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Effect of different proportions of cotton stalk, soybean straw and cow dung on the physico-chemical properties of vermicompost and vermicompost leachate

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ABSTRACT

The experiment entitled “Effect of Cotton and Soybean crop residue on Vermicompost and Vermicompost Leachate” was carried out during the year 2025-26 at Centre for Organic Agriculture Research and Training (COART) Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. (M.S.). Seven treatments were evaluated namely T_1 -Cotton Stalk (75%) + Cow dung (25%), T_2 - Cotton Stalk (50%) + Cow dung (50%), T_3 -Cotton Stalk (25%) + Cow dung (75%), T_4 -Soybean straw (75%) + Cow dung (25%), T_5 -Soybean straw (50%) + Cow dung (50%), T_6 -Soybean straw (25%) + Cow dung (75%) and T_7 -Cotton Stalk (33%) + Soybean straw (33%) + Cow dung (34%) were evaluated in a Randomized Block Design (RBD) and replicated thrice. Different yield and post-harvest quality of vermicompost and vermicompost leachate were recorded and the data were analysed using analysis of variance (ANOVA) to assess the significance of variation among the genotypes. Among the seven genotypes evaluated, result revealed that the treatment T_5 showed an overall superior performance for most of the important quality characteristics like pH, EC, and NPK content. It recorded the maximum percentage of Nitrogen, Phosphorous and Potassium after harvest in T_5 vermicompost (1.98%, 1.09% and 1.48% respectively) and vermicompost leachate (215, 33 and 198 ppm), although it remained statistically at par with treatment-4 and other better-performing treatments.

Keywords: Vermicompost, Vermicompost leachate, Cotton stalk, Soybean straw, Cow dung

Introduction

Agriculture depends greatly on the availability of nutrients in the soil for healthy crop growth and good yield. With increasing cropping intensity and continuous cultivation, maintaining soil fertility has become an important challenge. Organic fertilizers are an important part of such sustainable nutrient management practices. Materials such as farmyard manure, compost, vermicompost, crop residues, oilcakes and other plant- and animal-based materials can be used as sources of organic nutrients. Along with supplying nutrients, these materials add organic matter to the soil. As organic fertilizers decompose, nutrients are released gradually and become available to plants.

Cotton and soybean straw are readily available agricultural residues that can be effectively utilized for vermicompost production. Their incorporation into vermicomposting helps convert crop residues into nutrient-rich organic manure through the activity of earthworms and microorganisms. Recycling these residues reduces waste accumulation, improves nutrient recovery, and provides a useful source of organic matter for maintaining soil fertility and supporting sustainable crop production.

Among the various organic waste management technologies, vermicomposting has emerged as an efficient and eco-friendly method for converting biodegradable wastes into valuable organic manure. Vermicomposting is a biological process in which earthworms and microorganisms work together to decompose organic materials and transform them into a stabilized product known as vermicompost (Edwards *et al.*, 1988) [1]. This process not only facilitates the effective management of organic wastes but also helps minimize the environmental problems associated with their accumulation. Vermicompost serves as a valuable source of organic matter and essential plant nutrients and may contain biologically active substances, including enzymes, vitamins and plant growth-promoting compounds. Its application can improve soil fertility, enhance nutrient availability and promote plant growth.

With the continuous increase in global food demand, efficient utilization of organic waste resources has become essential for maintaining agricultural sustainability. Organic residues generated from agricultural and livestock activities contain significant quantities of nutrients and organic matter that can be recycled back into production systems. Cotton stalks contain about 1.11% nitrogen, 0.10% phosphorus, and 3.98% potassium, while soybean stalks contain approximately 51.1% organic carbon, 1.05% nitrogen, 0.20% phosphorus, and 2.20% potassium (Pandirwar *et al.*, 2023; Kausadikar *et al.*, 2020) [3, 2]. However, direct application of undecomposed organic materials may lead to nutrient immobilization, phytotoxic effects and inefficient

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nutrient utilization. Conversion of such residues into vermicompost and vermicompost leachate offers an effective means of transforming waste into valuable agricultural inputs.

Material and Methodology

The field experiment entitled “Effect of Cotton and Soybean crop residue on Vermicompost and Vermicompost Leachate” was carried out during the year 2025-26 at Centre for Organic Agriculture Research and Training (COART) Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. (M.S.). Seven treatments were evaluated namely T₁- Cotton Stalk (75%) + Cowdung (25%), T₂- Cotton Stalk (50%) + Cowdung (50%), T₃- Cotton Stalk (25%) + Cowdung (75%), T₄- Soybean straw (75%) + Cowdung (25%), T₅- Soybean straw (50%) + Cowdung (50%), T₆- Soybean straw (25%) + Cowdung (75%) and T₇- Cotton Stalk (33%) + Soybean straw (33%) + Cowdung (34%) were evaluated in a Randomized Block Design (RBD) and replicated thrice in the cement tanks of length 0.90 m, width 0.45 m and height 0.30 m and total 20 kg material was used for one cement tank.

