



Study of Potential Utilization of Guar (*Cyamopsis Tetragonoloba*) Gum Industrial Waste in Vermicompost Manure Production

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Abstract

Recycling of guar gum industrial waste through vermiculture technology was studied under laboratory conditions. Three different combination of guar gum industrial waste were, used: guar gum industrial waste: cow dung : saw dust in 40 : 30 : 30 ratio (T1), guar gum industrial waste : cow dung : saw dust in 60 : 20 : 20 ratio (T2) and guar gum industrial waste : cow dung : saw dust in 75 : 15 : 10 ratio (T3) for vermicomposting experiments. Vermicomposting was monitored over 150 days included some chemical changes of the guar gum industrial waste. Comparatively T2 showed great increase (from its initial level) for total N (25.4 %), phosphorus (72.8 %) and potassium (20.9 %) than the other treatments. Nevertheless, in T1 treatment organic C and C:N ratio decreased (from its initial level) maximally of 10 % and 28.3 %, respectively after 150 days of vermicomposting. As compare to control the increase/decrease in vermicompost was also analyzed for different chemical Parameters by using vermicomposting coefficient (VC) and greater values of it was recorded in T2 treatment. The growth pattern of *P. excavatus* in terms of biomass gain and cocoon production was also recorded. *P. excavatus* shows greater mean individual biomass 146.68 mg in T2 treatment with 0.268 mg/day mean individual growth rate. Similarly T2 treatment also showed about 21.9% and 645.5% more cocoon numbers than the T1 and T3 treatments, respectively. The T3 treatment showed maximum earthworm mortality while no mortality was recorded in T2 treatment during 150 days of composting. Overall, the T2 treatment was best to enhance the maximum biopotential of earthworm for guar gum industrial waste management as well as earthworm biomass production.

Introduction

The agriculture based industrial organic residues are candidate for transformation from expensive disposal problem to suitable vermiculture humus for use in food production. Much attention has been paid to evolve the low input basis ecofriendly technologies for industrial waste management. Now a day's intensive research has been conducted on the potential use of earthworms in the stabilisation of natural and anthropogenic wastes. Vermicomposting is an eco-biotechnological process that transfers energy-rich and 1 complex organic substances into stabilised humus like product (Benitez et. al., 2000). Earthworm aerates, shreds, grind and turn the organic material offsetting expensive specialised machinery, environmental pollution and, fossil - fuel consumptions disposal problem. There has been extensive research into using earthworm to manage the various industrial waste (Edwards, 1998, Kale, 1998, Ghantnekar, 1994, Butt, 1993, Elvira et al., '1997, Suthar, 2002). Elvira et al. (1997) and Butt (1993) demonstrated that solid paper mill sludge could be managed efficiently by using soil dwelling earthworms. Kale et. al. (1994) state that vermicomposting is one of the alternatives for safe disposal of distillery wastes. Earthworms aerate, shred, grind and turn the organic material into valuable Vermicompost. According to Kaviani et al. (1998) waste produced from coir processing industries can be converted into valuable biofertilizer (vermicompost) through vermiculture technology.

The guar gum is a agricultural based industrial product. It is mainly acquired from plant species: *Cyamopsis tetragonoloba* Linn. a major cereal crop of the western Rajasthan. There are more than 2000 guar gum industrial units in Rajasthan, producing guar gum powder mainly used for pharmaceutical industries. These guar gum industries produce a great quantity of lingo-cellulose waste material. Thus, this agro-industrial waste material could be a candidate for transformation from expensive disposal problem to suitable vermiculture humus for use in food production and soil restoration.

In this study guar gum industrial waste along with some organic supplements was subjected to recycle through vermicomposting process, by using composting earthworm species *Perinix*



excavatus (Perrier) for 150 days under laboratory condition.

Materials and Methods

Earthworm and waste collection

Composting earthworm species *Perionyx excavatus* (Perrier) was originally obtained from 1 Prof. R.D. Kale, Department of Zoology, University of Agricultural Sciences, Bangalore. The earthworms were acclimatized for laboratory conditions for about 15 days. The *Perionyx excavatus* was cultured using pre composted cow dung When sufficient size of earthworm acquired, the earthworms were used for experimentation.

The industrial waste was collected from Rajasthan Guar gum Ltd., RICCO Industrial Area, Jodhpur, India. The industrial waste was collected in gunny bags and brought to the laboratory The excess moisture was removed by shade drying for about 3 days. The waste material was analysed for certain chemical parameters i.e. organic C, total N, phosphorus, potassium, C-to-N ratio (Table 1).

