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Effect of Combined Sericulture Waste Compost on Nutrient Uptake, Flower Quality and Yield of *Tagetes erecta* Linn. (Asterales: Asteraceae)

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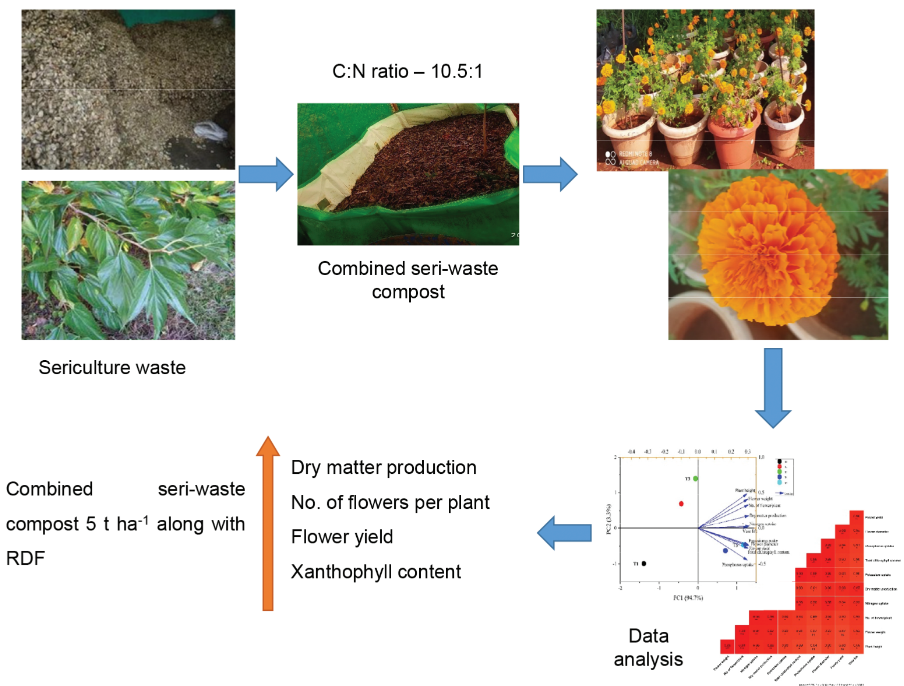
Graphical abstract



Abstract: A pot experiment investigated the impact of combined sericulture waste compost on African marigold (*Tagetes erecta* L.) growth, nutrient uptake, yield, and flower quality. The experiment employed a completely randomised design (CRD) with five treatments: T_1-Control (NPK alone), T_2-Vermicompost 5 t ha^{-1}, T_3-Vermicompost 5 t ha^{-1} + NPK, T_4-Combined seri-waste (CSW) compost 5 t ha^{-1}, and T_5-CSW compost 5 t ha^{-1} +

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NPK. All treatments significantly affected African marigold growth. The application of RDF + CSW compost @ 5 t ha^{-1} notably enhanced growth parameters, including plant height (80%), number of flowers per plant, flower diameter (97 %), flower yield (22 %), vase life, and dry matter production (62.5 %) compared to the control (RDF alone). CSW compost @ 5 t ha^{-1} with RDF showed a high xanthophyll content (470.05 mg $100g^{-1}$), contributing to orange coloration. Consequently, CSW compost @ 5 t ha^{-1}, combined with the recommended fertiliser dose, yielded the highest marigold output and increased xanthophyll content, enhancing the flower's value.

Key words: Combined seri-waste compost, *Tagetes erecta* L., nutrient uptake, flower yield, xanthophyll.

Introduction

Marigold, native to Central and South America, is part of the Asteraceae family, specifically the *Tagetes genus* with 33 species. In India, marigold cultivation spans 55.89 thousand hectares, producing 511.39 thousand metric tonnes as loose flowers, notably the African marigold (*Tagetes erecta* L.). Valued for cut flower production, marigold roots reduce soil nematode populations, and their essential oil is used in perfumes. Orange marigold petals enhance poultry feed for dark orange egg yolks. Commercial marigold cultivation is gaining popularity, and optimal fertiliser management is crucial for sustainable flower production. Organic manures offer an eco-friendly approach, promoting sustainability and improving crop quality and yield. Composting organic waste is considered a sustainable waste management method, enriching soil organic matter and countering deterioration from human activities (Soobhany, 2019).

Sericulture waste acts as a good source of organic nutrients for crops. It contains more plant nutrients like macro and micro nutrients which help in increasing the yield. A sericulture farm of 1 hectare can produce 50 MT of waste per year which is very rich in N, P and potash and micronutrients like Fe, Zn, and Cu, etc. But application of this sericulture waste directly to crops is not suitable as it affects the roots of plants because it generates more heat. Therefore, biocomposting is an eco-friendly technology that can convert Seri waste to nutrient-rich compost (Kalaiyarasan et al., 2015). Using sericulture waste compost from silk farming involves converting approximately 12-15 metric tonnes of waste, including silkworm litter, unused mulberry leaves, twigs, weeds, cocoons, pupae, and excreta, produced annually per hectare of the mulberry garden (Ganesan et al., 2022). This approach can significantly increase farmers' income up to 40%, reduce input costs, promote sustainable agriculture, and enhance crop yields. Ahmed et al. (2017) also reported that combined seri waste compost application (20 t ha^{-1}) with RDF enhanced the total leaf yield of mulberry (52.23 t ha^{-1}) than the RDF alone (47.25 t ha^{-1}). Hence, this study explores the impact of combined sericulture waste compost on African marigold's growth, nutrient uptake, yield, and flower quality.

