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Note

Growth, yield and biochemical responses of cowpea (*Vigna unguiculata*) to fish silage enriched vermicompost

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ABSTRACT

The study investigated effect of vermicompost enriched with fish silage on the growth, yield and biochemical constituents of cowpea. The experiment was laid out in a randomised complete block design (RCBD) in three replicates with plot size of 2.0×2.0 m each. The treatments were chemical fertiliser (CF) (100 kg urea + 300 kg single super phosphate ha^{-1}), fish silage enriched vermicompost (VCS) (3.33 t of enriched vermicompost and 300 kg single super phosphate ha^{-1}) and vermicompost (VC) (4.5 t vermicompost + 300 kg single super phosphate ha^{-1}). Data on growth and yield parameters of cowpea were analysed. Chlorophyll and carotenoid content of the leaves were also estimated. Results showed that cowpea performed best with the enriched vermicompost in terms of average yield of fruits per plant (209.27 g), plant height (114.2 cm), total number of branches per plant (13.4), weight per fruit (4.41 g) and number of seeds per fruit (10.5). Cowpea plants given inorganic fertiliser had a better biochemical profile with higher total chlorophyll (37.52 mg g^{-1}) and carotenoid (1.497 mg g^{-1}) content than the organic manure treated plants. Results revealed that enriching vermicompost with fish silage is a potential option for improving the nutrient content of vermicompost, resulting in higher crop production by converting fish waste into a useful byproduct.

Keywords: Cowpea, Enriched vermicompost, Fish silage, Growth, Yield

The changing or erratic climatic scenario is forcing farmers to use inorganic fertilisers in excessive doses to provide yield faster and better than normal yields. But the excessive use of inorganic fertilisers causes erosion of the original soil indicated by low pH level as well as deficiency of some important nutrients (Zhong and Cai, 2007). Hence plants get more and more dependent on the nutrients supplied artificially making them all the more vulnerable to water stress and low nutrient levels. Nowadays the tendency to supply all plant nutrients through chemical fertiliser is being reconsidered by supplementing them with organic manures. The reasonable use of organic manure can improve soil fertility and microbial content, decrease in requirement of soil nitrogen application and reduction in leaching loss, increase yield and quality and improve human ecological environment (Xinhao *et al.*, 2005)

Fish processing operations produce waste in solid form like fish carcasses, viscera, skin and heads. India is home to more than 75 minor fishing harbours, around 1500 fish landing centres, 350 seafood processing factories (www.nfdb.gov.in) and innumerable number of fish markets where a huge amount of processing waste is being generated. Quantum of waste generated through fish processing varies from 10 to 80% of the weight of the fish according to the processing activities. These fish processing wastes which are rich in proteins, fats and minerals could be converted to valuable byproducts like fermented fish silage which has huge potential to be used as organic manure. Fish silage is rich in macro and micronutrients, growth hormones and indigenous microorganisms which are needed for plant growth and development (Archer *et al.*, 2001). The liquid consistency of fish silage is a limitation in its storage. The probable solution to this would be the mixing and drying of silage with fillers like soil, sawdust and coirpith. But the mineralisation of sawdust or coirpith will be a slow process unless composted, so co-drying of fish silage with vermicompost is yet another viable option. Vermicompost which is produced by biodegradation of organic material through interactions between earthworms and microorganisms is already proven to be a good source of macronutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium. Although there are several reports on the enrichment of vermicompost with macro and micronutrients, microbes (Hashemi and Golchin, 2009; Baliah and Muthulakshmi, 2017) and probiotics (Saravanan and Aruna, 2013), studies on the possible effects of enriching vermicompost with liquid fish silage on its nutrient content and further effect on the growth and yield of horticultural crops has not been reported yet. The present study investigates the effect of enriching vermicompost with fish silage on the nutrient content of vermicompost and also on the growth, yield and biochemical characteristics of cow pea as it is an important legume rich in protein for human consumption and the haulms which are valuable source of protein for livestock feed.

