higher plant height (73.30, 173.15, 221.82 and 226.82 cm at 30, 60, 90 DAS and at harvest, respectively) and

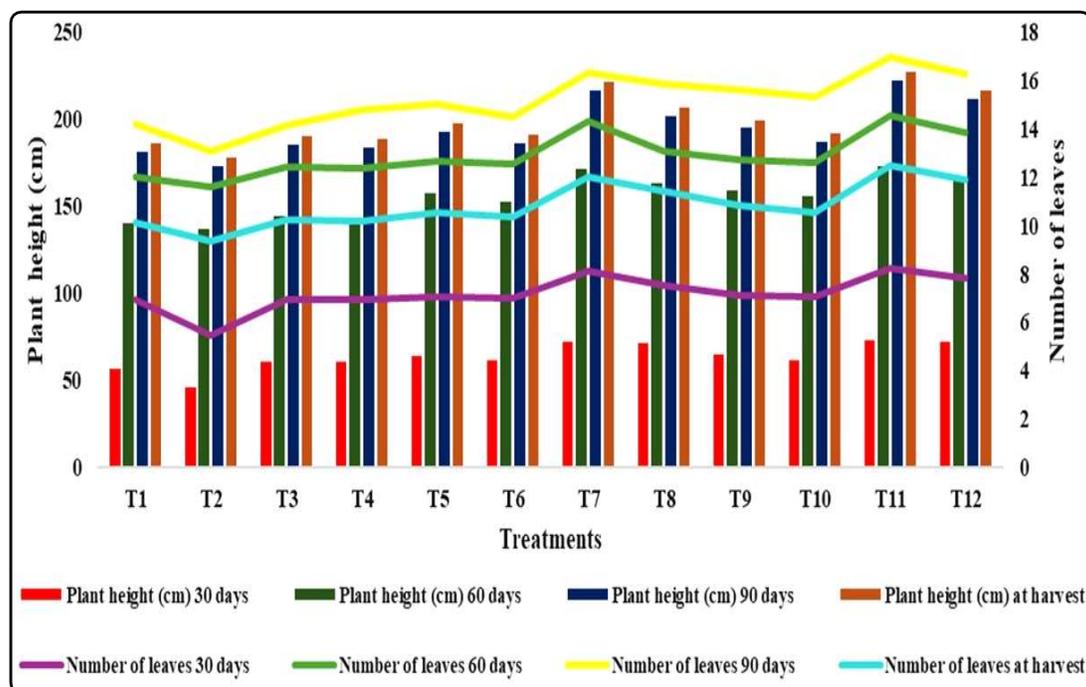


Fig. 1 : Effect of silkworm pupa compost on plant height and number of leaves of maize

was found to be on par with the treatment T_7 (72.29, 171.09.15, 216.42 and 221.82 cm at 30, 60, 90 DAS and at harvest, respectively) which received 100% RDF + C3 @ 10 t ha⁻¹. Lower plant height was recorded in treatment T_2 (45.75, 136.86, 172.69 and 177.66 cm at 30, 60, 90 DAS and at harvest, respectively) which received 75% RDF + FYM @ (10 t ha⁻¹).

Number of Leaves

At 30 DAS, treatment with 100% NPK through recommended dose of fertilizers (RDF) C5 @ (10 t ha⁻¹) (T_{11}) recorded significantly maximum number of leaves (8.22) and was on par with T_7 : 8.13 *i.e.* 100% RDF C3 @ 10 t ha⁻¹, T_{12} : 7.83 *i.e.* 75% RDF + C5 @ 10 t ha⁻¹ and T_8 : 7.55 (75% NPK through RDF + C3 @ 10 t ha⁻¹). Lower number of leaves at 30 days was observed in treatment T_2 (5.46) which received 75% RDF + FYM @ (10 t ha⁻¹).

At 60 DAS, 90 DAS and at harvest significantly maximum number of leaves (60 DAS: 14.54, 90 DAS: 16.97 and at harvest: 12.45) was recorded in 100% NPK through recommended dose of fertilizers (RDF)

and SPC through C5 @ 10 t ha⁻¹ and it was found to be on par with treatment T_7 (14.32, 16.30 and 12.02 at 60, 90 DAS and at harvest, respectively) T_{12} (13.81, 16.23 and 11.88 at 60, 90 DAS and at harvest, respectively) and T_8 (13.08, 15.84 and 11.43 at 60, 90 DAS and at harvest, respectively) compared to other treatments. Significantly minimum number of leaves (60 DAS: 11.58, 90 DAS: 13.04 and at harvest: 9.35) was noticed in treatment T_2 .

The increase in plant height of maize after the application of SPC can be attributed to the rich nutrient profile of the compost (Table 2), particularly its high nitrogen content. Nitrogen is a critical element for plant growth, as it plays a key role in the synthesis of chlorophyll, which is essential for photosynthesis. This process boosts energy production, enabling the plant to grow more vigorously. SPC also provides other important nutrients such as phosphorus, potassium and micronutrients, which contribute to enhanced root development and overall plant vitality. The organic matter in the compost improves soil structure, aeration and moisture retention, creating a favorable environment for maize roots to access

nutrients and water more efficiently. This combination of nutrient availability promotes stronger, healthier growth, leading to an increase in plant height. Similar results were obtained by Ashwini *et al.* (2015). Combination of SPC and inorganic sources which ensured ready availability of nutrients at initial stages of crop through inorganic sources and long-term nutrient availability through SPC. These results are in line with the findings of Narolia *et al.* (2009).

