FINDING OPTIMUM QUANTITY OF CATTLE DUNG FOR FASTER BIOCONVERSION OF WHEAT STRAW INTO A PLANT GROWTH MEDIUM

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Abstract: *Presence of cellulose, hemicellulose, lignin and silica delay decomposition and recycling of nutrients of wheat straw in nature. In the present study wheat straw was mixed with cattle dung in 1:1, 2:1, 3:1 and 4:1 ratios and subjected to aerobic composting (WA_1,WA_2, WA_3 and WA_4 respectively) and vermicomposting (with Eisenia fetida -WV_1, WV_2, WV_3 and WV_4 respectively). Fastest bioconversion of straw into a plant growth medium was observed for WV_1 and WV_2 (120 days) but longer time was required for WV_3 (130 days) and WV_4 (135 days). However, much more time was required for aerobic composting treatments viz. AV_1 (140 days), AV_2 (143 days), AV_3 (145 days) and AV_4 (150 days). Maximum population buildup (number and biomass of worms, cocoons and hatchlings) was observed in WV_2 which was followed by WV_1, WV_3 and WV_4. As the population buildup in WV_3 was fairly good, better than WV_4 and number of days for bioconversion (130 days) were much less than the days for all the mixtures of aerobic composting (140-150 days), therefore vermicomposting of wheat straw: cattle dung with E. fetida is a better strategy for management of wheat straw in an eco-friendly manner. It is suggested that 2:1 wheat straw: cattledung is best combination but the ratio can be increased to 3:1 also.*

IndexTerms – Wheat straw, Cattle dung, vermicompost, Eisenia fetida.

I. INTRODUCTION

Punjab is an agricultural state and is considered food basket of India. With only 1.5% geographical area of India it contributes 17.2% share in all India wheat production ranking third after U.P. and M.P. (Agriculture statistics, 2016). Increasing population is putting a constant demand on more food production but new and upcoming technologies focused on increased food grain production leave a large amount of loose residue in the fields. After harvesting, a huge amount of straw is produced as a by-product when grain and chaff have been removed (Khan and Mubeen, 2012). Around 6 tons of wheat straw is produced for every 4 tons of wheat grain (Thakur, 2003) but the stubble needs special attention. To prepare the fields for next crop, farmers resort to the cheapest and less time consuming method of stubble burning for clearance of land. Gupta et al (2004) estimated that nearly 85 million tons of wheat straw is generated in India and around 19 mt are burnt in the fields. Around 36% of wheat stubble was burnt in the year 2000 in India according to Garg (2008). Burning of crop residues causes harmful emissions that pollute the atmosphere and leads to loss of nutrients and degradation of soil properties (Singh and Panigrahy, 2000). Recycling of these wastes through composting not only produces plant nutrients but also improves physico-chemical conditions of soil and air (Mishra et al, 1989 and Bhardwaj, 1995). A long time is required for its degradation in nature because wheat straw consists of carbohydrates (cellulose, hemicellulose, lignin), proteins, minerals (calcium and phosphorous), silica, acid detergent fibres and ash (Khan and Mubeen, 2012). Generally cattle dung is mixed with such residues to improve C/N ratio and for enhancing the rate of composting. Vermicomposting can be used as an alternative technique for fast conversion of such organic wastes into a valuable wealth for agriculture (Benitz et al, 1999). In this process earthworms are used to convert organic wastes into humus like material known as vermicompost which is rich in various essential plant nutrients (Edwards et al, 1998).

During vermicomposting earthworms reduce the particle size and make the environment more conducive for microbes and the mutual action of earthworms and microbes not only reduces the time taken for bioconversion but also enriches the product with plant growth hormones. Vermicomposting of crop residues with the help of *Eisenia fetida* has been reported earlier (Suthar, 2008 & 2010; Jaybhaye and Bhalerao, 2016) but hardly any report is available on the weight of cattledung to be mixed with the wheat straw for its rapid conversion to a plant nutrient rich vermicompost. In the present study an attempt has been made to find an optimum ratio of cattle dung to be mixed with wheat straw that leads to fastest bioconversion of this crop residue. The ratio should support growth and reproduction of *E. fetida* because these are driving forces of vermicomposting.

II. RESEARCH METHODOLOGY

The experiment was performed in plastic tubs (65×45×30 cm) in triplicate under the sheds of GNDU. **Table 1** shows the composition of various feed mixtures. One kg mixture for all the treatments was subjected to vermicomposting with *E. fetida* and to aerobic composting. The mixtures were kept for 2 weeks for thermal stabilization and removal of volatile toxins prior to earthworm inoculation. Thereafter 100 non-clitellate *E. fetida* of almost same weight (average 0.20 g per worm) were released in all the tubs. Moisture was maintained by covering the tubs with jute mat and sprinkling water as and when required. The experiment was terminated on 120^{th} day (90 days after inoculation of earthworms) when a mixture was converted to brown crumbly balls (Vermicompost) or a brown earthy material (Aerobic compost) first of all, which is a sign for harvesting. Earthworm biomass and population build-up (number of hatchlings, cocoons and worms/ kg mixture) data were recorded on 0, 20^{th}, 40^{th}, 60^{th}, 80^{th}, 100^{th} and 120^{th}day during the experiment.