Fermented fish silage was prepared from fresh viscera and gills of Indian major carps [*Catla catla* (catla), *Labeo rohita* (rohu), *Cirrhinus mrigala* (mrigal)] collected from the local market which was transported to the laboratory in ice. The raw material was washed in potable water and minced. Twenty percent (w/w) jaggery was dissolved in 30% (v/w) water by heating. The jaggery was added to the mince after cooling down to room temperature. Ensilation was done in airtight plastic containers at ambient temperature (28±2°C). The mixture was stirred twice daily for 4-7 days or till it attained a semi-liquid consistency. Vermicompost enriched with fish silage was prepared by co-drying vermicompost and fish silage at 2:1 ratio under the sun. The enriched vermicompost was analysed for its nutrient content. Field study was conducted at the experimental farm of ICAR-Central Institute for Women in Agriculture (ICAR-CIWA), Bhubaneswar, Odisha. Experiment was conducted during the months of April-July, in Randomised Complete Block Design (RCBD) with three replications. The land was divided into 9 plots each with an area of 2x2 m. Cowpea seeds were planted at a spacing of 60x60 cm. The treatments were: chemical fertiliser (CF) [100 kg urea + 300 kg single super phosphate (SSP) ha^{-1}], fish silage enriched vermicompost (VCS) (3.33 t of enriched vermicompost and 300 kg SSP ha^{-1}) and vermicompost (VC) (4.5 t vermicompost + 300 kg SSP ha^{-1}). CF was applied one day before sowing and VCS and VC were applied 10 days prior to sowing. Different growth (plant height, number of branches, leaf length, leaf lamina length, leaf lamina width) and yield (pod yield, length of pods, number of seeds, seed weight and biomass) parameters were studied during the field investigation. Data on plant height, number of branches, leaf lamina length, leaf lamina width and leaf length taken from 5 plants per plot were recorded from 30 days after planting. Pods were harvested at 3 day intervals from 60^{th} day onwards with a total of 8 harvests. Different quality parameters of cowpea like crude protein (AOAC, 2000), chlorophyll and carotenoid (Arnon, 1949; Kirk and Allen, 1965) contents were studied during the field investigation.

Data sets were analysed parameter-wise using Analysis of Variance (ANOVA) and all possible pair-wise treatments were compared using Tukey's Honestly Significant Difference (HSD). The data were statistically analysed using SAS 9.3. The differences between the experimental groups were considered significant at a level of $p<0.05$.

The nutrient content of vermicompost, especially micronutrients, was enhanced by enriching it with fish silage (Table 1). Micronutrients like Iron (Fe), Copper (Cu), Manganese (Mn) and Zinc (Zn) are necessary for plant life for proper activity of several enzymatic systems, hormones and plant components which are required for photosynthesis, respiration, nitrogen assimilation and metabolism in plants (Sadegh *et al*., 2015).

The results of the field study showed that cowpea responded well in terms of growth and yield to the vermicompost enriched with fish silage manure. Plant height is an important component that helps to determine plant growth. VCS plants were the tallest although there was no significant difference ($p>0.05$) between the treatments (Table 2). Organic manures release nutrients in controlled manner and moreover the availability of already solubilised nitrogen in the VCS manure might have promoted the growth of plants. It has also been suggested by Arancon *et al.* (2003) that the addition of humic acid to the soil by the vermicompost enhances plant growth. Moyin-Jesu and Ogochukwu (2014) have also corroborated the positive effect of organic manure on the growth of coconut seedlings. Inorganic nitrogen fertilisers like urea is reported to make the soil more acidic because of the absorption of ammonia into the soil thereby reducing soil fertility. There was no significant difference ($p>0.05$) among the treatments with respect to other growth parameters like total number of branches and leaf lamina width (Table 2). The plants treated with vermicompost had significantly lower ($p<0.05$) leaf lamina length.

There was no significant difference in yield of pods, fruit weight, fruit length and number of seeds per pod from the different treatments ($p>0.05$) (Table 3). But VCS treatment gave the highest yield which was 17.96% higher than that in CF treatment possibly because of

Table 1. Nutrient content in vermicompost enriched with fish silage *vs*. vermicompost

Manure	Available N (%)	Total P (%)	Total K (%)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
VCS	1.38	0.37	0.903	353	90.48	298	161
VC	1.01	0.15	0.26	172.26	9.28	10.51	20.6

VCS - Vermicompost enriched with fish silage
VC - Vermicompost

Table 2. Effect of vermicompost enriched with fish silage on growth characteristics of cowpea

Treatments	Growth characteristics			
	Plant height (cm)	Leaf lamina length (cm)	Leaf lamina width (cm)	Total number of branches
CF	94.6±24.7[a]	29.8±1.83[a]	8.3±0.95[a]	12.53±0.61[a]
VCS	114.2±12.6[a]	29.1±0.82[ab]	7.8±0.44[a]	13.4±1[a]
VC	99.33±16.91[a]	26.7±0.1[b]	7.03±0.25[a]	13.2±0.72[a]