Organic manures have been recognized for their beneficial effects on crop production for a long time, as soil organic matter is a vital source of nearly all essential nutrients required by plants (Renu, 2009). The application of organic manure leads to vigorous plant growth and an increased number of leaves, due to favorable conditions, improved nutrient availability, and slow nutrient release. Furthermore, integrating organic manures, such as SPC and farmyard manure, with mineral fertilizers results in a substantial increase in maize growth and leaf production (Sarwar *et al.*, 2008; Buri *et al.*, 2012 and Ashwini *et al.*, 2015).

Leaf Area (cm²)

A similar trend of results was noticed with respect to leaf area of maize. The different treatments differed

significantly with respect to leaf area at different stages of crop growth. Significantly higher leaf area was observed in treatment T₁₁ (100% RDF+ C5 @ 10 t ha⁻¹) at all stages of growth (2434.27, 6552.59, 7096.11 and 6719.43 cm²) at 30, 60, 90 days and at harvest respectively. Lower number of leaf area were recorded in T₂ (75% NPK through RDF + FYM @ 10 t ha⁻¹) 1980.46, 3988.07, 4398.25 and 4021.57 cm² at 30, 60, 90 DAS and at harvest respectively as depicted in Table 4.

Dry Matter Accumulation (g plant⁻¹)

As the crop approaches harvest stage, the total dry matter production increased substantially from 30 to 90 DAS and there after the increase was marginal at harvest. There was a significant difference in total dry matter production maize as influenced by different SPC treatments. The treatment with 100% RDF along with C5 @10 tha⁻¹ (T₁₁) (13.99 g plant⁻¹: 30 DAS, 131.16 g plant⁻¹: 60 DAS, 151.89 g plant⁻¹: 90 DAS and 164.84 g plant⁻¹: at harvest) over the treatment with 75% RDF+ FYM @10 t ha⁻¹ (T₂) (7.32g plant⁻¹: 30 DAS, 91.31 g plant⁻¹: 60 DAS, 106.04g plant⁻¹: 90 DAS and 118.19g plant⁻¹: at harvest) and T₁₁ was found to be on par with T₇ (100% RDF + C3 @ 10 t ha⁻¹), T₁₂ (75% RDF + C5 @ 10 t ha⁻¹) and T₈ (75% RDF+ C3 @10 t ha⁻¹).

TABLE 4
Effect of silkworm pupa compost on leaf area and dry matter accumulation of maize

Treatments	Leaf area (cm ²)				Dry matter accumulation (g ⁻¹ plant)			
	30 days	60 days	90 days	At harvest	30 days	60 days	90 days	At harvest
T ₁ - 100 % RDF + FYM @ (10t/ha)	2043.94	4062.16	4605.68	4229.00	9.66	97.58	118.31	131.26
T ₂ - 75 % RDF + FYM @ (10t/ha)	1980.46	3988.07	4398.25	4021.57	7.32	91.31	106.04	118.99
T ₃ - 100 % RDF +C1 @ (10t/ha)	2133.87	4667.14	5210.66	4833.98	11.23	103.15	123.88	136.83
T ₄ - 75 % RDF +C1 @ (10t/ha)	2080.87	4253.19	4796.71	4420.03	10.65	99.82	120.55	133.50
T ₅ - 100 % RDF + C2 @ (10t/ha)	2247.31	5656.13	6199.65	5822.97	11.81	118.33	133.39	146.34
T ₆ - 75 % RDF + C2 @ (10t/ha)	2185.81	5077.14	5620.66	5243.98	11.25	110.09	130.82	143.77
T ₇ - 100 % RDF + C3 @ (10t/ha)	2425.84	6466.29	7009.81	6633.13	13.58	127.89	148.62	161.57
T ₈ - 75 % RDF + C3 @ (10t/ha)	2353.61	5850.83	6594.35	6017.67	12.51	123.41	139.14	152.09
T ₉ - 100 % RDF + C4 @ (10t/ha)	2292.95	5785.23	6228.75	5852.07	12.27	119.48	136.04	150.49
T ₁₀ - 75 % RDF + C4 @ (10t/ha)	2205.91	5383.19	5926.71	5550.03	11.33	115.49	131.55	144.50
T ₁₁ - 100 % RDF + C5 @ (10t/ha)	2434.27	6552.59	7096.11	6719.43	13.99	131.16	151.89	164.84
T ₁₂ - 75 % RDF + C5 @ (10t/ha)	2385.32	6262.29	6805.81	6429.13	12.75	125.06	142.46	155.41
S.EM±	32.23	232.37	272.26	257.12	0.55	3.26	5.08	4.54
CD at 5%	101.54	731.63	798.53	754.10	1.63	10.27	15.26	14.32

The increase in leaf area of maize after the application of SPC is primarily due to the compost's nutrient richness, particularly in nitrogen, phosphorus and potassium, which are crucial for vigorous leaf development. Nitrogen stimulates the production of proteins and enzymes that drive cellular growth and division, resulting in larger and more numerous leaves. Phosphorus, on the other hand, enhances energy transfer and root development, allowing the plant to uptake more nutrients and water, which supports expansive leaf growth. Potassium regulates water movement in plant cells and improves photosynthetic efficiency, leading to healthier, larger leaves. Additionally, the organic matter in SPC improves soil texture and water retention, ensuring that the maize plants have consistent access to moisture and nutrients, which are vital for maximizing leaf surface area. This enhanced leaf area increases the plant's photosynthetic capacity, further boosting its overall growth and productivity. Similar results were noticed with Heenkande, 2008.