The pH of vermicompost and vermicompost leachate samples was determined using a digital pH meter equipped with a combined electrode and thermo probe.

The electrical conductivity of samples was determined from the clear supernatant of overnight-kept suspensions.

Total nitrogen content of the vermicompost and vermicompost leachate samples was determined by the Kjeldahl method using a modified sulfuric acid-salicylic acid digestion mixture (Jackson, 1973) [4].

Total phosphorous of vermicompost and vermicompost leachate was determined by Vanadomolybdate phosphoric acid, yellow colour method using spectrophotometer (Jackson, 1967) [5].

Total potassium of vermicompost and vermicompost leachate was determined by neutral normal ammonium acetate using flame photometer (Jackson, 1973) [4].

Result and Discussion

pH of vermicompost and vermicompost leachate

At initial stage the pH of vermicompost and vermicompost leachate was found superiorly lowest for treatment T₄ (75% soybean straw + 25% cow dung) i.e. 7.57 and 7.85 respectively. However, highest pH

of vermicompost and vermicompost leachate was found in treatment T₆ (25% soybean straw + 75% cow dung) i.e. 8.01 and 8.45 respectively.

At maturity of vermicompost, the lowermost pH (7.02) was recorded with T₅ (50% soybean straw + 50% cow dung), followed by T₄ (7.13), T₇ (7.18), T₂ (7.25), T₁ (7.31) and T₆ (7.35). The highest pH (7.44) was registered with treatment T₃ (25% cotton stalk + 75% cow dung). Similarly, in vermicompost leachate, the lowest pH (7.65) was recorded with T₅ (50% soybean straw + 50% cow dung), followed by T₄ (7.72), T₇ (7.76), T₂ (7.84), T₁ (7.91) and T₆ (7.97). The maximum pH (8.05) was observed with T₃ (25% cotton stalk + 75% cow dung).

The decrease in pH during vermicomposting may be associated with decomposition of organic matter and formation of organic acids during microbial activity. The comparatively lower pH under T₅ indicates greater biochemical transformation of the organic substrates.

The observed decline in pH is in agreement with the findings of Garg *et al.* (2006) [6], Suthar (2009) [7] and Najjar *et al.* (2010) [8], who reported a reduction in pH and related it to the production of carbon dioxide, organic acids and mineralization of organic matter.

EC of vermicompost and vermicompost leachate

The rise in EC was observed from the initial stage to maturity in all the treatments. At initial stage, the EC of VC and VCL was found considerably higher for treatment T₄ (75% soybean straw + 25% cow dung) i.e. 1.04 and 1.08, respectively. However, lowest EC of VC and VCL was found in treatment T₆ (25% soybean straw + 75% cow dung) i.e. 0.63 and 0.82, respectively.

At maturity of vermicompost, significantly highest EC (2.35 dSm⁻¹) was recorded with T₅ (50% soybean straw + 50% cow dung). It was followed by T₄ (1.89 dSm⁻¹), T₇ (1.99 dSm⁻¹), T₂ (1.79 dSm⁻¹), T₁ (1.64 dSm⁻¹) and T₆ (1.45 dSm⁻¹). The lowest EC (1.30 dSm⁻¹) was recorded with T₃ (25% cotton stalk + 75% cow dung).

In vermicompost leachate, the highest EC at maturity (1.58 dSm⁻¹) was noted with treatment T₅ (50% soybean straw + 50% cow dung), followed by T₄ (1.46 dSm⁻¹), T₇ (1.36 dSm⁻¹), T₂ (1.28 dSm⁻¹), T₁ (1.18 dSm⁻¹), T₆ (1.10 dSm⁻¹). The least EC (1.04 dSm⁻¹) was measured with treatment T₃ (25% cotton stalk + 75% cow dung).

Table 1. pH of vermicompost and vermicompost leachate as influenced by cotton stalk and soybean straw treatments.

