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Effect of co-compost and vermicompost on yield and yield attributing parameters of *Abelmoschus esculentus* in acidic soil

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Abstract
A pot culture experiment was conducted at department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar taking *Abelmoschus esculentus***,** common name: Okra (variety *Anushri*) as the crop in acidic soil.

Co-compost (A stabilized organic product produced by controlled aerobic decomposition of organic compounds using more than one feed stock. Sources included industrial, agricultural or urban domestic household materials like sewage sludge, animal excreta, urban solid waste and plant residues etc.) was applied alongwith vermicompost in different treatment combinations. The treatments were [T_1: Absolute control, T_2: 100% soil test dose (STD),

T_3: 100%-N (vermicompost @ 7.6 t/ha), T_4: 50%-N (vermicompost @ 3.8 t/ha), T_5: 100% N (co-compost @ 9.1 t/ha), T_6: 50%-N (co-compost @ 4.55 t/ha), T_7: STD (100%)-N+ vermicompost @ 2 t/ha, T_8: STD (100%)-N + co-compost @ 2 t/ha, T_9: STD (75%)-N + Co-compost (25%)-N, T_{10}: STD (50%)-N + co-compost (50%)-N]. Yield and yield attributing parameters, such as, plant height, number of days to 1st flowering, number of fruits per plant, fruit weight, biomass yield and nutrient uptake etc. were observed and found that, okra fruit yield per plant was maximum in T_7 and minimum in T_1. The treatment T_8 was found to be statistically at par with T_7. All the yield attributing parameters also followed the same trend.

Keywords: Okra, Co-compost, vermicompost, yield and yield attributing parameters, soil test dose (STD)

Introduction
Natural farming can be characterised by avoiding the use of chemicals and relying on a diverse agroecological system, including crops, trees, and livestock. It focuses on using resources generated on the farm, optimizing functional biodiversity, thereby encouraging farmers to forgo the use of industrial pesticides and artificial fertilizers. Research indicates that natural farming is not only more productive and sustainable but also more water-efficient and ecologically beneficial for both farms and soil (Devarinti, 2016; Tiwari & Raj, 2020) [4, 5]. In this experiment, co-compost has been used as a component of natural farming, which is a stabilized organic product produced by controlled aerobic decomposition of organic compounds using more than one feed stock. It can be effectively utilized for all crops alongwith fertilizers to improve the nutrient use efficiency. The use of chemical fertilizer can be reduced by 37-44% by the use of co-compost (Fendel *et al.*, 2022) [5]. Co-compost enhances soil nutrient content, making it more suitable for producing high yields (Singh *et al.*, 2012) [13]. The quality of vegetables and the sale price was increased by the application of co-compost in vegetables, as per the result conducted in farmers' field in Tamil Nadu (Yazhini *et al.*, 2022) [16]. Co-composting using municipal and agricultural waste materials promises safe, economic and eco-friendly solution for bringing out organic fertilizers as part of resource recovery as reported by Zhang *et al.*, 2014 [17].

Okra is a vital vegetable crop extensively grown in tropical and subtropical regions for its tender, non-fibrous green pods. These nutritious pods are considered a powerhouse of valuable nutrients and can be used in various ways, such as boiling, canning, freezing, or drying, and are often added to soups and curries.

Additionally, okra is a rich source of iodine, which helps prevent goiter. Fresh okra fruits contain 2.1 g of protein, 0.2 g of fat, 8 g of carbohydrates, 36 calories, 1.7 g of fiber, and 175.2 mg of minerals, including 103 mg of potassium, 6.9 mg of sodium, 56 mg of phosphorus, 66 mg of calcium, 1.5 mg of iron, 30 mg of sulfur, 88 ml of water, 88 IU of vitamin A, 0.07 mg of thiamine, 0.1 mg of riboflavin, and 13 mg of vitamin C per 100 g of the edible portion (Tindall, 1983; Berry *et al.*, 1988) [14, 2]. Application of vermicompost and poultry manure subsequently increase yield attributing characters and yield of okra (Sameera *et al.*, 2005) [12]. The effect of co-compost and vermicompost on yield and yield attributing parameters was studied in this experiment.