The sufficient availability of nutrients from RDF, combined with the effective application of SPC throughout the growing season, likely enhanced the soil's nutrient-supplying capacity. The crop's strong initial growth and continued improvement in growth with increasing NPK levels suggest that the nutrients were effectively utilized. The higher nutrient availability in the soil, facilitated by the mineralization of organic manures and improved soil properties, likely contributed to greater dry matter production compared to the control. Similar results were obtained by Guggari & Kalaghatagi (2001) and Rajamani (2009).

Yield Parameters and Yield of Maize

Cob Length (cm) and Cob Girth (cm)

The data on length and girth of cob of maize as influenced by SPC are presented in Table 5. Variations in length and girth of cob were found to be significant with the compost application. Maximum cob length and cob girth was recorded with the application of 100% RDF + C5 @ 10 t ha⁻¹ (T₁₁-22.57 and 21.06 cm, respectively) and it was found on par with the

treatment 100 % RDF + C3 @ 10 t ha⁻¹ (T₇-21.27 and 20.76 cm, respectively), 75 % RDF + C5 @ 10 t ha⁻¹ (T₁₂-20.87 and 20.36, respectively) and 75% RDF + C3 @ 10 t ha⁻¹ (T₈- 20.43 and 19.93 cm, respectively) and followed by T₉, T₅, T₁₀, T₆, T₃ and T₄. The application of SPC improves cob length and girth in maize due to its high nutrient content, particularly nitrogen, phosphorus and potassium. These nutrients enhance soil fertility, promote root growth, improve water and nutrient uptake, leading to better plant growth and cob development. The compost also enhances microbial activity, improving soil structure and nutrient cycling, which directly impacts maize yield (Chandra *et al.*, 2023). SPC application at 100 % RDF + C5 @ 10 t ha⁻¹ having total nitrogen of 1.90 per cent resulted in significantly higher cob length and cob girth (22.57 and 21.06 cm, respectively) as compared to other treatments and it was followed by with UAS (B) package *i.e.*, 150:75:40 kg N: P₂O₅: K₂O ha⁻¹, FYM @ 10 t ha⁻¹ (15.62 and 17.09 cm, respectively). Lower cob length and girth of maize was recorded with the application of 75 % RDF + FYM @ 10 t ha⁻¹ plot (15.02 and 14.20 cm, respectively).

Number of Kernel Rows Per Cob and Number of Kernels Per Row

The data pertaining to number of kernel rows per cob and number of kernels per row of maize at harvest are presented in Table 5. Number of kernel rows per cob and number of kernels per row differed significantly among different ratios of SPC application and significantly higher number of kernel rows per cob and number of kernels per row was recorded with the application of 100 % RDF+ C5 @ 10 t ha⁻¹ (17.02, and 35.59, respectively) and it was on par with T₇- 100 % RDF+ C3 @ 10 t ha⁻¹ (16.51 and 35.17, respectively), T₁₂-75 % RDF+ C5 @ 10 t ha⁻¹ (16.10, and 34.09, respectively) and T₈ of 75 % RDF+ C3 @ 10 t ha⁻¹ (15.88, and 33.44, respectively). Whereas, lower number of kernel rows per cob and number of kernels per row was observed in T₂ treatment (12.56, and 28.87, respectively). The increase in the number of kernel rows per cob and the number of kernels per row in maize after applying silkworm pupae compost

TABLE 5
Effect of silkworm pupa compost on yield parameters of maize

Treatments	Cob length (cm)	Cob girth (cm)	No. of rows cob ⁻¹	No. of kernels row ⁻¹	Test weight (g)
T ₁ - 100 % RDF + FYM @ (10t/ha)	15.62	17.09	14.08	30.35	30.04
T ₂ - 75 % RDF + FYM @ (10t/ha)	15.02	14.2	12.56	28.87	28.63
T ₃ - 100 % RDF + C1 @ (10t/ha)	17.69	18.17	14.56	31.40	30.50
T ₄ - 75 % RDF + C1 @ (10t/ha)	16.79	18.12	14.38	31.87	30.41
T ₅ - 100 % RDF + C2 @ (10t/ha)	19.76	18.38	14.95	32.37	31.57
T ₆ - 75 % RDF + C2 @ (10t/ha)	18.17	18.23	14.60	32.74	31.30
T ₇ - 100 % RDF + C3 @ (10t/ha)	21.27	20.76	16.51	35.17	36.09
T ₈ - 75 % RDF + C3 @ (10t/ha)	20.43	19.93	15.88	33.44	33.13
T ₉ - 100 % RDF + C4 @ (10t/ha)	19.87	18.48	14.97	32.50	31.62
T ₁₀ - 75 % RDF + C4 @ (10t/ha)	18.43	18.28	14.76	32.39	31.49
T ₁₁ - 100 % RDF + C5 @ (10t/ha)	22.57	21.06	17.02	35.59	36.10
T ₁₂ - 75 % RDF + C5 @ (10t/ha)	20.87	20.36	16.10	34.09	34.76
S.EM±	0.87	0.86	0.65	0.96	1.41
CD at 5%	2.55	2.54	1.92	3.05	4.46

is attributed to the enhanced nutrient content of the compost. Silkworm pupae compost is rich in essential macronutrients and micronutrients which play a critical role in improving maize pollination, kernel filling and overall plant vigor. Additionally, the compost enhances soil microbial activity, promotes root development and improves the plant's ability to access water and nutrients, all of which contribute to increased kernel formation.