Treatment	pH			
	Vermicompost		Vermicompost leachate	
	Initial	At maturity	Initial	At maturity
T ₁ : Cotton Stalk (75%) + Cow dung (25%)	7.68	7.31	7.95	7.91
T ₂ : Cotton Stalk (50%) + Cow dung (50%)	7.74	7.25	8.10	7.84
T ₃ : Cotton Stalk (25%) + Cow dung (75%)	7.89	7.44	8.35	8.05
T ₄ : Soybean straw (75%) + Cow dung (25%)	7.57	7.13	7.85	7.72
T ₅ : Soybean straw (50%) + Cow dung (50%)	7.79	7.02	8.25	7.65
T ₆ : Soybean straw (25%) + Cow dung (75%)	8.01	7.35	8.45	7.97
T ₇ : Cotton Stalk (33%) + Soybean Straw (33%) + Cow dung (34%)	7.65	7.18	8.05	7.76
SE(m)±	0.04	0.03	0.02	0.01
CD at 5%	0.12	0.09	0.07	0.04
GM	7.76	7.24	8.14	7.84

The increase in EC from the initial stage to maturity in both VC and VCL may be attributed to the progressive decomposition of crop residues and release of soluble mineral constituents during vermicomposting. The activity of earthworms and microorganisms converts nutrients present in organic matter into dispersible forms, thereby increasing the concentration of soluble salts and consequently EC.

Similar findings were reported by Kaviraj *et al.* (2003) [9], Najjar *et al.* (2010) [8] and Mayadevi *et al.* (2016) [10], supporting the increase in EC observed in the present study.

influenced by cotton stalk and soybean straw treatments.

Total nitrogen

content of vermicompost and vermicompost leachate.

The data pertaining to total nitrogen content of vermicompost and vermicompost leachate are presented in Table 3 and graphically illus-

trated in Fig. 1 and 2. The total nitrogen content increased from the initial to the final stage in all the treatments.

Table 2. EC (dSm⁻¹) of vermicompost and vermicompost leachate

Treatment	Vermicompost		Vermicompost leachate	
	Initial	At maturity	Initial	At maturity
T ₁ : Cotton Stalk (75%) + Cow dung (25%)	0.85	1.64	0.99	1.18
T ₂ : Cotton Stalk (50%) + Cow dung (50%)	0.82	1.79	0.95	1.28
T ₃ : Cotton Stalk (25%) + Cow dung (75%)	0.74	1.30	0.87	1.04
T ₄ : Soybean straw (75%) + Cow dung (25%)	1.04	1.89	1.08	1.46
T ₅ : Soybean straw (50%) + Cow dung (50%)	0.77	2.35	0.90	1.58
T ₆ : Soybean straw (25%) + Cow dung (75%)	0.63	1.45	0.82	1.10
T ₇ : Cotton Stalk (33%) + Soybean Straw (33%) + Cow dung (34%)	0.90	1.99	1.02	1.36
	SE(m)± 0.04	0.07	0.01	0.01
	CDat5% 0.13	0.23	0.03	0.04
	GM 0.82	1.80	0.95	1.29

In vermicompost, the initial total N content ranged from 0.54 to 1.08 % and increased to 1.42 to 2.15 % at the final stage. Similarly, the total N content of vermicompost leachate elevated from 56.70 to 80.11 ppm initially to 153.00 to 215.00 ppm at the final stage.

At initial stage, total N content in both VC and VCL was maximum in treatment T₄ i.e. 1.08% and 80.11 ppm, respectively. The bottommost content was recorded in treatment T₆ (0.54% and 56.70 ppm), respectively.

At maturity of vermicompost, the maximum total N concentration (1.98%) was reported with treatment T₅ (50% soybean straw + 50% cow dung). It was followed by T₄ (1.85%), T₇ (1.82%), T₂ (1.63%), T₁ (1.59%), T₆ (1.47%) and T₃ (1.42%). The least total N content (1.42%) was observed with T₃ (25% cotton stalk + 75% cow dung), which was statistically at par with treatment T₆ (1.47%).

In vermicompost leachate, appreciably higher total N content at maturity (215.00 ppm) was recorded with T₅ (50% soybean straw + 50% cow dung), followed by T₄ (197.00 ppm), T₇ (192.00 ppm), T₂ (185.00 ppm), T₁ (179.00 ppm), T₆ (163.00 ppm) and T₃ (153.00 ppm). The lesser total nitrogen content (153.00 ppm) was recorded with T₃ (25% cotton stalk + 75% cow dung).

The enrichment in nitrogen content during vermicomposting may be attributed to organic matter decomposition, nitrogen mineralization, and carbon loss through microbial respiration, facilitated by earthworm and microbial activity.

leachate as influenced by cotton and soybean straw treatments.

The documented increase in N content is in conformity with the observations reported by Manna *et al.* (1997) [11], Suthar (2009) [7], Gajbhiye *et al.* (2014) [12], and Borang *et al.* (2016) [13].

