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USE OF VERMICOMPOSTING BIOTECHNOLOGY IN RECYCLING FLY-ASH FOR AGRICULTURAL USE

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ABSTRACT

Numerous coal fired plants operating in different parts of the world produce huge amount of fly-ash every year. Such large scale generation of this waste material poses several problems, the most important ones being environmental pollution and occupation of large areas of land for storage and disposal. Hence, the urgent and imperative needs to overcome these problems through not only safe disposal but also gainful utilization of these materials cannot probably be overemphasized. Among various uses of fly-ash, its application to agricultural soils has shown encouraging results in many countries owing to the fact that the waste contents many essential plant nutrients in varying concentrations. However, the major problem of recycling fly-ash in agriculture is that most of the nutrient elements in this waste material remain largely in insoluble forms and hence do not become available to plants in required concentrations. Under this context, use of fly-ash along with organic materials appears to be an effective proposition. In view of high efficiency of vermicomposting biotechnology in increasing the pace of the composting process and also in encouraging higher availability of different nutrients with the help of epigeic earthworms, a series of studies were carried out to assess the possibility of improving the usability of fly-ash in agriculture in combination with organic wastes through adoption of vermicomposting. The results of the investigation showed vermicomposting to increase the availability of different major and micro nutrients in fly-ash. On farm trials carried out on use of vermicomposted fly-ash and organic wastes showed use of 15 ton per hectare of vermicomposted fly-ash to result in significant yield increments in potato cultivation. This also reduced the application of 40% of mineral fertilization for this cultivation.

KEYWORDS

Vermicomposting; Fly-ash; Agricultural use.

1 INTRODUCTION

With the consistently increasing numbers of coal fired plants, large scale generation of fly ash is presenting acute environmental problems in different parts of the world [1]. Among various efforts of recycling fly ash, its application in agriculture is gradually gaining momentum owing to occurrence of most of the plant nutrients in appreciable amount in such material [2]. However, the major problem associated with plant nutrition through fly ash is low availability of the nutrient elements present in it. This behaviour has been attributed to limited microbiological activity in fly ash owing to lack of occurrence of organic matter [3]. Under this situation, some measures to bring high amount of these nutrients to easily available forms

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appear to the imperative. Among different efforts in this respect, simultaneous application of organic matter and fly ash has been reported to be effective [4]. Under the context of the huge quantum of fly ash generation and limited availability of traditional organic manures, it is necessary that large amount of organic wastes, available in different parts in the world, be utilized for this purpose. In view of the efficiency of vermicomposting biotechnology in accelerating the pace of decomposition of wide ranges of organic wastes with the help of earthworm gut microorganisms, a series of studies was carried out to assess the possibility of using vermicomposting as a biotechnological tool for increasing the use efficiency of fly ash as a source of plant nutrients. Present communication embodies a comprehensive report of the investigation.

2 MATERIALS AND METHODS

The study was carried out in two phases. During the first phase of the work programme, availability of three major (N, P and K) and five micro (Fe, Cn, Mg, Zn) nutrients in different combinations of fly ash (FA) and cow dung (CD) in presence and absence of epigeic earthworm *Eisenia fetida* at 10 worms/kg substrate were estimated periodically. Five treatments viz. FA, only, CD only, FA+CD (1:1), FA+CD (1:3) and FA+CD (3:1) were used for the study with three replications for each. The materials were incubated under moist condition for a period of 50 days and samples were drawn at 10 days intervals for different chemical analyses. Easily mineralisable N was estimated by following the procedure indicated by Subbiah and Asija [5]; available P was determined colorimetrically by following Bray's no.1 extraction [6]. For estimation of available K, neutral normal ammonium acetate extraction was employed and K was determined flame photometrically. Solubility of different micronutrients was estimated in DTPA extracts with the help of an atomic absorption spectrophotometer. Moisture contents of the samples were determined separately and necessary corrections were made to get the results on dry weight basis.

During the second phase of the study, an on-farm trial was carried out in a typical red and lateritic soil of Birbhum district, West Bengal, India using potato as the test crop. For this study, fly ash was vermicomposted with municipal solid waste at 1:1 ratio using epigeic earthworm *Eisenia fetida* at 10 nos. per kg of substrate. Five treatments viz. Control with 100% recommended fertilization i.e. 200:200:150 kg N:P:K ha^{1} (NPK_{100}), NPK_{100} + farm yard manure at 15 tons/ha (NPK_{100} + FYM), NPK_{100} + vermicomposted fly ash at 15 tons/ha (NPK_{100} +VC), 80% recommended fertilization + vermicomposted fly ash (NPK_{80} + VC) and 60% recommended fertilization + vermicomposted ash (NPK_{60} + VC) were used for the trial. The experiment was laid in randomized block design using four replicates for each treatment. Excepting source of nutrients, all other management practices were kept uniform under all the treatments. The effects of these treatments were assessed in terms of tuber yield rate.