Research from Tamil Nadu Agricultural University demonstrated that organic amendments like seri-compost significantly boosted the number of kernels per row and kernel rows per cob, due to better nutrient availability and soil health improvement (Chaudhary *et al.*, 2022). Similarly, a study by Gupta *et al.* (2021) found that vermi compost from silkworm pupae led to a notable increase in maize yield components, including kernel count, owing to the balanced nutrient release throughout the growth period.

Test Weight

Application of 100% RDF + C5 @10 t ha⁻¹ (T₁₁) recorded significantly highest test weight of 36.10 g and was observed to be on par with treatment receiving 100% RDF + C3 @10 t ha⁻¹ (T₇ - 36.09 g), 75% RDF + C5 @10 t ha⁻¹ (T₁₂ - 34.76 g) and 100 % RDF + C5 @10 t ha⁻¹ (T₈ - 33.13 g). Lower test weight of 28.63g was recorded in treatment (T₂) receiving 75% RDF+ FYM @10 t ha⁻¹ (Table 5).

The use of SPC had a notable and significant effect on the yield parameters studied. This enhancement was due to the increased metabolic activity in plants, which supported flower and silk initiation in maize while addressing soil fertility constraints through the sustained availability of nutrients over time (Chathurika *et al.*, 2015). The higher nutrient availability led to improved photosynthesis, boosting the synthesis of organic compounds such as starch, monosucrose, protein and vitamins A and C. These compounds were utilized for cell division and multiplication, contributing to higher yield and

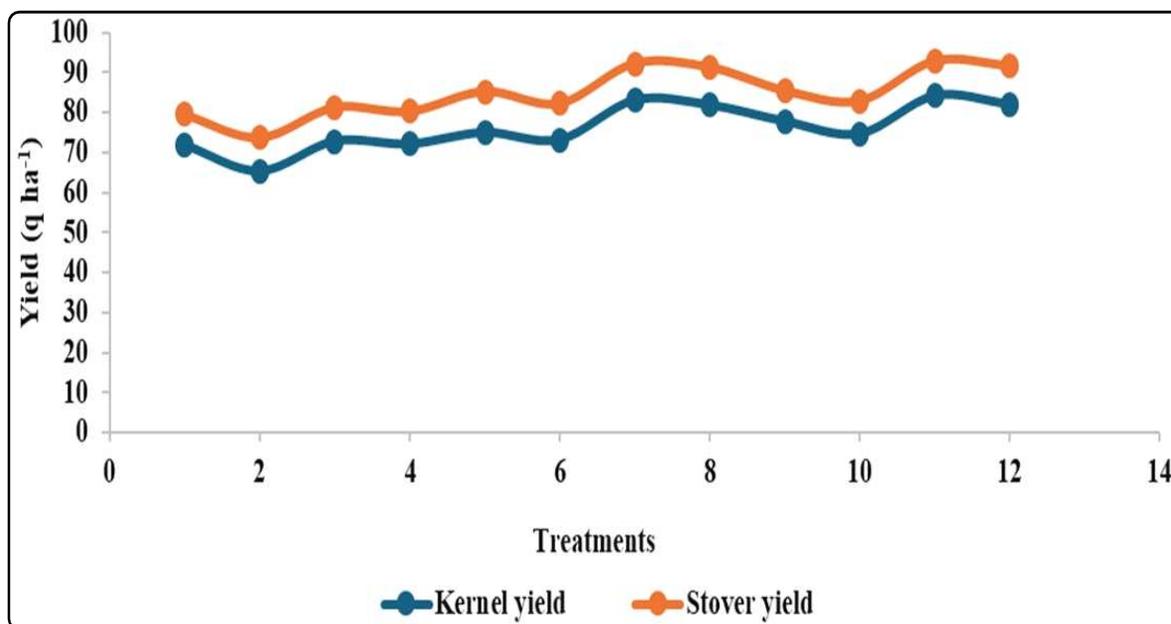


Fig. 2 : Effect of silkworm pupa compost on kernel yield and stover yield of maize

improved crop quality (Labib *et al.*, 2012 and Nath *et al.*, 2023).

Kernel Yield (q ha⁻¹) and Stover Yield (q ha⁻¹) of Maize

Kernel and stover yield of maize (Fig. 2) differed significantly due to influence of SPC in maize. Significantly higher kernel and stover yield of maize were obtained with the application of 100% RDF + C5 @10 t ha⁻¹ (T₁₁-84.15 and 92.81 q ha⁻¹, respectively) and it was found on par with 100% RDF+ C3 @10 t ha⁻¹ (T₇-83.06 and 92.21 q ha⁻¹, respectively), 75% RDF+ C5 @10 t ha⁻¹ (T₁₂-82.06 and 91.63 q ha⁻¹, respectively) and 75% RDF + C3 @10 t ha⁻¹ (T₈-81.86 and 91.26 q ha⁻¹, respectively) and it was followed by other treatments like T₉ which received 100% RDF+ C4 @10 t ha⁻¹ (74.96 and 85.24 q ha⁻¹, respectively), T₅ which received 75% RDF+ C2 @10 t ha⁻¹ (74.96 and 91.63 q ha⁻¹, respectively), T₁₀ which received 75 % RDF+ C4 @10 t ha⁻¹ (74.66 and 82.92 q ha⁻¹, respectively). Lower yield was observed in 75 % RDF + FYM @ 10 t ha⁻¹ with value of 65.31 and 73.79 q ha⁻¹, respectively.