Materials and Methods

Site Description

The experiment was conducted at the Forest College and Research Institute, Mettupalayam, India. The soil type and texture used for the experiment were red loam and sandy clay loam, respectively. The samples were thoroughly air-dried and sieved through a 2 mm sieve with a pore size of 2 m as per the standard methodology (Page, 1982). These processed samples were analysed for their physicochemical properties and the results are given in Table 1.

Characterisation of Combined Seri-Waste Compost and Vermicompost

Combined seri waste (mulberry leaf residues and silkworm rearing wastes) along with cow dung slurry at a 3:1 ratio and TNAU biomineraliser @ 2 kg ton^{-1}, were composted through biocomposting method. Quality assessment of the combined seri waste compost (CSW) was conducted through a pot experiment with Marigold as test crop, in comparison to commercial vermicompost (VC). Standard methods employed to characterise CSW compost and VC are given in Table 2.

Experimental Design and Treatment Application

The study used African marigold (*Tagetes erecta* L.) var. AVT Orange. Urea, single super phosphate (SSP), and muriate of potash (MOP) were applied to the crop as source of NPK at recommended doses 100:50:25 kg ha^{-1}. Growth and yield parameters of marigold, including plant height, number of flowers per plant, flower diameter, flower weight, and flower yield, were observed. Chlorophyll content was measured using a Chlorophyll content meter (CCM-200+, USA) on fully

Table 1: Characteristics of experimental soil

S. No	Parameters	Value	Method	Reference
1	Soil type	Red loam		
2	Texture	Sandy clay loam	Soil hygrometer method	(Bouyoucos, 1936)
3	pH (1: 2.5)	8.16	Glass electrode method	(Jackson, 1958)
4	EC (dS m^{-1})	1.31	Conductivity bridge method	
5	Organic carbon (%)	0.89	Chromic acid wet digestion method	(Walkley and Black, 1934)
6	Available nitrogen (kg ha^{-1})	240	Alkaline permanganate method	(Subbaiah and Asija, 1956)
7	Available phosphorus (kg ha^{-1})	33.1	Olsen's method	(Olsen et al., 1954)
8	Available potassium (kg ha^{-1})	294.2	Ammonium acetate method	(Hanway and Heidel, 1952)
9	Exchangeable calcium (cmol (p^+) kg^{-1})	4.10	Microwave Plasma - Atomic Emission Spectrometer (MP-AES, Agilent Technologies, United States)	(Ximénez-Embún et al., 2002)
10	Exchangeable magnesium (cmol (p^+) kg^{-1})	1.90		
11	Exchangeable sodium (cmol (p^+) kg^{-1})	1.41		
12	Exchangeable potassium (cmol (p^+) kg^{-1})	0.35		
13	Cation Exchange Capacity (cmol (p^+) kg^{-1})	9.68	Neutral normal ammonium acetate	(Rabhi et al., 2010)
14	Iron (mg kg^{-1})	1.678	Microwave Plasma - Atomic Emission Spectrometer (MP-AES, Agilent Technologies, United States)	(Ximénez-Embún et al., 2002)
15	Copper (mg kg^{-1})	1.362		
16	Zinc (mg kg^{-1})	0.696		
17	Manganese (mg kg^{-1})	24.10		

expanded young leaves. Vase life was determined by counting the days until petals lost turgidity and changed color after harvesting and storing at room temperature.

Treatment Details

Treatment notation		Treatment name
T_1	:	Control (RDF)
T_2	:	Vermicompost 5 t ha^{-1}
T_3	:	Vermicompost 5 t ha^{-1} + RDF
T_4	:	Combined seri-waste (CSW) compost 5 t ha^{-1}
T_5	:	Combined seri-waste (CSW) compost 5 t ha^{-1} + RDF

Statistical Analysis

The completely randomised design using SPSS 16.0 statistical software (WinWrap basic, Polar engineering and consulting) was used to test the significance ($p \leq 0.05$) (Rangaswamy, 2010). Pearson correlation analysis was done using Origin statistical software ver. 2021 (Gomez and Gomez, 1984). Using standard procedures, principal component analysis was done (Paul et al., 2013).

Results and Discussion

Effect of CSW Compost on Nutrient Uptake

CSW compost application significantly increased nutrient uptake in marigolds (Table 3). The highest N (107 kg ha^{-1}), P (24 kg ha^{-1}), and K (109 kg ha^{-1}) uptake occurred with CSW compost @ 5 t ha^{-1} + RDF, surpassing RDF-alone control. NPK uptake was 33.7 %, 33 %, and 21 % higher in CSW compost + RDF compared to RDF alone. This enhancement may result from higher nutrient concentrations in the soil due to increased organic manure doses compared to RDF application alone. John et al. (2022) reported similar findings with pressmud compost. The favourable growing medium, maintained by high moisture levels, likely improved nutrient solubility, contributing to