Materials and Methods

Experimental site: The pot culture experiment was conducted at AICRP on Micronutrients unit of Department of Soil Science and Agricultural Chemistry in the campus of College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar in 2023-2024. Bhubaneswar is situated in East and South Eastern coastal plain agroclimatic zone of Odisha and lies at 20°15” N latitude, 85°55” E longitude, an altitude of 25.9 meters above mean sea level and nearly 64 km towards west of Bay of Bengal. Climate of Bhubaneswar is humid-tropic and it experiences moist and warm climate with hot and humid summer and mild winter, average annual rainfall of 1467.05 mm and average annual temperature of 27.9 °C.

Experimental soil characteristics: The experimental soil is acidic in nature, with following nutrient contents. (Table 1)

Pot culture experiment details

Test crop: Okra (Variety-*Anushri*),
Scientific name: *Abelmoschus esculentus* (L.) Moench
Family: Malvaceae
Duration-90 Days
Recommended dose of fertilizer @ 100-50-50 kg N-P_2O_5-K_2O ha^{-1}
Compost used: Co-compost (CC) and vermicompost (VC)

The experiment was laid out in Completely Randomized Design (CRD) with 10 treatments, replicated thrice in acid soil of Odisha.

Observations recorded

The plants were harvested at maturity and yield attributing parameters were recorded. Plant height was measured at 30 and 60 days after sowing and after harvest, the number of days from the date of seeding to the date of first flowering, number of fruits harvested from the plant in each treatment, weight of tender fruits and average yield was recorded individually for each pot. Sample taken from the plants were oven dried at 60 °C and reduction in the weight was recorded consistently. When constant dry weight was found for few days, dry weight was taken and harvest index was calculated.

$$\text{Harvest Index} = \frac{\text{Fruit yield}}{\text{fruit yield + stover yield}} \times 100$$

Uptake of nutrients (N, P, K, Ca and Mg) was computed by multiplying the respective nutrient concentration to dry matter yield obtained.

$$\text{Uptake of nutrients (kg/ha)} = \frac{\text{Nutrient content (\%) x Dry matter yield}}{100}$$

Statistical analysis

All the data pertaining to the present investigation were statistically analyzed by Analysis of Variance (ANOVA) as per the method described by Gomez and Gomez, 1984. The statistical significance of various treatment effects was tested at 5 per cent level of probability. In order to test the significance of mean differences between treatments, the following statistical parameters were computed.

SEm (±) = √(Error MS/No. of replications)

CD (p = 0.05) = SEm x t value x √2

Results and Discussion

The nutrient content of co-compost and vermicompost is mentioned in table 2. It was observed that, pH of co-compost was slightly alkaline, may be due to presence of cations and release of acids at the time of decomposition. Presence of the plant nutrients in the form of soluble salts may have increased the EC values of both CC and VC. Organic carbon was slightly more in vermicompost than co-compost and N was slightly more on vermicompost than co-compost. This variation may be due to inputs and ingredients used for co-compost and vermicompost preparation. The carbon nitrogen ratio (C:N ratio) of 12.9, indicated that well decomposed and maintenance of the proper ratio of C & N in compost. N, P, K, Ca, Mg of vermicompost was higher than co-compost because of the source material used for preparation and handling after preparation. Heavy metals content like Cd, Pb, Ni were found below permissible limit of compost. Pb content was higher than other but within the permissible limit, which might be find route to petrochemicals, fossil fuel or geogenic. This result was in accordance with the report by Khater, 2015.

Plant height (cm)

The height at 30 and 60 days after sowing and at maturity stage (90 days after sowing) were recorded and presented in table 3. It was revealed that with the age of the crop, plant height increased. Maximum plant height (64.32 cm) in T_7 and minimum (44.92 cm) in T_1 was recorded at maturity. Similar trend was observed in % increase in plant height over control. The plant height recorded in T_2, T_7, T_8 and T_9 were statistically at par and significantly different from rest other treatments. Application of soil test dose of nutrients with the vermicompost helped in supplying appropriate quantity of nutrient required by the crop at different growth stage where non application of ever manure and fertilizer restricted the height of plant in control treatment. T_8 showed higher heights compared to the other combination. This type of result where also reported by Khatun *et al.*, 2020 [8] and Akber and Joardar, 2020 [1] in okra crop.

Days to first flowering

Flowering at comparatively earlier stage increased the yield of the crop. First flowering was observed at 35 days in T_7, which was lesser than other treatments, followed by T_8 and longer (48 days) in T_1 was observed (Table 3). Lesser days to first flowering made the plant able to bear more number of flowers, ultimately increasing the yield of crop.

