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RESEARCH NOTE

Utilization of calico plant (*Alternanthera bettzickiana (Regel)* Voss. as bio-organic manure through vermicomposting

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ABSTRACT

Calico plant (*Alternanthera bettzickiana (Regel)* Voss., an invasive weed, is now a major weed in different upland crops and waste lands in Kerala, India. The studies were conducted on vermicomposting of *A. bettzickiana* mixed with and without banana pseudostem in various proportions (v/v) (8:1, 4:1, 2:1, 1:1 and weed alone) along with cow dung. There was an increase in electrical conductivity and total contents of macronutrients (N, P and K) and micronutrients (Fe, Zn and Cu) along with a decrease in pH, total organic carbon (TOC) and C/N ratio after vermicomposting. Use of weed biomass alone and in combination with pseudostem (8:1) had significantly higher N, P content and earthworm growth and lower TOC and C/N ratio. Treatments with higher proportion of pseudostem produced compost with higher TOC, C/N ratio and K content. Compost recovery to the extent of 47 and 45.3% was observed in vermi-reactors with weed alone and mixed material (8:1), respectively, along with a lower rate of recovery (34%) in uniformly mixed proportion of weed + pseudostem (1:1). Increase in nutrient content and growth of earthworms in all the vermi-reactors indicated the suitability of *A. bettzickiana* for vermicomposting, which might be an effective way of utilizing the invasive weed biomass as bio-organic manure.

Keywords: *Alternanthera bettzickiana*, Banana pseudostem, bio-organic manure, Earthworm, *Eisenia fetida*, Vermicomposting, Weed utilization

Alternanthera bettzickiana (Regel) Voss., commonly known as calico plant, is an invasive weed species belonging to Amaranthaceae family. It is a native of tropical America, and is now distributed throughout the plains, degraded deciduous forests and wastelands in the southern and north-eastern states of India. Currently, it has been appearing as a major weed in vegetables, plantation crops, fruits, spices and tuber crops throughout Kerala (Rao *et al.* 2019, Alex and Menon 2022). Management of invasive weeds is a major concern all over the world. Vermicomposting is regarded as one of the effective methods in utilizing the weed biomass.

Banana (*Musa* sp.) is a major fruit crop in India, and it produces large quantities of plant residue after harvest, that contain remarkably higher amount of cellulose acting as carbon source for the microbes involved in composting, and potassium which can contribute significantly to the total potassium content of the vermicompost (Khalil *et al.* 2006, Saibaba *et al.* 2013). Therefore, vermicomposting of *A. bettzickiana* and banana pseudostem in various proportions was attempted to assess the suitability of the weed in mixed combinationas bio-organic manure, and to develop an effective strategy for the appropriate utilization of the weed.

The study was conducted during the period from September to December in 2021 at the Kerala Agricultural University (KAU), Thrissur Campus, Kerala. Fresh biomass of *A. bettzickiana* (root, stem and leaves) and banana pseudostem was collected from the farms and premises of the KAU, Thrissur Campus. Hatchlings of earthworm (*Eisenia fetida*) with an average weight of about 170-200 mg were obtained from the vermicompost unit situated in the campus. Weeds and banana pseudostem were chopped into small pieces of 4-5 cm to ease the action of earthworms. Mixed combinations of *A. bettzickiana* and banana pseudostem in different proportions (8:1, 4:1, 2:1, and 1:1) were compared along with sole use of *A. bettzickiana* in a completely randomized design (CRD) with four replications. Composting was carried out in cement rings of 1 m diameter and 0.5 m height and with concrete base. A layer of coconut husk was spread at the base of the ring, with the concave side upward, for easy drainage of excess water. Above the moistened husk, weed

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material, banana pseudostem, and cow dung were spread in alternate layers. The rings were filled up to the brim and sprinkled with cow dung slurry. The materials were left for partial decomposition, and earthworms were introduced on the 25th day at 500 numbers/ring. Water was sprinkled whenever necessary, and the materials were turned once in a week to ensure adequate aeration. After 70-80 days, compost was collected, heaped under shade for two days, and sieved to remove undecomposed materials.

Samples were collected initially on the day of earthworm release and at the end of experimentation for analysing various physico-chemical parameters like pH, electrical conductivity (EC), organic carbon, total nitrogen, phosphorus and potassium, and micronutrients (Fe, Zn, Cu). C/N ratio of the initial and final materials was also calculated. Initial weight (average weight before inoculation) and final weight of the worms collected from the rings after composting were recorded. Based on these observations, net biomass gains and growth rate/ worm/day were worked out. Significant differences between the treatments for various parameters were analysed using one-way ANOVA, and Tukey's test was performed at a significance level of a= 0.05 to distinguish homogenous groups among the treatments using WASP 2.0 statistical package.

Effect on physico-chemical properties of feed mixture and vermicompost

There was a decrease in pH in all the treatments relative to the initial values in the feed mixture due to the production of organic acids and carbon dioxide during the decomposition process (**Table 1**). Level of EC increased during vermicomposting, and a similar pattern was observed in the change of EC for all treatments, and the difference in EC among the treatments was found to be non-significant (**Table 1**). This rise in EC could be attributed to the release of mineral salts such as ammonium and phosphate ions during the decomposition of biomass.