The increase in maize kernel and stover yield after the application of SPC is attributed to the rich organic matter and nutrient content of the compost,

especially nitrogen, which boosts photosynthesis and biomass accumulation (Singh *et al.*, 2023). The improved nutrient availability promotes efficient plant metabolism, leading to enhanced kernel filling and robust stover growth. Additionally, the compost enhances soil microbial activity, which improves nutrient mineralization and uptake, contributing to better overall plant productivity. The results are in line with Ananda and Sharanappa (2017). The increase in yield is mainly attributed to higher yield parameters like number of kernel rows, number of kernels per row and test weight. Combined application of SPC and RDF ensure the release of readily available nutrients in adequate quantity to promote early growth as compared to sole organic manuring treatments, in which nutrients are available slowly over a long period of time. The improved growth and yield parameters can be linked to the availability of essential macronutrients and micronutrients from organic manure, which are vital for the growth and development of plants (Boraiah *et al.*, 2017). The reduced kernel yield might have been caused by limited nutrient availability during the early vegetative phase, potentially leading to nutrient deficiency during the reproductive phase,

which could have negatively affected both kernel and stover yields (Urkurkar *et al.*, 2010 and Parameshnaik *et al.*, 2024). The increase in green fodder yield is attributed to higher plant height, leaf number, leaf area, leaf area index and total dry matter production (Patil *et al.*, 2022).

Effect of Silkworm Pupa Compost Nutrient Uptake by Kernel and Stover of Maize

Major Nutrients (N, P and K) Uptake by Kernel and Stover

Nitrogen Content

The highest concentration of N in kernel (1.27%) was recorded in the treatment applied with 100% RDF + C5 @ 10 t ha⁻¹ (T₁₁) which was significantly superior than the treatment T₁ (100% RDF + FYM @ 10 t ha⁻¹: 0.92 %) and T₂ (75% RDF + FYM @ 10 t ha⁻¹: 0.91). The treatment T₁₁ was found on par with T₇ (100% RDF + C3 @ 10 t ha⁻¹: 1.19%), T₁₂ (75% RDF + C5 @ 10 t ha⁻¹: 1.18%) and T₈ (75% RDF + C3 @ 10 t ha⁻¹: 1.16 %) as observed in Fig. 3.

The highest concentration of N in stover (0.87 %) was recorded in the treatment applied with 100 % RDF

+ C5 @ 10 t ha⁻¹ and found to be was on par with T₇ (100% RDF + C3 @ 10 t ha⁻¹: 1.15%), T₁₂ (75% RDF + C5 @ 10 t ha⁻¹: 1.12%) and T₈ (75% RDF + C3 @ 10 t ha⁻¹: 1.09%). The lower nitrogen content was observed in treatment T₁ (100% RDF + FYM 10 t ha⁻¹: 0.88%) and T₂ (75% RDF + C5 @ 10 t ha⁻¹: 0.87%).

Phosphorus Content

Data revealed that maximum phosphorus content in kernel (0.25%) was found under application C5 (T₁₁: 100% RDF + C5 @ 10 t ha⁻¹) and it was followed by T₉ (0.21%) minimum phosphorus content (0.14%) was recorded in T₂ received 75% RDF + FYM @ (10 t ha⁻¹) as depicted in Fig. 3.

The P content in stover was maximum with 100% RDF + C5 @ 10 t ha⁻¹ (T₁₁: 0.21%) which was it was found on par with T₇ which received 100% RDF + C3 @ 10 t ha⁻¹ (0.21%), T₁₂ which received 75% RDF + C5 @ 10 t ha⁻¹ (0.20%) and T₈ which received 75% RDF + C3 @ 10 t ha⁻¹ (0.20%). Lower P content in stover (0.15%) was recorded in T₂ (75% RDF + FYM @ 10 t ha⁻¹).