Table 2: Characteristics of combined seri-waste compost and vermicompost

S.No	Parameters	CSW	VC	Method	Reference
1	pH	7.90	7.70	Glass electrode method	(Jackson, 1958)
2	EC (dS m^{-1})	1.70	0.96	Conductivity bridge method	
3	Organic carbon (%)	21.30	12.0	Chromic acid wet digestion method	(Walkley & Black, 1934)
4	Total Nitrogen (%)	1.90	1.70	Diacid extract - Semi automatic kjeldahl distillation	(Jackson, 1973)
5	Total Phosphorus (%)	1.10	0.90	Triacid extract - Vanadomolybdate colorimetric method	
6	Total Potassium (%)	1.80	1.60	Diacid extract - Estimated using Microwave Plasma - Atomic Emission Spectrometer (MP-AES)	(Ximénez-Embún et al., 2002)
7	Calcium (%)	6.85	5.54		
8	Magnesium (%)	3.95	3.40		
9	Sodium (%)	0.12	0.10		
10	Iron (mg kg^{-1})	871.0	9.30	MP-AES, Agilent Technologies, United States	(Ximénez-Embún et al., 2002)
11	Copper (mg kg^{-1})	71.3	9.50		
12	Zinc (mg kg^{-1})	260.0	7.50		
13	Manganese (mg kg^{-1})	243.0	4.35		
14	Bacteria (x 10^6 CFU g^{-1})	46	42	Standard serial dilution plating technique	(Durbin, 1961)
15	Fungi (x 10^3 CFU g^{-1})	36	32		
16	Actinomycetes (x 10^4 CFU g^{-1})	19	17		
17	C/N ratio	10.5:1	11.5:1		

Note: EC – Electrical conductivity; C/N – Carbon Nitrogen Ratio; CFU – Colony forming units; CSW - Combined seri-waste compost; VC – Vermicompost

increased nutrient uptake (Sumangala et al., 2018). The elevated availability of N and P in the soil enhanced marigold root growth and density, leading to better uptake of macro and micronutrients, consequently increasing plant dry matter content through enhanced photosynthesis and cell formation processes (Polara et al., 2014).

Effect of CSW Compost on Total Chlorophyll Content

The highest chlorophyll content (2.40 mg g^{-1}) was in Combined Seri-Waste (CSW) compost @ 5 t ha^{-1} + Recommended Dose of Fertiliser (RDF) (T_5), followed by CSW compost alone (T_4) at 2.35 mg g^{-1} (Table 3). RDF-alone treatment (T_1) had the lowest chlorophyll content at 1.70 mg g^{-1}. Applying CSW compost, especially in conjunction with RDF, resulted in significantly higher chlorophyll content, attributed to the positive impact of nutrient assimilation. The increased nitrogen concentration in leaves indicated higher chlorophyll and CO_2 assimilation enzymes, notably RUBISCO (Kathpalia and Bhatla, 2018). CSW compost application showed 1.5 times higher chlorophyll content compared to the control. Similar findings were reported by Chaupoo and Kumar (2020), recording 57.76 and 49.27 mg g^{-1} total chlorophyll content in vermicompost and Farm Yard Manure (FYM) applied marigold plots.

Effect of CSW Compost on Biometric Observations and Plant Growth Parameters

Plant height, a crucial indicator of marigold vigour, varied from 63 to 103 cm at harvest (Table 4). The treatment with Combined Seri-Waste (CSW) compost 5 t ha^{-1} + Recommended Dose of Fertilizer (RDF) exhibited the tallest plants at 103 cm, surpassing VC and CSW compost alone treatments at 94 and 92 cm, respectively. Sudhagar et al. (2019) also reported increased plant height (99.12 cm) with 75% RDF + vermicompost @ 5 t ha^{-1}. The enhanced availability of macro and micronutrients in the CSW compost treatments likely contributed to increased plant height, branching, and bud development, as observed in higher harvest numbers, with CSW compost 5 t ha^{-1} + RDF yielding the most, in contrast to the RDF-alone control. Similarly, Sangeetha et al. (2012) investigated the impact of comparing the effects of pupal waste and composted silkworm litter with other organic manures on the development and leaf production of the mulberry tree. They found that composted silkworm litter and pupal waste outperformed farmyard manure and vermicompost in terms of performance and nutrient content.

Dry matter production significantly influences crop productivity, driven by improved plant development, increased branching, and leaf area (Kathpalia and Bhatla, 2018). The CSW compost 5 t ha^{-1} + RDF treatment recorded the highest dry matter content (65 g $plant^{-1}$), followed by CSW compost 5 t ha^{-1} (58 g $plant^{-1}$), while the RDF-alone treatment had the lowest (40 g/plant) (Table 4). Similar trends were observed with 75% RDF + vermicompost @ 5 t ha^{-1} (112.96 g/plant) compared to the control (85.98 g/plant). Composts positively impact crop production by enhancing soil properties, such as physical structure, moisture retention, and organic carbon content. The favourable soil conditions support beneficial microorganisms, enhancing nutrient availability and contributing to the robust growth of marigolds, leading to increased dry matter production (Figure 1).