Number of fruits per plant and fruit weight
Maximum no. of fruits (15) in T_7 and minimum (7) in T_1 was recorded (Table 3). The no. of fruits observed in T_2, T_7, T_8 and T_9 were statistically at par and significantly different from other treatments. Similar trend was observed in fruit weight. The number of fruits trend was due to application of organic manure with chemical fertilizer to light texture, acid soil with low fertility. Okra being a nutrient responsive crop showed higher number of fruit content to the application of chemical fertilizer with compost either in the form of co-compost or vermicompost. Although T_8 (co-compost with STD) recorded the second maximum weight of fruit per plant but statistically at par with T_7.

Fruit yield and % yield increase over control
Maximum yield and % yield increase over control was evaluated and found to be maximum (128.87 g/plant) in pot having STD and 2 t/ha vermicompost, followed by having 2 t/ha co-compost (Table 4). Lowest yield was recorded in absolute control. The same observation was recorded by Pandiyan *et al.*, 2020 in sugarcane.

Total biomass (Dry matter Yield) and Harvest Index
T_7 receiving STD with 2 t/ha vermicompost had maximum biomass yield between fresh and dry compared to other treatments, may be because of the supply of nutrients in smooth harmony with the nutrient requirement of the crop through chemical fertilizer and vermicompost. The treatment application of 2 t/ha of co-compost was at par. Application of co-compost helped in creating a positive, congenial, edaphic condition for better availability, water, air, nutrients, temperature and other nutrients in the experimental pot soil. Different combinations of organic and inorganic exhibited the biomass yield accordingly whereas absence of organics application resulted with lower biomass. D'Hose *et al.*, 2012 [3] also confirmed that co-composted animal manure considerably increased dry matter yield of potatoes, fodder beets, forage maize, okra and Brussels sprouts. The HI percentages, which are a key indicator of the efficiency of resource allocation between plant organs, were noticeably affected by the application co-compost and exhibited a range from 64.6 to 70.8%. Highest value was observed in the treatment receiving STD with 2t per hectare vermicompost, which was due to the highest biomass yield in this treatment with the impacts of nutrient source applied to it. This type of findings was reported by Kumar and Prasad, 2020.

Nutrient uptake (N, P, K)
It was observed from the table 5 that uptake of N per plant varied from 0.141 g/plant to 0.290 g/plant in different treatments. It was lowest in control and highest in T_7, receiving 100% N through chemical source with 2 t/ha vermicompost. The same trend was followed for P and K uptake by okra crop. Maximum uptake was due to more fruit yield and stover, which was further increased due to more concentration in fruit and stover compared to other treatments.
The P uptake found in T_3, T_4, T_5, T_6 and T_{10} were statistically at par. Application of organic manure, either in the form of co-compost or vermicompost increased the nutrient uptake for better growth of plants. Malhi, 2012 also reported that the application of organic manures favoured the uptake of N, K and S in wheat. K uptake was lowest in control and highest in treatment receiving 100% N through chemical source with 2 t/ha vermicompost. K applied through 100% chemical source with 2 t of vermicompost per ha was at par with 100% chemical source with 2 t of co-compost per ha.

Table 1: Initial characteristics of experimental soil

Parameters	Value
Soil texture	Sandy loam
Bulk Density (Mg/m^3)	1.42
pH_w(1:2.5)	5.53
EC (dS/m)	0.06
Organic carbon (%)	0.68
Available Nitrogen (kg/ha)	344.42
Available Phosphorous (kg/ha)	38.71
Available Potassium (kg/ha)	91.28
Exchangeable Ca (cmol (p+)/kg)	1.32
Exchangeable Mg (cmol (p+)/kg)	0.81
DTPA Fe (mg/kg)	138.46
DTPA Mn (mg/kg)	36.72
DTPA Cu (mg/kg)	4.94
DTPA Zn (mg/kg)	1.27
DTPA Ni (mg/kg)	0.58
DTPA Cd (mg/kg)	Trace
DTPA Cr (mg/kg)	Nil
DTPA Pb (mg/kg)	Trace

Table 2: Characterization of Co-compost (CC) and vermicompost (VC)