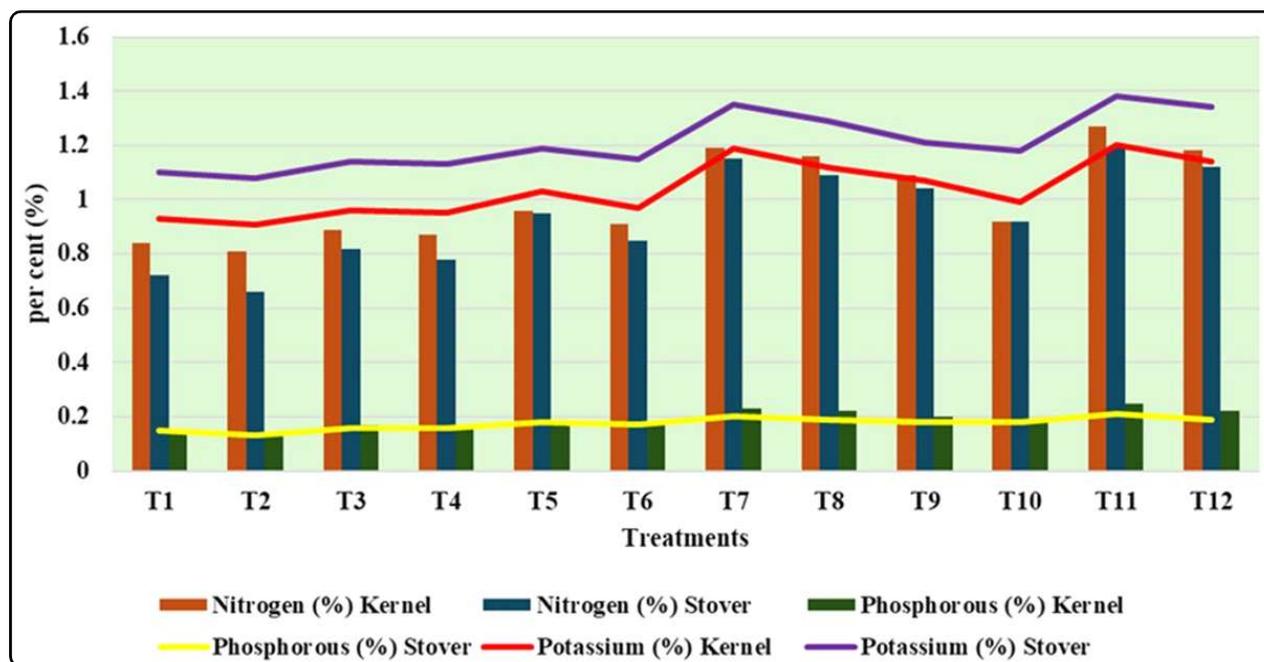


Fig. 3 : Effect of silkworm pupa compost on kernel and stover NPK content of maize

Potassium Content

It is apparent from the data that increasing NPK levels (100% NPK through RDF + C5 @10 t ha⁻¹) (T₁₁: 1.20 %) resulted into significant increase in potassium content over lower NPK levels (75% RDF and FYM @10 t ha⁻¹) by kernel (0.91%), whereas K concentration in stover significantly influenced by these treatments. Maximum K content by stover was recorded with 100% RDF with C5 @10 t ha⁻¹ *i.e.*, 1.38%, while the minimum K concentration was noticed with in lower RDF level treatment *i.e.*, 75% RDF + FYM @ 10 t ha⁻¹ (1.08%).

The NPK content in kernel and stover was significantly different among different treatments but maximum concentration of NPK in kernel and stover were recorded in treatment with highest NPK content in compost of 1.90, 0.96 and 1.50% NPK (100% RDF + C5 @ 10 t ha⁻¹) and the increase in nutrient content of maize kernels and stover after SPC application can be attributed to the high nutrient content of the compost, which includes organic forms of phosphorus (Tripathi *et al.* 2023). This organic matter enhances microbial activity, promoting the mineralization of phosphorus, making it more bioavailable to plants

(Chaturvedi *et al.*, 2022 and Singh., *et al.* 2021). Additionally, SPC improves soil structure and water retention, facilitating better root development and nutrient uptake. Higher availability of P in soil hence increased P content in plant due to better physical environment for plant growth and nutrient uptake. The similar finding was reported by Murthy *et al.* (2015), Gangadhar Nanda (2015) and Walia *et al.* (2010).

Secondary Nutrients (Ca, Mg and S) in Kernel and Stover

The higher calcium in kernel and stover (Fig. 4) was recorded in treatment T₁₁ which received 100% RDF + C5 @ 10 t ha⁻¹ (0.41 and 0.21% in kernel and stover, respectively) and it was found on par with other treatments like T₇ which received 100% RDF + C3 @ 10 t ha⁻¹ (0.40 and 0.21 % in kernel and stover, respectively), T₁₂ which received 100% RDF + C5 @ 10 t ha⁻¹ (0.39 and 0.20% in kernel and stover, respectively) and T₈ which received 100% RDF + C5 @ 10 t ha⁻¹ (0.37 and 0.20% in kernel and stover, respectively) and it was followed by T₉, T₆, T₁₀, T₃, and T₄. Lower calcium content in kernel and stover was recorded in T₁- 0.25 and 0.16% in kernel and stover, respectively which received 100% RDF+ FYM

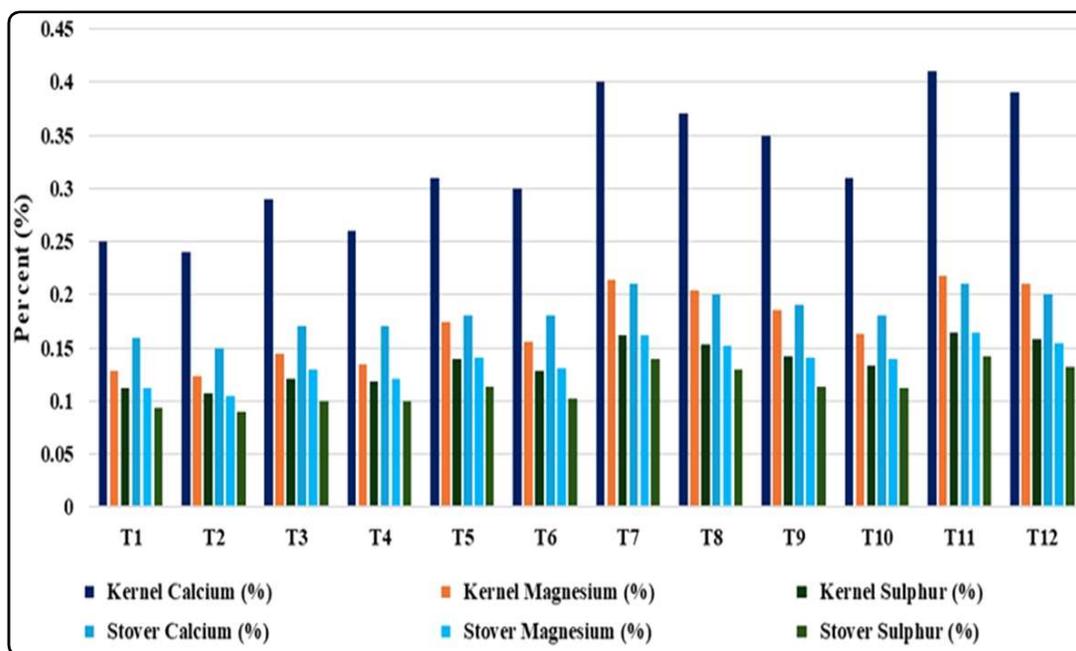


Fig. 4 : Effect of silkworm pupa compost on kernel and stover Ca, Mg, S content of maize