Effect of CSW Compost on Flower Yield and Quality

During the cropping season, the inclusion of Combined Wood Chips (CWC) compost with fertilisers significantly

Table 3: Effect of Combined seri-waste compost on nutrient uptake and plant pigments during harvesting stage

Treatments	*Nitrogen uptake ($kg\ ha^{-1}$)*	*Phosphorus uptake ($kg\ ha^{-1}$)*	*Potassium uptake ($kg\ ha^{-1}$)*	*Total chlorophyll content ($mg\ g^{-1}$)*
T_1	80	18.0	90.0	1.70
T_2	91	19.5	98.0	1.97
T_3	95	19.7	97.0	1.95
T_4	104	23.5	107.0	2.35
T_5	107	24.0	109.0	2.40
Mean	95.4	20.94	100.2	2.074
SE (d)	0.91	0.25	0.75	0.01
CD (0.05)	1.80	0.51	1.50	0.02

T_1: Control (RDF); T_2: Vermicompost 5 t ha^{-1}; T_3: Vermicompost 5 t ha^{-1} + RDF; T_4: Combined seri-waste (CSW) compost 5 t ha^{-1}; T_5: Combined seri-waste (CSW) compost 5 t ha^{-1} + RDF

Table 4: Effect of combined seri-waste compost on plant growth parameters

Treatments	*Plant height (cm)*				*No. of harvest*	*Dry matter production ($kg\ ha^{-1}$)*
	Days					
	S_1	*S_2*	*S_3*	*Mean*		
T_1	28	53	63	48.0	5	40
T_2	50	76	88	71.3	6	49
T_3	55	80	92	75.7	6	55
T_4	60	83	94	79.0	7	58
T_5	67	90	103	86.7	8	65
Mean	52.0	76.4	88.0			53.4
SE.d	0.10	0.15	0.17			0.76
CD(0.05)	0.21	0.30	0.34			1.50

S_1: Vegetative stage; S_2 - Flowering stage; S_3 - Harvesting stage

T_1: Control (RDF); T_2: Vermicompost 5 t ha^{-1}; T_3: Vermicompost 5 t ha^{-1} + RDF; T_4: Combined seri-waste (CSW) compost 5 t ha^{-1}; T_5: Combined seri-waste (CSW) compost 5 t ha^{-1} + RDF

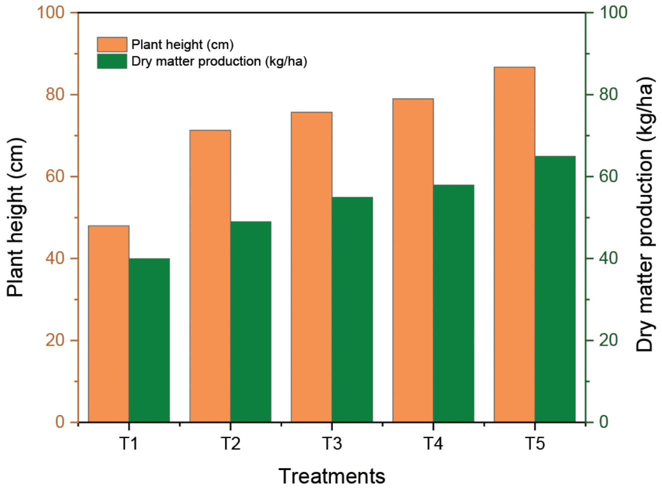

Figure 1: Relation between mean plant height and dry matter production of African marigold

enhanced flower diameter (Table 5), ranging from 4 to 7.9 cm. The treatment involving Combined Seri-Waste (CSW) compost at 5 t ha^{-1} + Recommended Dose of Fertiliser (RDF) demonstrated the largest flower diameter, while the control exhibited the smallest. Improved nutrition intake during the reproductive phase potentially led to increased floret production, enhancing flower diameter. Similar findings by Sivasankar et al. (2021) showed that farmyard manure (FYM) and vermicompost application resulted in a 57% higher flower diameter compared to FYM alone.

Furthermore, the CSW compost applied treatment, along with RDF, showed higher individual flower weight (19.7 g) and a greater number of flowers per plant (129), followed by the CSW compost alone treatment (Table 5). The number of flowers per plant was notably higher (35.2) with the application of 10 kg m^{-2} of medicinal plant waste compost, 2.36 times more than the control (Filipović et al., 2023). The increased flower size, weight, and quantity in African marigolds may be attributed to optimal levels of nitrogen and phosphorus, expediting protein synthesis and promoting faster floral primordial development, consistent with previous research (Patel et al., 2018; Sivasankar et al., 2021). Additionally, phytohormones released from chemical and organic fertilisers may have influenced the synthesis of nitrogenous molecules like amino acids, acting as precursors to polyamines and secondary messengers in marigolds (Kumar et al., 2020).

Flower yield was higher in CWC compost-applied treatments compared to vermicompost (Table 5). The CWC compost @ 5 t ha^{-1} + RDF treatment recorded 31.1 t ha^{-1}, followed by CWC compost @ 5 t ha^{-1} alone (29.5 t ha^{-1}). The favourable influence on flower yield attributes, such as flower weight, number, and diameter, resulted in a 22 % higher yield in the CWC compost + RDF applied treatment than the control. Increased overall vegetative growth from the application of CSW compost may have contributed to improved flowering parameters, enhancing photosynthetic area, metabolic activity, and transport/utilization of photosynthetic products, leading to higher flower quality and yield (Kumar et al., 2022). CSW compost application demonstrated a significant improvement in the vase life of flowers, with treatment T_5 (CSW compost @ 5 t ha^{-1} + RDF) registering a longer vase life of 4.3 days compared to the three days in the control.