Vermicomposting experiments

The plastic container (20 cm. ht., 28 cm dia) were used for laboratory screening of guar gum industrial wastes. The guar gum industrial waste was mixed with other supplements i.e. saw dust and cow dung in different ratios. Three different combination of industrial waste with other supplements were used: (i) Guar gum industrial waste + cow dung + saw dust in 40: 30: 30 ratio (T1), (ii) guar gum industrial waste + cow dung + saw dust in 60: 20: 20 ratio. (T2), and (iii) guar gum industrial waste + cow dung + saw dust in 75: 15: 10 ratio (T3). Each treatment was kept in triplicate and same setup without earthworm were also maintained, which served as control. All beddings were kept for 20 days prior to experimentation for thermal stabilization, initiation of microbial degradation and softening of waste. The moisture level of containers was maintained about 60 — 70%. Twenty healthy earthworms were isolated from the stock culture, pre weighed, and placed in each experimental container. To prevent evaporation of water content mulching was done using paddy straw. All containers were incubated at a room temperature of 26.3 0.39 C. Container were placed in moist and dark place. At the start of the experiment the guar gum industrial waste and the vermicompost produced at the each 30 days interval during the course of experiment were measured for organic C, total N, available P, exchangeable K and C-to-N ratio. Mean individual biomass, cocoon production and total mortality in different containers were also calculated at the each 30 days interval.

The vermicomposting coefficient for different chemical parameter was calculated by following formula:

$VCx = \frac{\text{Total increase I decrease in x during vermicomposting (experimental)}}{\text{Total increase I decrease in x during composting (control)}}$

Total increase I decrease in x during composting (control)

Chemical analysis

Organic carbon was determined following Walkley - Black method. Nitrogen was estimated by Microkjeldhal method. Phosphorous was detected by using tecator model 5012 - autoanalyser. Potassium was determined after extracting the sample using ammonium acetate extractable method; analysed by Perki-elmer model 3110 double beam atomic absorption spectrophotometer.

Statistical analysis

Data were subjected for analysis of variance (ANOVA) followed by Duncan's multiple-ranged test to differentiate the significant difference between -different-treatments for chemical parameters, earthworm growth, cocoon production, and total mortality during experimentation. A Pearson correlation coefficient as well as regression equation was used to evaluate the relationship between different chemical parameters and vermicomposting period.

Results and discussions

Chemical changes during vermicomposting

Organic carbon During vermicomposting organic C showed drastic variation in all the three treatments, and it decreased over 150 days (Fig. 1(a)). The organic C contents of Ti



treatments differed significantly ($p < 0.05$) for that of T2 and T3 treatments. Nevertheless, the organic C decrease did not show statistically significant ($p = 0.072$) difference for T2 and T3 treatments. Comparatively the organic C loss was higher in T1 treatment (10 % of initial level); than the T2 (9.63 %) and T3 (5.01 %) treatments, after 150 days of vermicomposting (Table 2). Organic C content was negatively correlated with composting time ($r = -0.982^{***}$, T1 treatment; $r = -0.992^{***}$, T2 treatment; and, $r = -0.829^{***}$ T3 treatments) (Table 3). After 150 days of experimentation the vermicomposting coefficient for organic C (VCC) was calculated 1.02, 1.03 and 1.05 for T1, T2 and T3 treatment, respectively (Table 4). Vermicomposting process is generally characterized by measurement of the growth and reproduction of earthworms and/or determining different physico-chemical parameters, such as changes in C/N ratio, variations of available nutrients, or increase in humic substances (Elvira et al., 1997). Cheshire and Griffiths (1989) pointed out that C14 losses in the presence of earthworm were 66% after 12 months and 60% after 2 years respectively. Edwards and Heath (1963) reported more than 30% loss of organic carbon from oak leaves when composted through *Lumbricus rubellus*. The vermicomposting process accelerates microbial degradation as well as assimilation. Earthworm per motes suitable microclimatic conditions that consequently affects C losses from substrates through microbial respiration. The mucous secreted by earthworms contain high concentration of organic matter and ammonium (Needham, 1957) that may serve as a better substrate for fungi and bacteria (Edwards and Fletcher, 1988). So earthworm mediated microbial propagation further accelerates the degradation process of organic waste. The present study extended and confirmed earlier observation that earthworm plays significant role in organic matter transformation.

Total Nitrogen The total N content in T1 treatment differed significantly ($p < 0.05$) from that of T2 and T3 treatments, and it increased linearly over 150 days of vermicomposting (Fig. 1(b)). The total N content in T2 and T3 treatment did not show any significant difference ($p = 0.161$) after 150 days. The greater concentration of total N was recorded in T2 treatment (Table 1). Nevertheless, by 150 days of vermicomposting, total N content has increased maximally in T1 treatment (25.4 % from the initial level) as compared to T2 (25.2 %) and T3 (9.83 %) treatments (Table 2). Total N content was also strongly positively correlated with composting time ($r = 0.947^{***}$, T1 treatment; $r = 0.958^{***}$, T2 treatment; and, $r = 0.829^{***}$, T3 treatment) (Table 3). The vermicomposting coefficient for total N (VCN) was recorded maximum in T1 treatment than the other two (Table 4). Frederikson and Knight (1988) stated that there was a tendency for the NO_3 level of vermicompost to be higher in treatment with earthworm than in treatment without earthworms. Edwards and Burrows (1988) reported that amount of NO_3 in cattle waste with earthworms were much greater than in those without earthworms. Earthworm enriches the vermicompost with nitrogen through excretory products; mucous and even by decaying worm tissue after death. Similar reports have been published by Vincelas - Akpa and Loquet (1997). Gunadi et al. (2002) pointed out that nitrogen content in the end-product vermicompost for all waste treatment after six months vermicomposting were very high.