3 RESULTS AND DISCUSSION

Concentrations of the three major nutrient elements under different treatment combinations with and without earthworm after 50 days of incubation have been presented in table-1. As evidenced from the table, adoption of vermicomposting helped to increase the availability of the three major nutrient elements in case of all the treatments with fly ash. That epigeic earthworms harbour high concentrations of different microorganisms and enzymes in their intestines which help in rapid degradation of the ingested materials have been reported by Edward and Lofty [7], Kale [8] and many other workers. This activity of the gut microorganisms was favoured by inclusion of organic matter with fly ash. Increased concentration of N_2 fixing and P solubilising microorganisms in vermicomposted fly ash have been reported Bhattacharya and Chattopadhyay [3, 9].

Table 1. Availability of three major plant nutrients in different combinations of fly ash and cow dung after 50 days of incubation.

Treatments	Available nutrients (mg/kg)					
	N		P		K	
	E	E_0	E	E_0	E	E_0
FA	52.2	44.8	54.1	38.6	21.9	10.1
CD	396.6	359.3	153.2	109.4	21.9	8.1
FA + CD (1:1)	266.0	224.0	83.3	66.6	185.5	67.5
FA + CD (1:3)	280.0	233.3	90.4	67.8	257.5	164.9
FA + CD (3:1)	191.3	144.6	65.9	68.5	101.6	42.4

FA = Fly ash; CD = Cow dung, E = With earthworm; E_0 = Without earthworm

The availability of four micronutrients viz. Fe, Cu, Mn and Zn also increased in different combinations of fly ash and organic manure under vermicomposting, obviously owing to increased microbiological activity in these treatments, as has been discussed earlier. Among different micronutrients, concentrations of Fe and Mn appeared to occur in higher concentrations and were followed by Zn and Cu respectively. Similar pattern of total occurrence of these micronutrients has been reported by Kumar et al. [10] also.

Table 2. Mean concentrations of some micronutrients in available form under different combinations of fly ash and cow dung.

Treatments	Available nutrients (mg/kg)							
	Fe		Cu		Mn		Zn	
	E	E_0	E	E_0	E	E_0	E	E_0
FA	66.6	49.6	3.8	2.9	90.0	84.1	31.7	26.7
CD	28.6	25.9	1.5	1.3	4.7	3.3	4.6	4.2
FA + CD (1:1)	48.5	29.9	2.6	1.7	40.7	30.0	13.2	10.2
FA + CD (1:3)	37.3	23.7	2.3	1.8	29.5	21.0	9.5	8.2
FA + CD (3:1)	57.3	38.2	3.5	2.4	59.0	45.4	16.1	12.8

FA = Fly ash; CD = Cow dung, E = With earthworm; E_0 = Without earthworm

In view of the encouraging results of vermicomposting of fly ash along with organic matter at 1:1 ratio, an on-farm trial was conducted to assess the efficiency of this vermicomposted material under integrated nutrient management of potato. The results of the study have been presented in table-3. As compared to NPK_{100} + FYM treatment, NPK_{100} + VC treatment resulted in significantly higher yield of potato. Since both FYM and vermicomposted fly ash were applied at same rates to the soil, it appears from the yield data that vermicomposted fly ash was more efficient than FYM in increasing the yield. This beneficial effect of vermicomposted fly ash was pronounced in other treatments also. In the NPK_{60} + VC treatment, the potato yield was found to be statistically similar to the yield level obtained from NPK_{100} treated plots, in spite of reducing the rate of fertilizer application by 40%. As reported by Bhattacharya and Chattopadhyay [11], the application of vermicomposted fly ash at 15 tons/ha may take care of 40% of the mineral fertilization during potato cultivation which may amount to 80 kg N, 80 kg P and 60 kg K.

Table 3. Effect of vermicomposted fly ash on yield of potato.

Treatment	Potato yield (ton/ha)
Control (NPK_{100})	21.95
NPK_{100} + FYM	25.47
NPK_{100} + VC	30.12
NPK_{80} +VC	27.42
NPK_{60} + VC	22.42
CD at 5%	3.33

NPK_{100} = Recommended doses of NPK fertilizers,
NPK_{80} & NPK_{60} = 80% and 60% of recommended fertilization
FYM = Farm yard manure
VC = Vermicomposted fly ash

The results of the study, therefore, indicate that adoption of vermicomposting biotechnology may be considered to be an effective proposition for recycling fly ash along with organic wastes as a source of plant nutrients in agriculture and reducing the environmental pollution, thereby.

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