Moreover, CSW compost and vermicompost applications significantly differed in enhancing xanthophyll content. The highest xanthophyll content was observed in CSW compost @ 5 t ha^{-1} + RDF (470.5 mg $100g^{-1}$), 17 % higher than the control (Table 5).

Table 5: Effect of combined seri-waste compost on flower quality of marigold

Treatments	*Flower Diameter (cm)*	*Flower weight (g)*	*No. of flower/plant*	*Flower yield (t ha^{-1})*	*Vase life (days)*	*Xanthophyll Content (mg $100g^{-1}$)*
T_1	4.0	9.50	70	25.5	3.0	401.1
T_2	5.1	15.2	101	26.5	3.2	415.6
T_3	5.5	17.0	110	27.9	3.8	430.4
T_4	7.1	18.5	120	29.5	4.0	461.5
T_5	7.9	19.7	129	31.1	4.3	470.5
Mean	5.92	15.98	106	28.1	3.66	435.82
SE (d)	0.01	0.12	1.1	0.09	0.01	0.04
CD (0.05)	0.02	0.24	2.2	0.18	0.02	0.08

T_1: Control (RDF); T_2: Vermicompost 5 t ha^{-1}; T_3: Vermicompost 5 t ha^{-1} + RDF; T_4: Combined seri-waste (CSW) compost 5 t ha^{-1}; T_5: Combined seri-waste (CSW) compost 5 t ha^{-1} + RDF

Elevated nitrogen levels contributed to higher flower xanthophyll content. Previous research has highlighted the role of carotenoids in marigold petal colour, with organic manure affecting the carotenoid content of fresh and dried marigold petals (Sharma et al., 2016). The positive impact on flower development, increased flower yield, and enhanced xanthophyll content can be attributed to factors such as early disruption of apical dominance, improved nutrient transport to flowers, enhanced availability of nutrients promoting overall plant growth, and efficient movement of photosynthates. The use of organic manures likely contributes to these effects by stimulating the release or synthesis of growth hormones.

Pearson Correlation and Principal Component Analysis Between Nutrient Uptake and Plant Growth Parameters

Figure 2 presents the correlation matrix between nutrient uptake and plant growth parameters. Total chlorophyll content showed a significant positive correlation with nitrogen and potassium uptake ($p < 0.001$), indicating a strong impact of nutrient assimilation on leaf chlorophyll content. Dry matter production exhibited a strong positive correlation (> 0.90) with nitrogen, phosphorus, and potassium uptake at a 5 % significance level. NPK uptake also showed significant positive correlations (> 0.90) with flower yield in African marigolds at $p < 0.05$. However, phosphorus uptake did not significantly correlate with plant height and flower weight.

Principal Component Analysis (PCA) in Figure 3 revealed that PC1 and PC2 contributed to 94.7% and 3.3%, respectively, of the total cumulative variance (98.0%). The biplot analysis indicated that plant height, nitrogen uptake, dry matter production, number of flowers per plant, and flower weight exhibited positive dispersions. Vectors concentrated in the first and fourth