Reduction in total organic carbon (TOC) was observed in all the treatments when compared to that of initial feed mixture. The highest reduction in TOC (52.5%) was observed in the treatment of only weed, and it was the lowest (40%) in weed + pseudostem (1:1). These results are in accordance with the findings of Yadav and Garg (2011) and Zhi-Wei *et al*. (2019) who reported 38-48 and 38.2-43.5% reduction in TOC with vermicomposting of *Parthenium hysterophorus* and rice straw + kitchen waste, respectively. About 20-43% of organic matter in the initial feed material was lost as CO_2 during vermicomposting,whereas digestion of polysaccharides and carbohydrates by the inoculated earthworms might also reduce the carbon content of the feed material (Elvira *et al*. 1998). Composting of weed material alone recorded the lowest TOC (22%). Treatments containing higher proportion of banana pseudostem recorded higher TOC (**Table 1**) which might be due to its higher lignin content, making the degradation difficult.

Enhancement in N, P and K content was observed in all the treatments. There was an increase in total N content to the extent of 29.5-50.0% during composting of *Alternanthera*. Similar results were reported by Sridevi *et al.* (2016) in vermicomposting of water hyacinth, which showed 51% increase in N content. Total N content was significantly higher in sole use of weed (1.67%) as well as mixed use of

Table 1. Physico-chemical properties of initial feed mixture and final vermicompost of different proportions of *A. bettzickiana* (weed) and banana pseudostem (pseudostem)

Treatment	pH	EC (dS/m)	TOC (%)	N total (%)	P total (%)	K total (%)	C:N ratio
Initial feed mixture							
Weed + pseudostem (8:1)	8.84^{a*}	1.51	49.1^{b}	1.12^{a}	0.66	0.79^{b}	43.8^{c}
Weed + pseudostem (4:1)	8.49^{ab}	1.23	53.2^{a}	1.03^{ab}	0.56	0.80^{b}	51.7^{c}
Weed + pseudostem (2:1)	8.29^{b}	1.26	54.9^{a}	0.93^{bc}	0.51	1.03^{a}	59.2^{b}
Weed + pseudostem (1:1)	8.30^{b}	1.21	56.1^{a}	0.85^{c}	0.48	1.08^{a}	66.3^{a}
Weed alone	8.81^{a}	1.48	46.3^{b}	1.11^{a}	0.64	0.71^{b}	41.7^{c}
LSD (p=0.05)	0.41	NS	3.11	0.11	NS	0.13	6.41
Final vermicompost							
Weed + pseudostem (8:1)	7.64	2.03	26.16^{b}	1.66^{a}	0.99^{a}	0.89^{b}	15.8^{c}
Weed + pseudostem (4:1)	7.60	1.80	30.29^{a}	1.33^{b}	0.78^{b}	0.97^{b}	22.7^{b}
Weed + pseudostem (2:1)	7.28	1.72	32.50^{a}	1.25^{bc}	0.75^{b}	1.31^{b}	25.9^{b}
Weed + pseudostem (1:1)	7.56	1.44	33.66^{a}	1.10^{c}	0.70^{b}	1.44^{a}	30.6^{a}
Weed alone	7.69	1.78	22.02^{c}	1.69^{a}	0.94^{a}	0.86^{b}	13.2^{c}
LSD (p=0.05)	NS	NS	3.91	0.17	0.16	0.11	3.22

*In a column, figures followed by the same letters do not differ significantly (Tukey, a=0.05)

weed and pseudostem in 8:1 proportion (1.66%), where as it was the lowest (1.1%) in the mixture of1:1 proportion (**Table 1**). Plants belonging to Amaranthaceae family might be the efficient accumulators of nitrogen as evidenced from the present study. Nitrogen content in the leaves of *Alternanthera* was found to be 1.6-2.2% which might have caused higher total N content in the treatments with higher proportion of the weed biomass.

Increase in total P content during composting was in the range of 40.7-49.7%. Several P solubilizers inhabiting the earthworm gut produce phosphatase which is responsible for P mineralization during composting (Gopal *et al.* 2009). Significantly higher total P was recorded in weed + pseudostem mixture (8:1) and weed alone, which constituted higher proportion of *A. bettzickiana* biomass (**Table 1**). Easier degradability of weed biomass than that of pseudostem might enhance the earthworm and microbial activity, leading to higher rate of P mineralization.

An increase in total K content by 21-33% was observed during vermicomposting which might be ascribed to the release of certain acids by the microbes during the decomposition process that were responsible for the dissolution of organic potassium. Annathavalli *et al.* (2019) reported 58% increase in K content during vermicomposting of sea weed species (*Ulva reticulata*). Higher mineralization of K was reported in vermicomposting of water hyacinth than that in a system without earthworms (Sridevi *et al.* (2016)). Significantly higher total K content was recorded in weed + pseudostem in 1:1 proportion (1.44%) and 2: 1 proportion (1.31%) which constituted more amount of banana pseudostem (**Table 1**) due to remarkably greater concentration of K in banana waste as it luxuriantly consumes K from the soil.