Total phosphorus content of vermicompost and vermicompost leachate

The data on total phosphorus content of vermicompost and vermicompost leachate as influenced by different treatments is presented in Table 4 and graphically illustrated in Fig. 1 and 2. An increase in total phosphorus content was observed from the initial stage to maturity in all the treatments.

At initial stage, the total phosphorus content of vermicompost and vermicompost leachate was found substantially higher in treatment T₄

(75% soybean straw + 25% cow dung), i.e. 0.35% and 13.80 ppm, respectively. However, the lowest total phosphorus content of vermicompost and vermicompost leachate was recorded in treatment T₃ (25% cotton stalk + 75% cow dung), i.e. 0.17% and 11.50 ppm respectively.

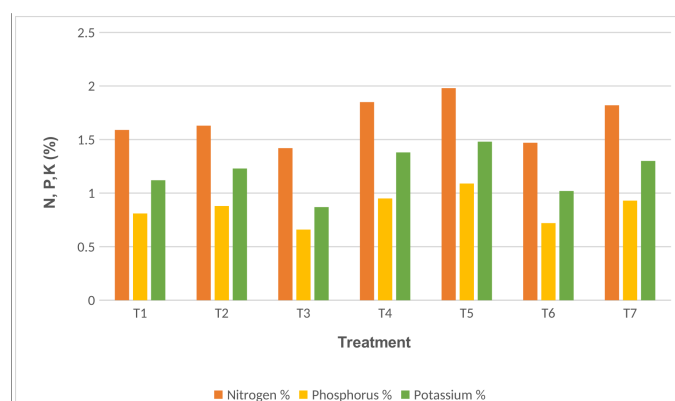


Figure 1. Total NPK (%) concentration of vermicompost as influenced by cotton stalk and soybean straw treatments.

At maturity of vermicompost, statistically superior total phosphorus content (1.09%) was recorded with T₅ (50% soybean straw + 50% cow dung). It was followed by T₄ (0.95%), T₇ (0.93%), T₂ (0.88%), T₁ (0.81%), T₆ (0.72%) and T₃ (0.66%). The lowest phosphorus content (0.66%) was recorded with T₃ (25% cotton stalk + 75% cow dung), which was at par with T₆ (0.72%).

In vermicompost leachate, significantly highest phosphorus content at maturity (33.00 ppm) was registered with treatment T₅ (50% soybean straw + 50% cow dung), followed by T₄ (30.00 ppm), T₇ (28.00 ppm), T₂ (27.00 ppm), T₁ (23.00 ppm) and T₆ (20.00 ppm). The significantly inferior phosphorus content (18.00 ppm) was noted with T₃ (25% cotton stalk + 75% cow dung).

leachate as influenced by cotton and soybean straw treatments.

Table 3. Total Nitrogen content in vermicompost and vermicompost leachate

Treatment	N (%)		N (ppm)	
	Vermicompost		Vermicompost leachate	
	Initial	Final	Initial	Final
T ₁ : Cotton Stalk (75%) + Cow dung (25%)	0.95	1.59	77.00	179.00
T ₂ : Cotton Stalk (50%) + Cow dung (50%)	0.83	1.63	66.13	185.00
T ₃ : Cotton Stalk (25%) + Cow dung (75%)	0.71	1.42	59.47	153.00
T ₄ : Soybean straw (75%) + Cow dung (25%)	1.08	1.85	80.11	197.00
T ₅ : Soybean straw (50%) + Cow dung (50%)	0.79	1.98	61.00	215.00
T ₆ : Soybean straw (25%) + Cow dung (75%)	0.54	1.47	56.70	163.00
T ₇ : Cotton Stalk (33%) + Soybean Straw (33%) + Cow dung (34%)	0.87	1.82	73.38	192.00
SE(m)±	0.014	0.04	2.438	5.40
CD at 5%	0.043	0.12	7.512	16.65
GM	0.82	1.68	67.68	183.43

The increase in phosphorus content may be attributed to organic matter decomposition, phosphorus mineralization, and solubilization by earthworm enzymes and microorganisms. The higher phosphorus content in T₅ may be due to the balanced soybean straw and cow

dung proportion, promoting efficient decomposition and phosphorus release.

The observed increase in phosphorus content is in conformity with the findings of Suthar (2009) [7], Nedunchezhiyan *et al.* (2011) [14] and Gajbhiye *et al.* (2014) [12].