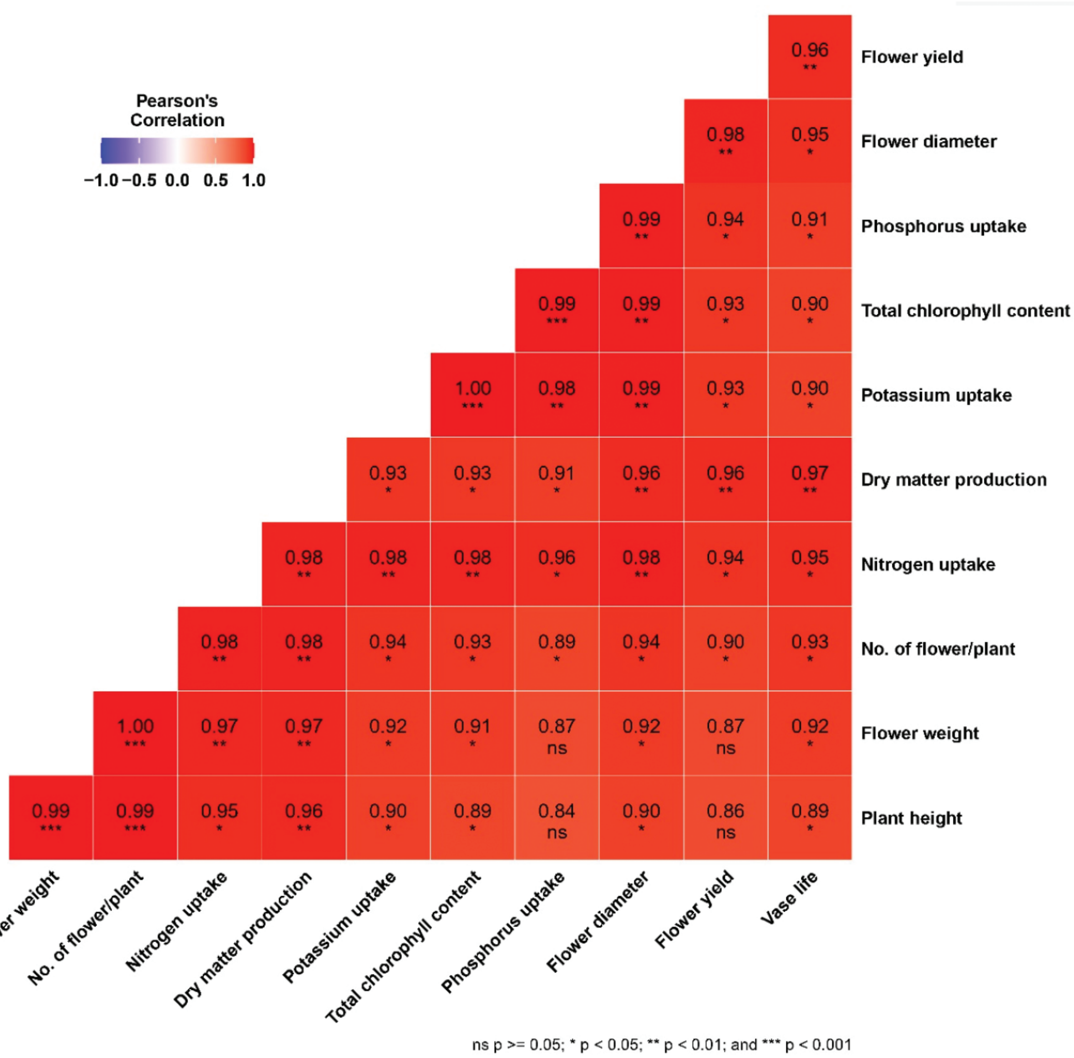

Figure 2: Correlation analysis between nutrient uptake and plant growth attributes with flower yield.

quadrants, suggesting high correlation and proximity among the majority of attributes.

Recommendations and Way Forward from the Study

Sericulture plays a crucial role in the socioeconomic development of rural areas (Vishakanta, 2018). Various socioeconomic studies have confirmed that the benefit-cost ratio of sericulture is higher compared to other agricultural crops, leading to improved socioeconomic status (Deewangan, 2017). Additionally, sericulture waste, such as silkworm excreta and mulberry waste, can enhance soil health through nutrient recycling, reducing the need for chemical fertilisers. Jadhav et al. (2020) highlight the significant impact of sericulture waste on the environment and soil health, which can be further exploited. Furthermore, specific by-products from sericulture waste can be produced by adjusting process parameters to achieve the desired outcomes. For instance, modifying the composting process can yield different types of compost suited for various agricultural or horticultural applications (Qayoom and Manzoor, 2024). By optimising these processes, sericulture waste can be transformed into valuable products such as biofertilisers, biopesticides, or bioenergy sources. This approach reduces waste and adds economic value, turning what would otherwise be a disposal problem into a revenue stream. For example, silkworm excreta can be processed into nutrient-rich compost that enhances soil fertility, while mulberry waste can be converted into mulberry leaf powder, which is high in protein and can be used as animal feed.

This process of repurposing waste aligns with sustainable development goals by promoting circular economy principles, where waste products are continuously recycled into the production cycle. It highlights the interconnectedness of waste management and economic gain, as efficient waste utilization not only mitigates environmental impact but also contributes to the profitability and sustainability of sericulture and related agricultural practices. The potential economic benefits are significant. By developing markets for these by-products, rural economies can be bolstered through the creation of new industries and job opportunities. This, in turn, can lead to improved livelihoods for rural populations, greater food security, and enhanced resilience against economic shocks. Therefore, strategic investment in sericulture waste management can drive both environmental sustainability and economic development.

Conclusion

The study establishes that combined seri-waste compost, coupled with recommended fertilisers, outperforms

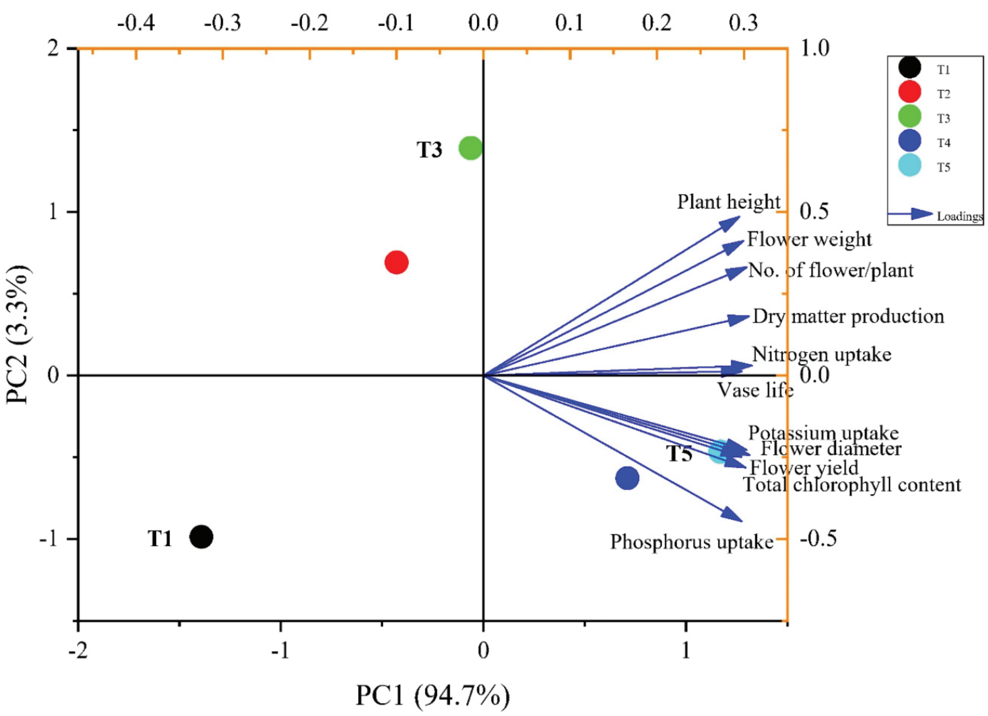

Figure 3: Principal component analysis between nutrient uptake and plant growth attributes with flower yield.