@ 10 t ha⁻¹ and T₂ recorded 0.24 and 0.15% in kernel and stover, respectively which received 75% RDF+ FYM @ 10 t ha⁻¹.

The highest content of magnesium in kernel and stover was recorded in T₁₁ *i.e.*, 100% RDF + C5 @ 10 t ha⁻¹ (0.218 and 0.165%, in kernel and stover respectively) and it was found on par with treatments (T₇) 100% RDF + C3 @ 10 t ha⁻¹ (0.214 and 0.162%, in kernel and stover respectively), T₁₂ which received 75% RDF + C5 @ 10 t ha⁻¹ (0.210 and 0.154% in kernel and stover, respectively) and T₈ which received 75% RDF + C3 @ 10 t ha⁻¹ (0.204 and 0.152% in kernel and stover, respectively). Lower magnesium content in kernel and stover was recorded in T₂ which received 75% RDF+ FYM @ 10 t ha⁻¹ (0.124 and 0.105% in kernel and stover, respectively).

The sulphur content in maize kernel and stover was significantly higher in the treatments T₁₁ (0.164 and 0.142%, respectively) which received 100% RDF+ C5 @ 10 t ha⁻¹ and it was on par with all other treatment like T₇ (0.162 and 0.139%, respectively), T₁₂ (0.158 and 0.132%, respectively) and T₈ (0.153 and 0.130%, respectively). Lower sulphur content in

kernel and stover was recorded in T₂ of 0.107 and 0.090%, respectively where 75% RDF and FYM @ 10 t ha⁻¹ were added.

The increase in calcium (0.41 and 0.21%), magnesium (0.218 and 0.165%) and sulfur (0.164 and 0.142%) content in the kernel and stover of maize after the application of SPC can be attributed to the nutrient-rich composition of the compost. SPC is known for its high concentration of essential macro and micronutrients, including calcium (2.32%), magnesium (1.29%) and sulfur (0.78%). These nutrients are present in bio available forms, which promote their uptake by plants. Calcium plays a crucial role in strengthening plant cell walls and overall structural development, while magnesium is a central element of chlorophyll and is essential for photosynthesis. Sulfur, an important component of amino acids and proteins, contributes to enzyme activity and nitrogen metabolism. The organic matter in the compost also enhances soil structure, improving water retention and nutrient availability, which in turn promotes better root growth and nutrient absorption by maize plants. Studies such as those by Siddique *et al.* (2015) and Rajasekaran *et al.* (2016), have

TABLE 6
Effect of silkworm pupa compost on micro nutrient content of maize

Treatments	Iron (mg/kg)		Zinc (mg/kg)		Manganese (mg/kg)		Copper (mg/kg)	
	Kernel	Stover	Kernel	Stover	Kernel	Stover	Kernel	Stover
T ₁	76.69	55.93	43.23	22.97	59.99	45.83	11.69	5.91
T ₂	76.25	54.63	42.50	22.40	59.46	45.13	11.25	5.47
T ₃	79.21	60.41	44.53	24.27	63.97	48.12	12.04	6.46
T ₄	78.41	57.61	44.20	23.94	60.15	47.60	11.87	6.29
T ₅	85.21	65.82	45.61	25.35	67.09	51.47	13.06	7.48
T ₆	80.95	61.24	44.82	24.56	66.34	50.65	12.21	6.63
T ₇	96.09	73.35	51.80	31.54	73.12	59.98	14.97	9.46
T ₈	91.84	70.52	48.41	29.31	70.33	56.19	14.53	9.16
T ₉	87.22	66.37	45.98	26.42	67.25	52.87	13.43	7.96
T ₁₀	83.68	64.38	45.39	25.13	66.44	51.19	12.65	7.07
T ₁₁	98.55	75.30	52.36	32.10	76.21	60.08	15.52	9.94
T ₁₂	94.35	72.86	50.79	30.53	71.00	58.70	14.63	9.35
S.EM±	3.78	2.98	2.17	1.21	2.87	2.42	0.60	0.37
CD at 5%	11.08	8.73	6.35	3.55	8.61	7.26	1.75	1.08

demonstrated the positive effects of organic amendments like SPC on nutrient enrichment in crops, highlighting its efficacy in improving the nutritional quality of produce in sustainable agriculture systems.

Micronutrients (Fe, Zn, Cu and Mn) in Kernel and Stover of Maize

Iron content varied significantly with different treatments at the harvest of maize as observed in Table 6. Among the different treatments, higher iron content of 98.55 mg kg⁻¹ and 75.30 mg kg⁻¹ was recorded in T₁₁ (100% RDF + C5 @ 10 t ha⁻¹) in kernel and stover respectively and it was found on par with treatment T₇ (96.09 and 73.35 mg kg⁻¹ in kernel and stover, respectively), T₁₂ (94.35 and 72.86 mg kg⁻¹ in kernel and stover, respectively) and T₈ (91.84 and 70.52 mg kg⁻¹ in kernel and stover, respectively).