C/N ratio, which is an indication of biomass stabilization and a criterion for accessing compost maturity, exhibited a sharp decline in all the treatments (**Table 1**). This might be due to loss of carbon as CO_2 during microbial respiration, enhanced mineralization of N in the organic matter and production of N containing compounds like mucus, hormones etc. by the earthworms. Among the treatments, weed + pseudostem (1:1) recorded significantly higher C/N ratio (30.6**)** while weed alone (13.2**)** and weed+ pseudostem in 8:1 proportion (15.8**)** recorded the lowest (**Table 1**). This might be attributed to lower organic C and higher total N content in compost obtained from these treatments.

Effect on micronutrient contents of feed mixture and vermicompost

Concentrations of micronutrients like zinc (Zn), iron (Fe) and copper (Cu) were observed to be slightly increasing during composting process (**Table 2**). Enhancement in the concentration of micronutrients through vermicomposting was also observed during composting of *Salvinia natans* (Singh and Kamaldhad 2016) and *Parthenium hysterophorus* (Yadav and Garg 2011). Modification of pH and microbial release of organic acids might cause the release of organically bound metals, leading to the increase in their concentration at the final stages of composting. Compost prepared from *Alternanthera* contained 123.5-146.7 ppm Zn, 3300.0- 3843.3 ppm Fe and 31.8-41.8 ppm Cu whilst the maximum limits of Zn and Cu in vermicompost were1000 and 300 ppm, respectively (GOI 1985).

Effect on earthworm growth and compost recovery

Growth rate of earthworms is an important factor determining the suitability of the raw material for the earthworms to work upon. The average weight of the worms during inoculation was 177.6 mg which increased to a range of 831.3-979 mg during harvest of the compost (**Table 3**). Significantly higher final biomass, net biomass gain and growth rate per worm was recorded in 8 weed: 1 pseudostem, 4 weed: 1 pseudostem and weed alone treatment. Growth rate of the worms depends upon the quality of the feed, feeding rate, constitution of easily digestible polysaccharides and growth promoting nutrients (Edwards *et al.* 1998). High

Table 2. Micronutrient contents in initial feed mixture and final vermicompost of different proportions of *A. bettzickiana* (weed) and banana pseudostem (pseudostem)

Treatment	Initial feed mixture			Final vermicompost		
	Zn (ppm)	Fe(ppm)	Cu (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
Weed + pseudostem (8:1)	114.1	3334.2	26.8	146.7	3488.3	37.3
Weed + pseudostem (4:1)	117.2	3610.8	31.7	137.7	3843.3	41.8
Weed + pseudostem (2:1)	110.3	3115.0	26.5	123.5	3300.0	33.7
Weed + pseudostem (1:1)	113.4	3386.7	24.9	128.7	3620.0	31.8
Weed alone	103.7	3430.8	26.2	127.9	3742.5	33.5
LSD (p=0.05)	NS	NS	NS	NS	NS	NS

Table 3. Earthworm growth during vermicomposting proportions of *A. bettzickiana* (weed) and banana pseudostem (pseudostem)

Treatment	Final biomass (mg)	Net biomass gain (mg)	Growth rate worm (mg/day)
Weed + pseudostem (8:1)	979.0[a*]	801.5[a]	11.4[a]
Weed + pseudostem (4:1)	964.0[a]	786.4[a]	11.2[a]
Weed + pseudostem (2:1)	831.3[b]	653.7[b]	11.2[b]
Weed + pseudostem (1:1)	842.6[b]	665.1[b]	9.34[b]
Weed alone	959.3[a]	781.7[a]	9.50[a]
LSD (p=0.05)	113.4	113.4	1.62

*In a column, figures followed by the same letters do not differ significantly (Tukey, *a*=0.05)

growth rate of earthworms in *A. bettzickiana* rich treatments can be attributed to the palatability, easy digestibility and nutrient availability of the weed biomass.

Based on the difference in initial weight of the feed mixture and final weight of the compost, compost recovery was found higher in the weed alone treatment (47%) and weed+ pseudostem at 8:1 (45.3%), followed by other proportions as 4:1 (36.1%), 2:1 (34.6%) and 1:1 (34%). Thus, higher proportion of *A. bettzickiana* proved to be more conducive for decomposition by earthworms with higher compost production.

It was concluded that *Alternanthera bettzickiana* biomass could be effectively utilized for the preparation of nutrient rich vermicompost. Enhancement of both macro and micronutrient contents in the vermicompost relative to the initial feed materials in all the treatments indicated the suitability of *A. bettzickiana* and banana pseudostem mixture for vermicomposting. Earthworm growth and biomass gain was within satisfactory range in all the treatments, indicating that the weed biomass could be successfully composted using *E. fetida*. Thus, the invasive weed, *A. bettzickiana* might be effectively utilized through its vermicomposting as a bio-organic manure.

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