Statistical analysis:

The data were subjected to one way analysis of variance and the means were compared using Tukey's test ($p< 0.05$) with the help of SPSS 16 program.

III. RESULTS AND DISCUSSION:

In the present study it was observed that WV_1 and WV_2 were converted into vermicompost after 120 days while 130 and 135 days were required for bioconversion of WV_3 and WV_4 respectively. A longer time was required for conversion of all the mixtures of aerobic composting. Bioconversion of AV_1 was observed after 140 days (first of all) whereas 143, 145 and 150 days were required for complete conversion of AV_2 and AV_3 and AV_4. During vermicomposting earthworms decrease the particle size and increase surface area for action by microbes which enhances rate of bioconversion (Kristufek et al, 1992). The enzymes (dehydrogenases) of earthworm gut also help in faster degradation of organic matter (Kumar et al, 2010). Other authors have also reported faster degradation of organic matter with vermicomposting in comparison to composting (Tognetti et al, 2005; Mupondi et al, 2010 and Ngo et al, 2011).

Population buildup in the form of number of worms, cocoons, hatchlings and biomass as a measure of acceptance of a particular feed mixture by *E. fetida* was significantly different ($p<0.01$) in various feed mixtures of wheat straw and cattle dung. The trend for increase or decrease in biomass, number of adults, cocoons and hatchlings varied in different feed mixtures. The number of worms at different time intervals were significantly different ($p<0.01$) in all the mixtures of present study. The number was maximum on 80th day in all the feed mixtures, started to decline on 100th day and the decline continued till termination of the experiment on 120th day. At the end of the experiment maximum increase over initial was observed in WV_2 (6%) while a decline over initial was observed in WV_1 (6%), WV_3 (25.67%) and WV_4 (29.77%) (**Fig1A**). An increase in the number of earthworms was also observed during vermicomposting of pre-decomposed wheat straw by Singh and Sharma (2002).They observed maximum number of worms in the straw treated with *Azotobacter chrococcum* and suggested that more suitability of this mixture as feed was responsible for higher population buildup of worms. Maximum number of worms in WV_2 in the present study could also be due to an appropriate C/N ratio of the feed as it has been reported to be critical for supporting growth of worms (Ndegwa et al, 2000).

The number of cocoons in different mixtures of straw was significantly different ($p<0.01$). Cocoon production started between 35th to 50thday after release of worms in all the mixtures. The number of cocoons increased till 100th day and after that a decline was seen on 120th day. On the 100th day maximum number of cocoons was observed in WV_2 (453) and minimum in WV_4 (158). After this a decline occurred on 120th day and 365 cocoons were seen in WV_2 and 104 in WV_4 (**Fig 1 B**).The number of hatchlings was significantly different ($p< 0.01$) in various mixture of straw. The hatchlings were observed for the first time on 60th day. The number of hatchling increased after this and was maximum on 120th day in WV_2 (388) and minimum in WV_4 (102) (**Fig 1 C**). Maximum population buildup in WV_2 in the present study clearly shows suitability of this mixture for growth and reproduction of the worm. Suthar (2009) suggested that organic waste palatability for earthworms was directly related to the chemical nature of the organic waste, which consequently affects the rate of cocoon production in earthworms. Edwards et al (1998) concluded that the important difference between the rates of cocoon production in the organic wastes was related to the quality of the wastes.

Worm biomass showed significant difference ($p<0.01$) in different proportions of wheat straw in the mixtures. Maximum worm biomass was observed in WV_2 followed by WV_4, WV_3 and WV_1 (**Fig 1 D**). Shak et al (2014) reported that rice straw: cattledung (1:2) supported best growth of *Eudrilus euginae* and was converted into nutrient rich product in 60 days. Manaig (2016) reported that 3:2 rice straw and cattledung supported biomass of *Eudrilus euginae* and was second best combination in comparison to rice straw and chicken manure, rice straw and hog manure, *Gliricidia sepium* leaves and cattle manure, *Gliricidia sepium* leaves and chicken manure, *Gliricidia sepium* leaves and hog manure, sawdust and cattle manure, sawdust and chicken manure & sawdust and hog manure. The worm biomass was at peak on 80th day, a decline was observed on 100th day and the decline continued till the end of experiment on (120th day) in all the feed mixtures. Kaur et al (2010) reported similar results of decline in weight at the termination of experiment and suggested that the decline was due to conversion of most of the feed material into vermicompost leaving no feed for earthworms to grow further. Other studies have also reported that the worm biomass decreases near termination of the experiment due to non-availability of feed (Suthar, 2007, 2009a; Gupta and Garg, 2008). In the present study we also noticed that 2:1 ratio of wheat straw and cattledung was best for population buildup of *E. fetida*. Variation in the number of cocoons and hatchlings in the feed mixtures of present study could be due to variation in the availability of nutrients. Quality of the feed and palatability of the feed have been reported to directly influence cocoon and hatchling production in other studies also (Edward et al, 1998; Suthar, 2009, Sharma and Garg, 2018). An increase in earthworm biomass in all the feed mixtures of the present study suggests that feeds were palatable but less increase in WV_3 (21.34%), WV_1 (11.94%) and WV_4 (9.85%) over WV_2 suggests better quality of WV_2 mixture as quality of the feed has been reported to directly affect biomass gain in worms (Vodounnou et al, 2016).Higher biomass of worms in WV_4 along with lower number of cocoons and hatchlings clearly indicates that the energy diverted for reproduction is assimilated by these worms. Similar findings have been reported by Kaur et al (2010).