Parameters	Co-compost	Vermicompost
pH_w(1:2.5)	7.12	7.14
EC (dS/m)	4.55	3.62
OC (%)	14.2	15.6
N (%)	1.1	1.3
C:N ratio	12.9	12.0
P (%)	0.52	0.82
K (%)	0.97	1.21
Ca (%)	0.86	1.08
Mg (%)	0.45	0.46
Fe (mg/kg)	213.65	175.00
Mn (mg/kg)	95.2	92.3
Cu (mg/kg)	12	16
Zn (mg/kg)	18.8	19.7
Cd (mg/kg)	2.33	0.51
Cr (mg/kg)	Nil	Nil
Pb (mg/kg)	7.25	1.32
Ni (mg/kg)	2.14	1.33

Table 3: Effect of co-compost on plant height (cm), days to flowering, no. of fruits per plant, fruit weight (g)

Treatment	30 days after sowing	60 days after sowing	Maturity (90 days after sowing)	Percentage increase in plant height over control (%)	Days to flowering	No. of fruits per plant	Fruit weight (g)
T_1	12.23	29.42	44.92	-	48	7	14.45
T_2	16.75	39.76	61.25	40.34	40	13	18.34
T_3	16.26	35.44	54.39	31.08	41	11	17.27
T_4	14.84	32.40	52.53	29.61	45	9	15.86
T_5	15.87	34.15	54.31	30.90	43	10	17.12
T_6	14.56	31.38	52.20	28.21	45	9	15.59
T_7	18.63	41.62	64.32	43.17	35	15	20.20
T_8	17.54	40.43	62.98	42.52	37	14	19.65
T_9	17.12	40.14	61.75	41.79	38	13	18.46
T_{10}	15.35	33.52	60.56	30.47	44	9	16.35
SEm (±)	0.77	1.30	2.58	1.19	2.4	0.9	0.90
CD (p = 0.05)	2.29	3.84	7.62	3.52	7.0	2.7	2.65

Table 4: Effect of co-compost on fruit yield and yield increase over control (%), biomass yield (dry matter), harvest index

Treatment	Yield (g/plant)	Yield increase (%)	Biomass yield (g per plant)			HI
			Stover	Fruit	Total	
T_1	95.89	-	18.91	34.61	53.53	64.6
T_2	125.23	30.98	23.17	55.46	78.63	70.5
T_3	120.16	25.32	22.42	48.15	70.57	68.1
T_4	116.41	21.42	21.32	43.62	64.94	67.1
T_5	118.82	23.90	22.12	45.90	68.02	67.4
T_6	115.84	20.83	21.23	43.22	64.45	67
T_7	128.87	34.42	24.87	60.56	85.43	70.8
T_8	127.32	32.80	24.37	57.06	81.43	70
T_9	125.85	31.28	23.45	55.89	79.34	70.4
T_{10}	117.32	22.37	22.69	42.57	65.27	65.2
SEm(±)	1.64	1.16	0.65	1.28	3.86	
CD (p = 0.05)	4.86	3.44	1.91	3.79	11.39	

Table 5: Effect of co-compost on macronutrient uptake (g/plant)

Treatment	N uptake	P uptake	K uptake
T_1: Absolute control	0.109	0.014	0.069
T_2: 100% STD	0.239	0.079	0.147
T_3: 100%-N (VC @ 7.6t/ha)	0.189	0.046	0.117
T_4: 50%-N (VC @ 3.8t/ha)	0.168	0.043	0.112
T_5: 100%-N (CC @ 9.1 t/ha)	0.172	0.044	0.115
T_6: 50%-N (CC @ 4.55 t/ha)	0.166	0.040	0.111
T_7: STD (100%)-N+ VC @ 2 t/ha	0.252	0.088	0.165
T_8: STD (100%)-N +CC @ 2 t/ha	0.245	0.084	0.159
T_9: STD (75%)-N + CC (25%)-N	0.242	0.081	0.152
T_{10}: STD (50%)-N + CC (50%)-N	0.235	0.051	0.113
SEm(±)	0.014	0.003	0.003
CD (p = 0.05)	0.040	0.010	0.010

Conclusion
Addition of co-compost @ 2 t/ha with chemical fertiliser enhances the marketable yield, which increases the profit, compared to other treatments. Higher benefit creates a positive mindset of the farmer towards the acceptability of technology. Application of 2 t/ha co-compost with STD for okra crop is statistically at par with that of STD + 2 t/ha of vermicompost with regard to yield, uptake and yield attributing parameters etc. But presence of few toxic elements like Cd, Pb and Ni may limit its use in agricultural crop, particularly in edible vegetables. In order to enable the good quality of co-compost the elements should be avoided at the time of preparation.

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