Table 4. Total Phosphorus content in vermicompost and vermicompost leachate

Treatment	P (%)		P (ppm)	
	Vermicompost		Vermicompost leachate	
	Initial	Final	Initial	Final
T ₁ : Cotton Stalk (75%) + Cow dung (25%)	0.28	0.81	13.20	23.00
T ₂ : Cotton Stalk (50%) + Cow dung (50%)	0.23	0.88	12.10	27.00
T ₃ : Cotton Stalk (25%) + Cow dung (75%)	0.17	0.66	11.50	18.00
T ₄ : Soybean straw (75%) + Cow dung (25%)	0.35	0.95	13.80	30.00
T ₅ : Soybean straw (50%) + Cow dung (50%)	0.21	1.09	11.90	33.00
T ₆ : Soybean straw (25%) + Cow dung (75%)	0.19	0.72	11.70	20.00
T ₇ : Cotton Stalk (33%) + Soybean Straw (33%) + Cow dung (34%)	0.26	0.93	12.60	28.00
SE(m)±	0.01	0.04	0.06	0.87
CD at 5%	0.04	0.13	0.20	2.67
GM	0.24	0.86	13.20	25.27

Total potassium

content of vermicompost and vermicompost leachate.

The data pertaining to total potassium content of vermicompost and vermicompost leachate as influenced by different treatments is presented in Table 5 and graphically illustrated in Fig. 1 and 2.

The initial potassium content of vermicompost ranged from 0.38 to 0.72 per cent within the treatments. The highest initial potassium content was recorded in T₄ (0.72%) whereas, the lowest was observed in T₆ (0.38%). In vermicompost leachate, the initial potassium content ranged from 137.10 to 150.00 ppm, with the highest value recorded in treatment T₄ (150.00 ppm) and the lowest in T₆ (137.10 ppm).

At maturity of vermicompost, maximally elevated potassium content (1.48%) was recorded with T₅ (50% soybean straw + 50% cow dung), followed by T₄ (1.38%), T₇ (1.30%), T₂ (1.23%), T₁ (1.12%) and T₆ (1.02%). The lowest potassium content (0.87%) was noticed with treatment T₃.

The highest potassium concentration at maturity of vermicompost leachate (198 ppm) was registered with treatment T₅ (50% soybean straw + 50% cow dung), followed by T₄ (177 ppm), T₇ (170 ppm), T₂ (162 ppm) and T₁ (155 ppm). T₆ treatment recorded 147 ppm, while

the minimal concentration (133 ppm) was documented with treatment T₃.

The results are in conformity with the findings of Shailaja (2005) [15], Suthar (2008) [16] and Nedunchezhiyan *et al.* (2011) [14].

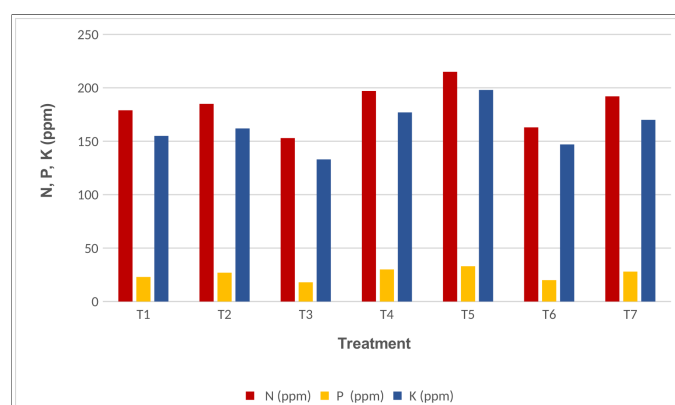
**Figure 2.** Total NPK (ppm) concentration of vermicompost leachate as influenced by cotton and soybean straw treatments

Table 5. Total Potassium content in vermicompost and vermicompost leachate.

Treatment	K (%)		K (ppm)	
	Vermicompost		Vermicompost leachate	
	Initial	Final	Initial	Final
T ₁ : Cotton Stalk (75%) + Cow dung (25%)	0.58	1.12	147.78	155.00
T ₂ : Cotton Stalk (50%) + Cow dung (50%)	0.50	1.23	144.01	162.00
T ₃ : Cotton Stalk (25%) + Cow dung (75%)	0.43	0.87	134.00	133.00
T ₄ : Soybean straw (75%) + Cow dung (25%)	0.72	1.38	150.00	177.00
T ₅ : Soybean straw (50%) + Cow dung (50%)	0.48	1.48	140.66	198.00
T ₆ : Soybean straw (25%) + Cow dung (75%)	0.38	1.02	137.10	147.00
T ₇ : Cotton Stalk (33%) + Soybean Straw (33%) + Cow dung (34%)	0.55	1.30	145.91	170.00
SE(m)±	0.010	0.029	0.85	6.16
CD at 5%	0.030	0.088	2.62	18.99
GM	0.52	1.20	142.78	163.86

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