CF: 100 kg urea+300 kg single super phosphate ha^{-1}; VCS: 3.33 t of enriched vermicompost and 300 kg single super phosphate ha^{-1}
VC: 4.5 t vermicompost+300 kg single super phosphate ha^{-1}
Values represent Mean± SD of 3 replications
Means bearing different superscripts in the same column differ significantly ($p<0.05$)

Table 3. Effect of vermicompost enriched with fish silage on yield characteristics of cowpea

Treatments	Yield characteristics				
	Average yield per plant (g)	Fruit weight (g)	Length of fruit (cm)	Number of seeds per pod	Biomass after sun drying (g)
CF	177.4±65.6[a]	4.32±0.49[a]	19.25±1.12[a]	10.08±1.77[a]	409±64.2[a]
VCS	209.27±62.6[a]	4.41±0.52[a]	19.11±1[a]	10.5±1.15[a]	451.33±15.58[ab]
VC	167.53±24.73[a]	4.16±0.51[a]	18.76±1.31[a]	9.08±1.59[a]	382.33±17.56[b]

CF: 100 kg urea+300 kg single super phosphate ha^{-1}; VCS: 3.33 t of enriched vermicompost and 300 kg single super phosphate ha^{-1}
VC: 4.5 t vermicompost+300 kg single super phosphate ha^{-1}
Values represent Mean± SD of 3 replications
Means bearing different superscripts in the same column differ significantly ($p<0.05$)

the comparatively better utilisation and translocation of the nutrients absorbed from the micronutrient-enriched vermicompost happening within the plants. This finding supported the work of Yoldas *et al.* (2011) that organic fertiliser supplied adequate plant nutrients for proper growth and development of crop. The lower yield in CF treated plants could be because of the leaching of readily available nutrients in the chemical fertiliser from the soil while the nitrogen from organic source is not easily leached. Inorganic fertilisers do not possess good aggregating characteristics of the soil particles whereas organic manures are good at improving the soil properties including its texture. As a result, the plants produced by inorganic fertilisers showed relatively lower yield compared to organic materials. VCS and VC treatments had a beneficial effect on dry biomass of cowpea plants (Table 4). This could be due to the varied carbohydrate distribution caused by the different fertilisation sources (Han *et al*., 2016). The different fertilisation treatments did not exert a significant influence on the protein content of cowpea. Similar results were found by Bommesha *et al.* (2012). There was no significant difference in the total chlorophyll content of cowpea plants receiving nutrients through CF and VCS possibly because of the ready release of nutrients especially nitrogen which is needed for chlorophyll formation from these sources.

The study concluded that enriching vermicompost with fish silage not only results in its nutrient enhancement but also its application results in improved overall growth and yield characteristics in cowpea when compared to inorganic nitrogen source, urea. This also opens up a potential way of utilising the fish processing waste in the form of fish silage as organic manure in horticultural crops. Further validation on other horticultural crops could

Table 4. Effect of vermicompost enriched with fish silage on the biochemical characteristics of cowpea

Treatments	Biochemical characteristics				
	Chlorophyll a (mg g^{-1})	Chlorophyll b (mg g^{-1})	Total Chlorophyll (mg g^{-1})	Carotenoid (mg g^{-1})	Crude protein (%)
CF	24.19±0.26[a]	13.72±0.66[a]	37.37±1.04[a]	1.50±0.06[a]	20.03±2.16[a]
VCS	23.01±0.23[a]	9.6±0.18[a]	32.52±0.3[ab]	1.19±0.06[a]	16.09±1.95[a]
VC	21.12±3.65[a]	9.6±3.05[a]	27.82±4.92[b]	1.14±0.27[a]	17.19±0.28[a]

CF: 100 kg Urea+300 kg single super phosphate ha^{-1}; VCS: 3.33t of enriched vermicompost and 300 kg single super phosphate ha^{-1}
VC: 4.5 t vermicompost+300 kg single super phosphate ha^{-1}
Values represent Mean± SD of 3 replications
Means bearing different superscripts in the same column differ significantly ($p<0.05$)

be done to confirm the manurial effects of vermicompost enriched with fish silage.

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