other treatments in economic parameters. This nutrient-rich compost minimises environmental pollution, serves as a viable alternative to inorganic fertilisers, and enhances plant growth and yield. The findings endorse the use of Combined seri-waste compost @ 5 t ha^{-1} with NPK as a beneficial biomanure for agricultural and horticultural crops. This study lays the groundwork for promoting mixed seri-waste compost as a sustainable farming method. However, additional studies and field trials are crucial to validate and optimise its use across diverse agroecosystems and regions.

Conflicts of interest

There are no conflicts to declare.

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References

Ahmed, F., Sultana, R., Ahmed, O. and Md. Toufiq Iqbal (2017). Seriwaste compost enhances mulberry leaf yield and quality in Bangladesh. *American Journal of Plant Nutrition and Fertilization Technology*, **7:** 1-10.

Bouyoucos, G.J. (1936). Directions for making mechanical analyses of soils by the hydrometer method. *Soil Science*, **42(3):** 225-230.

Chaupoo, A.S. and S. Kumar (2020). Integrated nutrient management in marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *International Journal of Current Microbiology and Applied Sciences*, **9(5):** 2927-2939.

Deewangan, S.K. (2017). Employment generation and socioeconomic change through sericulture in Rajgarh District, Chattisgarh, India. *Annals of Natural Sciences*, **3(2)**: 32-42.

Durbin, R.D (1961). Techniques for the observation and isolation of soil microorganisms. *The Botanical Review*, **27:** 522-560.

Filipović, V., Ugrenović, V., Popović, V., Dimitrijević, S., Popović, S., Aćimović, M., Dragumilo, A. and L. Pezo (2023). Productivity and flower quality of different pot marigold (*Calendula officinalis* L.) varieties on the compost produced from medicinal plant waste. *Industrial Crops and Products*, **192:** 116093.

Ganesan, S., Padmapriya, G., Debbarma, A., De Zoysa, A.S.A. and T.H. Tharudini (2022). Eco-friendly approach for sericulture waste management and nutrient enhancement using vermicomposting technology to improve socioeconomic status of Karnataka: A review. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*, **24(2):** 357-360.

Gomez, K. and A. Gomez (1984). *Statistical procedures for agricultural research* (Second). Wiley-Interscience publications.

Hanway, J.J. and H. Heidel (1952). Soil analysis methods as used in the Iowa State College Soil Testing Laboratory. *Iowa Agriculture*, **57(1):** 1-13.

Jackson, M.L. (1958). Soil chemical analysis prentice Hall. *In, Englewood Cliffs, NJ*, **498:** 183–204.

Jackson, M.L. (1973). *Soil chemical analysis-advanced course: A manual of methods useful for instruction and research in soil chemistry, physical chemistry of soils, soil fertility, and soil genesis*. UW-Madison Libraries parallel press.

Jadhav, Y.T., Kiran Kumar Babu, B., Chavan, A.D. and K.N. Tambave (2020). Mulberry and its waste utilization an important socio-economic status in sericulture. *International Journal of Plant Protection*, **13(1)**: 119-124.

John, J.E., Thangavel, P., Balasubramanian, G., Kalaiselvi, T. and E. Kokiladevi (2022). Effect of amendments on Growth and Nutrient uptake of African marigold (*Tagetus erecta*) under Paper and Pulp Mill Effluent Irrigated Soil. *Biological Forum – An International Journal*, **14(1):** 785-789.

Kalaiyarasan, V., Nandhini, D.U. and K. Udhayakumar (2015). Seriwaste vermicompost-A trend of new sustainable generation–A Review. *Agricultural Reviews*, **36(2):** 159-163.

Kathpalia, R. and S.C. Bhatla (2018). Plant Mineral Nutrition. *In:* Plant Physiology, Development and Metabolism. Springer, Singapore. pp. 37-81.

Kaur, M., Bhat, A., Sadik-Zada, E.R. and R. Sharma (2022). Productivity analysis and employment effects of marigold cultivation in Jammu, India. *Horticulturae*, **8(3)**: 263.

Kumar, A., Gautam, R.D., Kumar, A., Singh, S. and S. Singh (2022). Understanding the effect of different abiotic stresses on wild marigold (*Tagetes minuta*) and role of breeding strategies for developing tolerant lines. *Frontiers in Plant Science*, **12:** 754457.

Kumar, P., Singh, A., Laishram, N., Pandey, R.K., Dogra, S., Jeelani, M.I. and B.K. Sinha (2020). Effects of plant growth regulators on quality flower and seed production of marigold (*Tagetes erecta* L.). *Bangladesh Journal of Botany*, **49(3):** 567-577.

