Toxic effects of Lignite Fly ash During Vermicomposting on the growth and Reproduction of Earthworm Lampito Mauritii

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Abstract

Fly ash is a serious source of air pollution since it remains air borne for a long period of time and causes health hazards. Besides being a health hazard, fly ash degrades the environment, fly ash (FA) a waste material of national concern, arising out of lignite based thermal power plants was mixed with cashew leaf litter(CLl) and cow dung (CD) utilized for the present study. In the present study , the feed substrates were prepared on weight basis as control(C)- cow dung alone,T_1-FA+CLl+CD (2:4:4), T_2-FA+CLl+CD(3:3.5:3.5), T_3-FA+CLl+CD(4:3:3), T_4-FA+CLl+CD(5:2.5:2.5), T_5-FA+CLl+CD(6:2:2). For each treatment 1 kg of feed substrate was taken in plastic troughs and 15 grams of Lampito mauriti was inoculated and reared in laboratory at room temperature with 60-70% moisture. Once in 15 days, up to 90 days the zoomass of earthworms, number of cocoons and hatchlings were observed .The best growth and reproduction of L. mauritri was observed in T_2. It could be due to the availability of optimum nutrients from leaf litter than other treatments.

INTRODUCTION

Fly ash is the portion of the combustion residue that enters the flue gas stream in power generating facilities and consists of many small, glass-like particles ranging in size from0.01 to 100 µm(1). Fly ash which contains silica, aluminum, oxides of iron, calcium, magnesium, arsenic, chromium, lead, zinc, nickel and other toxic metals is a by product of coal-fired power plants.

Most fly ash materials are disposed in landfills or slurry ponds. Land filling of fly ash may serve as a major source of environmental pollution through erosion and leaching of heavy metals (2). To prevent fly ash from being air borne, the dumping ground needs to be kept well at time. However in India where 150 million tones fly ash is produced annually, there is an urgent need to develop methods for use of fly ash, on a small scale as well as on large scale. Each new application has to be evaluated from the environmental point of view(3).Another use of fly ash is in agriculture since the hydroxide and carbonate salts give fly ash one of its principle beneficial chemical characteristics, the ability to neutralize acidity in soils(4). Fly ash amendment has been reported to modify soil pH, improve soil texture, and provide essential plant nutrients for increasing crop production(5).

Cashew nut (Anacardium occidentale L.) is a multifaceted industrial and commercial crop cultivated in tropical and sub-tropical region. World production of cashew nut is around 9 lakhs tonnes per year and the highest production (42%) has been recorded in India. Leaf litter is a potential and unexploited source of nutrients inputs in agriculture. The natural decomposition of cashew leaves requires long period. Hence the accumulation of cashew leaves causes environmental pollution, forest fire, nutrient loss etc. The dry leaves of cashew trees served as a good manure if properly decomposed(6).

Lampito mauritii was chosen as an indicator species in India because of its wide spread occurrence in aerable and pasture lands and its consequent vulnerability to surface applied pesticides, making it an ideal candidate for assessment of agro ecosystem contamination(7).

The reproductive potential of earthworm was influenced by the quality and availability of food (8,9). Vermicomposting is an eco friendly and inexpensive

technology in which the earthworms are used as bioreactors to convert the organic materials into valuable compost. Bhattacharya and Chattopadhyay (10) found the survival of earthworms in three different ratios (1:1, 1:3 and 3:1) of cow dung and fly ash. Ananthakrisnasamy(11)also reported the survival of earthworms in three different ratios (1:1, 2:1 and 3:1) of cow dung and fly ash mixture. The fly ash was vermicomposted with cow dung and solubility of micronutrients was analysed (12).To the authors knowledge no studies have been made on the toxic role of fly ash on the growth and reproduction of indigenous anaecic earthworm. The main objective of the present study was (i) To find out the appropriate proportion of fly ash –leaf litter-cow dung for sustainable and efficient vermicomposting. (ii) To know the toxic role of fly ash on the growth and reproduction of earthworms in different fly ash mixtures.

MATERIALS AND METHODS

The FA was collected from a thermal power station I, Neyveli Lignite Cooperation, Neyveli. The fallen leaves (CLl) of cashew trees were collected from cashew fields around Neyveli, Tamil Nadu, India. The CD was collected from the dairy farm, Faculty of agriculture, Annamalai University.

The FA was thoroughly mixed with CLl and CD (w/w). All these mixtures were maintained at 60% moisture content. Six replicates were maintained in all the treatments. Treatment substrates were prepared in the following proportions on weight basis such as; T_1-FA+CLl+CD (2:4:4), T_2-FA+CLl+CD (3:3.5:3.5), T_3-FA+CLl+CD (4:3:3), T_4-FA+CLl+CD (5:2.5:2.5) and T_5-FA+CLl+CD(6:2:2) CD alone was used as control(C). In each treatment one kg of mixture was added with 200 gram of clay loam soil (CLS) to prepare the substrate and it was precomposted for 30 days.