Higher zinc content of 52.36 mg kg⁻¹, 51.80 mg kg⁻¹, 50.79 mg kg⁻¹ and 48.41 mg kg⁻¹ was recorded in T₁₁ (100% RDF + C5 @ 10 t ha⁻¹), T₇ (100 % RDF + C3 @ 10 t ha⁻¹), T₁₂ (75% RDF + C5 @ 10 t ha⁻¹) and T₈ (75% RDF + C3 @ 10 t ha⁻¹) respectively. Similarly, the higher zinc content in in stover of maize was of 32.10 mg kg⁻¹, 31.54 mg kg⁻¹, 30.53 mg kg⁻¹ and 29.31 mg kg⁻¹ was recorded in T₁₁ (100% RDF + C5 @ 10 t ha⁻¹), T₇ (100% RDF + C3 @ 10 t ha⁻¹), T₁₂ (75% RDF + C5 @ 10 t ha⁻¹) and T₈ (75% RDF + C3 @ 10 t ha⁻¹) respectively.

Maximum content of copper in kernel and stover were recorded in high dose of nutrient applied along C5 SPC *i.e.*, T₁₁ (100% RDF + C5 @ 10 t ha⁻¹) of 15.52 mg kg⁻¹ and 9.94 mg ka⁻¹ whereas minimum copper content of 11.25 mg kg⁻¹ and 5.47 mg kg⁻¹ in kernel and stover respectively were recorded in 75 per cent fertilizer and FYM @ 10 t ha⁻¹ applied treatment *i.e.* (T₂).

With respect to kernel manganese content in maize, significant differences were recorded among treatments. But higher kernel concentration of manganese was recorded in T₁₁ (100 % RDF + C5 @ 10 t ha⁻¹) recording 76.21 mg kg⁻¹, and it was on par with the treatment T₇ (73.12 mg kg⁻¹), T₁₂ (71.00 mg kg⁻¹) and T₈ (70.33 mg kg⁻¹) whereas lower content of

manganese concentration in kernel was recorded in T₂ (75% RDF+ FYM @ 10 t ha⁻¹) of 59.46 mg kg⁻¹ (Table 6). The manganese content in maize stover recorded significant differences among different treatments. But higher stover concentration of manganese was recorded in T₁₁ (100% RDF + C5 @ 10 t ha⁻¹) recording 60.08 mg kg⁻¹ and it was on par with the treatment T₇ (59.98 mg kg⁻¹), T₁₂ (58.70 mg kg⁻¹) and T₈ (56.19 mg kg⁻¹) whereas lower content of manganese concentration in kernel was recorded in T₂ which received 75% RDF+ FYM @ 10 t ha⁻¹ of 45.13 mg kg⁻¹.

The increase in kernel and stover micronutrient content following SPC application can be attributed to several key factors. SPC is rich in organic matter, nitrogen, phosphorus, potassium and essential micronutrients such as zinc, iron, copper and manganese, which contribute to enhanced soil fertility. When applied to soil, this compost improves soil structure, promotes microbial activity and increases the availability of nutrients for plants. The microorganisms present in the compost break down organic matter, releasing nutrients in forms that are more accessible to plant roots (Bhat *et al.*, 2019). Moreover, the composted silkworm pupa contains significant amounts of nitrogen, which plays a critical role in the growth and development of plants, improving their ability to uptake micronutrients from the soil (Kumar *et al.*, 2021).

The presence of humic substances in SPC improves nutrient retention in the soil and helps in the chelation of micronutrients, making them more available for absorption by plant roots (Singh *et al.*, 2020b). Additionally, the application of organic amendments like SPC enhances the microbial population in the soil, which in turn facilitates nutrient cycling and enhances the bioavailability of micronutrients (Yadav *et al.*, 2018). These microorganisms also promote the synthesis of growth-promoting substances like phytohormones, which help in the efficient uptake of micronutrients. The improvement in soil organic matter content enhances the cation exchange capacity (CEC), which allows for better retention and supply of essential micronutrients to the crops (Patel *et al.*,

2017). Similar results were noticed by Pravalika *et al.*, 2024.

Furthermore, SPC contributes to the increased production of secondary metabolites, which can enhance plant nutrient uptake and overall growth (Rai *et al.*, 2019). In conclusion, the application of SPC leads to improved soil health, enhanced microbial activity, and better nutrient cycling, all of which contribute to the increased micronutrient content in both the kernel and stover of plants.

The findings of this investigation showed that the growth, yield and nutrient content of maize have considerably enhanced by SPC. Increased plant height, biomass, and grain production were all signs of improved soil fertility brought about by the application of this organic fertilizer. Moreover, plants treated with SPC had higher levels of nutrients in maize, specifically nitrogen (N), phosphorus (P) and potassium (K), than plants grown with regular fertilizers or without compost. This implies that SPC is a useful and environmentally responsible substitute for synthetic fertilizers, providing advantages for crop productivity and the health of the soil. Given these results, it is advised that SPC be taken into consideration as a sustainable agricultural input to enhance maize cultivation, particularly in regions that prioritize organic farming methods. To find out how SPC affects soil health over the long run and whether it is suitable for other crops, more research is required.

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