Kumawat, A., Gupta, N.K., Jain, N. R. and S. Nayama (2019). Studies on the Effect of Plant Growth Regulators and Micronutrients on Okra (*Abelmoschus esculentus* L) cv. Parbhani Kranti. *International Journal of Current Microbiology and Applied Sciences*, **8:** 3216-3223.

Olsen, S.R., Cole, C.V, Watnab, F.S. and L.A. Decan (1954). *Estimation of available phosphorous in soil byextra action with sodium bicarbonate. US Department of Agriculture,* pp. 939.

Page, A.L. (1982). *Methods of Soil Analysis: Part 2 Chemical and Microbiological Properties, 9.2.2, Second Edition* (Second). The American Society of Agronomy, Inc., Soil Science Society of America, Inc.

Patel, V.D., Patel, G.D., Desai, K.D., Patel, D.J. and B.D. Mangave (2018). Effect of integrated nutrient management on growth and flower yield of African marigold (*Tagetes erecta* L.). *International Journal of Pure and Applied Biosciences*, **6(1)**: 568-572.

Paul, L.C., Al Suman, A. and N. Sultan (2013). Methodological analysis of principal component analysis (PCA) method. *International Journal of Computational Engineering & Management*, **16(2):** 32-38.

Polara, N.D., Gajipara, N.N. and A.V. Barad (2014). Effect of nitrogen and phosphorus on nutrient content and uptake in different varieties of African marigold (*Tagetes erecta* L.). *The Bioscan*, **9(1):** 115-119.

Qayoom, K. and S. Manzoor (2024). Recent Sustainable Practices for Eco-Friendly Utilisation of Sericultural Waste Products. *Journal of Experimental Agriculture International*, **46(7):** 918-927.

Rabhi, M., Ferchichi, S., Jouini, J., Hamrouni, M. H., Koyro, H.W., Ranieri, A., Abdelly, C. and A. Smaoui (2010). Phytodesalination of a salt-affected soil with the halophyte *Sesuvium portulacastrum L. t*o arrange in advance the requirements for the successful growth of a glycophytic crop. *Bioresource Technology*, **101(17):** 6822-6828.

Rangaswamy, R. (2010). A text of agricultural statistics. *New Age International Publishers. New Delhi*, p. 210.

Sangeetha, R., Mahalingam, A.C. and P. Priyadharshini (2012). Effect of silkworm litter–pupal waste compost on mulberry leaf yield. *International Journal of Advanced Life Sciences*, **5(1):**1-5.

Shakib, A.K., Rezaei Nejad, A., Khandan Mirkohi, A. and S.J. Kalate (2019). Vermicompost and manure compost reduce water-deficit stress in pot marigold (*Calendula officinalis* L. cv. Candyman Orange). *Compost Science & Utilization*, **27(1)**: 61-68.

Sharma, G., Sahu, N.P. and N. Shukla (2016). Effect of bio-organic and inorganic nutrient sources on growth and flower production of African marigold. *Horticulturae*, **3(1):** 11.

Sivasankar, S., Ilakkiya, P., Rameshkumar, S., Muruganandam, C. and P.K. Karthikeyan (2021). Effect of organic manures and foliar application of fish amino acid on yield and quality parameters of African marigold (T*agetes erecta* L.). *Plant Archives*, **21(1):** 2532-2534.

Soobhany, N. (2019). Insight into the recovery of nutrients from organic solid waste through biochemical conversion processes for fertilizer production: A review. *Journal of Cleaner Production*, **241**: 118413.

Subbaiah, B.V. and G.K. Asija (1956). A rapid procedure for utilization of available nitrogen in soil. *Current Science*, **26:** 258-260.

Sudhagar, R., Alexander, R., Elisheba, B.P. and S. Kamalakannan (2019). Effect of integrated nutrient management on the growth of African marigold (*Tagetes erecta* L.) CV. local orange. *Journal of Pharmacognosy and Phytochemistry*, **8(3):** 3669-3671.

Sumangala, H.P., Babu, K.R. and T.R. Rupa (2018). Nutrient uptake by African marigold (*Tagetes Erecta* L.) as influenced by fertigation, irrigation and mulching. *Journal of Pharmacognosy and Phytochemistry*, **7(6):** 2005-2009.

Tiwari, H., Kumar, M., Naresh, R.K., Singh, M.K., Malik, S., Singh, S.P. and V. Chaudhary (2018). Effect of organic and inorganic fertilizers with foliar application of gibberellic acid on productivity, profitability and soil health of marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *International Journal of Agricultural and Statistical Sciences,* **14(2):** 575–585.

Vishakanta (2018). Socio-Economic status of sericulture farmers of Ramanagaram district of Karnataka. *International Journal for Research in Applied Science and Engineering Technology,* **6(4)**: 5005-5014.

Walkley, A. and I.A. Black (1934). An examination of the degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, **37(1)**: 29-38.

Ximénez-Embún, P., Rodríguez-Sanz, B., Madrid-Albarrán, Y. and C. Cámara (2002). Uptake of heavy metals by lupin plants in artificially contaminated sand: preliminary results. *International Journal of Environmental & Analytical Chemistry*, **82(11–12):** 805-813.