After 30 days 15.0 gram of adult clitellate L.mauritii were collected from the stock culture and introduced in control and treatment substrates. Once in 15 days upto 90 days weight of the worms (gram), number of cocoons and number of hatchlings were observed and recorded. The statistical significance of the data was tested by two way ANOVA.

RESULTS

The growth and reproduction of L.mauritii were observed in different level of fly ash mixture. Table 1-3 show the values obtained for different parameters of growth and reproduction of L.mauritii.

Biomass (gram) of earthworms in general increased in control and in all fly ash mixtures significantly($p<0.05$), but the rate of biomass production decreased after 60th day (i.e 75th and 90th day). The overall rate of biomass production was maximum in T_2 (27.6±1.51 gram) and the least growth was observed in T_5 (16.5±1.37 gram) on 60th day.

The variation in the cocoon production is depicted in Table.2.The inoculated adult clitellate worms started to produce cocoon and they were observed on 15th day in C, T_1, T_2 and T_3 but in T_4 observed on 30th day and in T_5 on 45th day. Among all the treatments the total number of cocoon was higher in T_2 (108.9±1.76) than the other treatments; it was followed by T_1, C, T_3, T_4 and T_5 respectively. From the table significant ($p<0.05$) differences were found in the cocoon production

Figure 1

Table 1. Role of flyash (with cashew leaf litter and cowdung) on the biomass (gram) of

Substrate proportions	Vermicomposting days						
	Initial (0)	15	30	45	60	75	90
Control C	15.09 ± 1.38	17.4 ± 1.09 (15.30)	19.9 ± 1.35 (31.87)	22.4 ± 1.24 (48.44)	24.6 ± 1.51 (63.02)	21.2 ± 1.22 (40.49)	19.6 ± 1.54 (29.88)
(FA + CLl + CD) 2:4:4 T_1	15.0 ± 1.10	18.1 ± 1.36 (20.66)	21.2 ± 1.10 (41.33)	25.5 ± 1.60 (70.0)	26.9 ± 1.51 (79.33)	21.6 ± 1.37 (44.0)	20.4 ± 1.36 (36.0)
(FA + CLl + CD) 3:3.5:3.5 T_2	15.02 ± 1.45	18.2 ± 1.39 (21.17)	21.9 ± 1.64 (45.80)	26.0 ± 1.31 (73.10)	27.6 ± 1.51 (83.75)	22.4 ± 1.17 (49.13)	21.0 ± 1.32 (39.81)
(FA + CLl + CD) 4:3:3 T_3	15.05 ± 1.36	16.2 ± 1.36 (7.64)	17.5 ± 1.22 (16.27)	19.3 ± 1.09 (28.2)	20.8 ± 1.67 (38.20)	19.6 ± 1.52 (30.23)	18.5 ± 1.41 (22.92)
(FA + CLl + CD) 5:2.5:2.5 T_4	15.01 ± 1.45	16.0 ± 1.29 (6.59)	16.2 ± 1.46 (7.92)	18.4 ± 1.52 (22.58)	19.9 ± 1.42 (32.57)	18.7 ± 1.35 (24.58)	17.6 ± 1.32 (17.25)
FA + CLl + CD) 6:2:2 T_5	15.0 ± 1.10	15.3 ± 1.08 (2.0)	15.8 ± 1.08 (5.33)	16.9 ± 1.34 (6.66)	16.5 ± 1.37 (10.0)	16.3 ± 1.39 (8.66)	15.8 ± 1.08 (5.33)

ANOVA

Analysis of variance	Sum of square	Mean of square	F-value
Rows	188.836	37.76721	15.55019
Coloums	241.6979	40.28298	16.58602

Mean± SD of six observation, () – percentage of increase over the initial

Figure 2

Table 2. Role of flyash (with cashew leaf litter + cowdung) on the coccon production (number) of

Substrate proportions	Vermicomposting days							Total
	Initial (0)	15	30	45	60	75	90	
Control C	0	9.0±1.41	10.4±1.27	17.6±1.46	22.1±1.13	19.5±1.84	16.3±1.33	94.9±1.90
FA + CLI + CD 2:4:4 T_1	0	9.4±1.47	12.3±1.17	19.5±1.06	24.5±1.40	20.2±1.31	19.4±1.69	105.3±1.29
FA + CLI + CD 3:3.5:3.5 T_2	0	10.2±1.77	13.7±1.43	20.7±1.29	26.9±1.27	21.5±1.37	21.3±1.47	114.3±1.76
FA + CLI + CD) 4:3:3 T_3	0	8.3±1.27	9.1±1.33	11.1±1.37	15.3±1.65	13.6±1.41	8.4±1.17	65.8±1.55
FA + CLI + CD 5:2.5:2.5 T_4	0	0	3.2±1.26	6.3±1.41	9.4±1.31	8.4±1.47	3.2±1.34	30.5±1.06
FA + CLI + CD 6:2:2 T_5	0	0	0	1.2±0.44	3.6±1.24	1.4±0.37	1.1±0.41	7.3±1.48