Conclusion:

The present study clearly shows that wheat straw when spiked with cattle dung in 2:1 ratio gives best population buildup of *E. fetida* and yields a value added product (vermicompost) in 120 days. This study also shows that vermicomposting enhances rate of bioconversion of wheat straw as the maximum time taken for conversion of 4:1 wheat straw and cattledung (WV_4) was 135 days which was less than the time taken for all the mixtures of aerobic composting (140, 143, 145 and 150 days for AV_1,AV_2, AV_3 and AV_4 respectively). Therefore vermicomposting is a better option for recycling of nutrients even when we mix wheat straw and cattledung in 3:1 ratio.

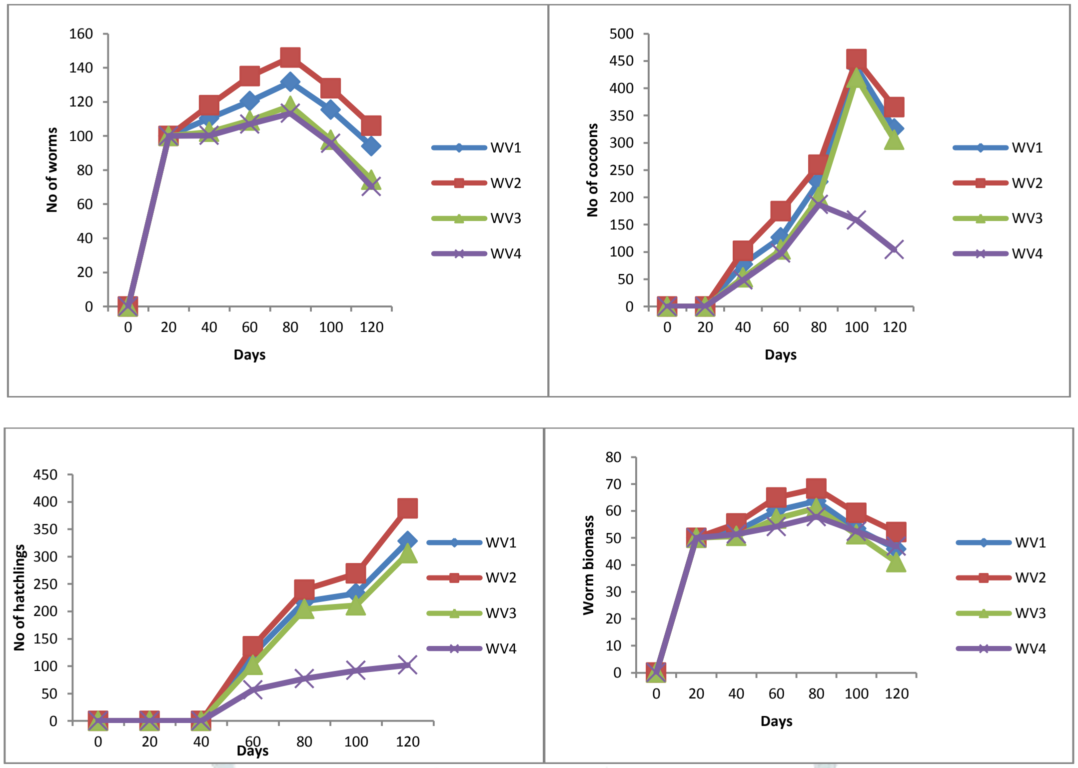

Figure1: Population buildup of *Eisenia fetida* in different mixtures of Wheat straw (W) and Cattle dung.

Table 1: Proportion of wheat straw and cattle dung in various feed mixtures (on dry weight basis) for vermicomposting (WV) and Aerobic composting (AV).

Feed mixtures	Wheat straw (W)	Cattle dung(C)
WV_1 /AV_1	1 parts(500g)	1(500 g)
WV_2 / AV_2	2 parts (667 g)	1(333 g)
WV_3 / AV_3	3 part (750g)	1(250g)
WV_4/ AV_4	4 parts (800g)	1(200g)

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