ANOVA

Analysis of variance	Sum of square	Mean of square	F-value
Rows	1246.234	249.2467	19.29861
Coloums	1050.256	175.0427	13.55316

Mean± SD of six observation

Figure 3

Table 3. Role of flyash (with cashew leaf litter + cowdung) on the hatchling production (number) of

Substrate proportions	Vermicomposting days							Total
	Initial (0)	15	30	45	60	75	90	
Control C	0	0	16.2±1.36	17.3±1.31	24.1±1.48	33.1±1.75	30.2±1.17	109.9±1.67
FA + CLI + CD 2:4:4 T_1	0	0	18.3±1.48	22.9±1.10	28.2±1.38	33.1±1.75	31.1±1.16	133.6±0.94
FA + CLI + CD 3:3.5:3.5 T_2	0	0	19.2±1.69	24.5±1.47	30.2±1.70	35.6±2.95	34.4±1.92	143.9±1.52
FA + CLI + CD 4:3:3 T_3	0	0	11.0±1.45	16.3±1.30	21.6±1.32	22.2±1.36	18.2±1.47	89.3±1.32
FA + CLI + CD 5:2.5:2.5 T_4	0	0	4.5±1.05	6.5±1.23	11.5±1.49	16.0±1.21	3.3±1.25	41.8±1.48
FA + CLI + CD) 6:2:2 T_5	0	0	0	0	2.3±1.26	8.2±1.33	2.6±0.94	13.1±1.55

ANOVA

Analysis of variance	Sum of square	Mean of square	F-value
Rows	1840.581	368.1162	12.0548
Coloums	3502.421	583.7369	19.11578

Mean± SD of six observation

The numbers of hatchlings by the L.mauritii in various combinations are presented in Table.3.The hatchlings were observed in all treatments except T_5 from 30th day onwards. In T_5 the hatchlings were observed only on 60th day. More number of hatchling were observed in T_2 (Total number143.9±1.52) and the least number of hatchlings were observed in T_5 (Total number 20.6±1.55). The Hatchlings in other treatments are in the following order T_1(133.6±0.94)> C(109.9±1.67)> T_3(89.3±1.32)>

T_4 (41.8±1.48)> T_5 (13.1±1.55).

DISCUSSION

The enhanced growth and reproduction of L. mauritii were observed in control and in treatments, but the rate of biomass production decreased after 60th day because the availability of feed is decreased in the total experimental period of 90 days. As described by Neuhauser et al (13)When E. foetida received food below a maintenance level, it lost weight which depended upon the quantity and nature of its ingestible substrates.

The rate of biomass and reproduction of L. mauritii were maximum in T_2 mixture.

The growth and reproduction of earthworms are highly influenced by the quality and availability of feed, various physiochemical parameters etc (14,15). Growth and reproduction in earthworms require OC, N and P (16) which is obtained from litter, grit and microbes (17, 18). The first step in the vermiculture is selection of suitable feed materials for earthworms. These can be nitrogen rich materials like cow dung, pig manure, poultry manure, etc or other organic material should be like leguminous agro waste(19).

Manivannan et al (20) reported higher growth of earthworm Eudrilus eugeniae, Perionyx excavatus, Eisenia fetida and Lampito mauritii in press mud, trash, bagasse(PTB) mixture. They added the enhanced growth and reproduction must be due to rich cellulose content, rich microbial population and higher nutritive value. Studies of Ananthakrishnasamy et al.(21) revealed that cow dung- bagasse mixture 2:8 ratio was the better feed mixture to increase the biomass of L. mauritii. They reported that particular mixture probably provided earthworm with sufficient amount of easily metabolizable organic matter and non-assimilated carbohydrates that favors growth and reproduction. The Perionyx sansibaricus grew faster and had higher fecundity when feeding on nitrogen rich diets such as vegetable waste and leaf litter (22) and E. fetida in leguminous leaf litter (9).

According to Sarojini et a l(23) E. fetida was able to grow more in bedding material alone, which contains more nutrients than the other mixtures of bedding material and fly ash in various proportions. At the same time the mixture which contains less quantity of FA seems to be the better combination than the others which contains more quantity of FA. This could be probably due to contribution of more nutrients to the medium by the addition of more quantity of bedding materials.

In our observation, the maximum worm biomass and reproduction was observed in T_2-FA+CLl+CD (3:3.5:3.5). It may be due to higher N content/ higher microbial content/ higher palatability for the growth of earthworms. Similarly, Gupta et al (3) reported higher zoo mass in 20% FA+CD and higher number of juveniles and more vermicast recovery in 40% FA+CD mixture and it was due to less toxicity exerted by less quantity of fly ash in these combinations than 60% and 80% FA+CD mixtures. They added that the use of E. fetida to mitigate toxicity of metals seems to be feasible technology and upto 60% FA+CD mixture can be sustainable and efficient vermicomposting without showing any toxicity to earthworms.

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