C/N ratio: Statistically C : N ratio - time profile of T1 treatment was significantly different ($p < 0.05$) from that of T2 and T3 treatments. The C : N difference for T2 and T3 was not statistically significant ($p = 0.282$). The C : N ratio decreased linearly over time (Fig 3 (c)). T1 treatment showed maximum reduction (28.3% of initial level) in C : N ratio from that of T2 (27.5 %) and T3 (5.6 %) treatment, after 150 days of vermicomposting (Table 2). The C:N ratio also the most strongly, negatively correlated with vermicomposting time period ($r = -0.974^{***}$, T1 treatment; $r = 0.971^{***}$, T2 treatment, and $r = -0.954^{***}$, T3 treatment) (Table 3). The vermicomposting coefficient for C:N ratio (VCC:N) was calculated lower in T3 treatment than other treatment (Table 4). According to Vincelas — Akpa and Loquet (1997) the C/N ratio that is one of the most widely used indices for vermicomposting process decrease sharply when inoculated with earthworms. It reflects the decreased carbon and a higher proportion of total nitrogen and ionic protein content in the vermicompost. Senapati and Dash



(1984) stated that release of CO₂ in the process of respiration; production of nitrogen lowers the C/N ratio. Jedrijevic et al. (1991) observed that in cattle and goat manure *E. fetida* activity contributed of variation in C/N ratio and CO₂ release. Since, decreasing C/N ratio indicated the increases of nitrogen of substrate directly by secretion of mucous and excretory products and indirectly by microbial nitrogen fixation as well as mineralization.

Phosphorous: The content in T₁ treatment showed statistically difference ($p < 0.05$) from that of T₂ and T₃ treatments. However, the phosphorous concentration in vermicompost obtained from the T₂ and T₃ treatment did not varied statistically ($p = 0.368$) from each other. The maximum increase in phosphorous concentration from its initial level was registered in T₂ treatment (72.8 % of its initial level) and compare to T₁ (45.7 %) and T₃ (54.8%) treatment after 150 days of vermicomposting (Table 2). It increased linearly over the time (Fig. 1(d)). The phosphorous concentration positively correlated with vermicomposting time ($r = 0.918^{***}$, T₁ treatment; $r = 0.953^{**}$, T₂ treatment; and, $r = 0.949^{***}$ T₃ treatments) (Table 2). The vermicomposting coefficient for phosphorous (VCP) was recorded higher in T₂ treatment than the other two (Table 4). According to Lee (1992) organic C passes through the gut of earthworm results in sum of phosphorous being converted to forms that are plant available. He concluded that some release of P in forms available to plants is than mediated by phosphatases that are produced within the earthworm and further release of P may be introduced by microorganism in casts, after their excretion. The increase levels in vermicompost strong the above hypothesis.

Potassium: The extractable potassium content in all the three treatments showed statistically significant difference ($p < 0.05$) after 150 days of vermicomposting. It increased linearly over the time (Fig. 1(e)). In T₂ treatment the potassium concentration increased maximally (20.9 % of initial level) than the T₁ (10.0 %) and T₃ treatment (9.2 %), after 150 days of vermicomposting (Table 2). The potassium concentration was also the most strongly positively correlated with vermicomposting period ($r = 0.983^{***}$, T₁ treatment; $r = 0.958^{***}$, T₂ treatment, and, $r = 0.965^{**}$, T₃ treatment) (Table 3). The vermicomposting coefficient for potassium (VCK) was calculated higher in T₂ than other treatments (Table 4). Plant nutrient present in organic material is released by the combined action of earthworm and microorganisms. Increased levels of plant available potassium in vermicompost further extends and confirm earlier observation. Abundant studies indicate that the interaction between earthworm and microorganism is of major importance in degradation of organic matter and release of microbial nutrients (Edwards and Lofty, - 1972, Lee, 1985). Earthworm primes its symbiotic gut micro flora with secreted mucus and water to increase their degradation of ingested organic matter and the release of available metabolites (Barois and Lavelle, 1986). This study further extends and confirms the potential of earthworm in release of nutrients from organic wastes.

Earthworm growth and cocoon production during vermicomposting Vermicomposting process is considered in terms of earthworm biomass and cocoon production. *P. excavatus* showed significant difference between mean individual biomass ($F=24.170$, $p<0.01$), mean growth rate of individual (mg/day) ($F=32.36$, $p<0.01$) and mean total cocoon number ($F=111.41$, $p<0.01$) in different treatments of guargum industrial waste, after 150 days. As data indicates *P. excavatus* showed greater mean individual biomass 146.68 4.50 mg. with mean growth rate of individual 0.26g 0.03 (mg day⁻¹), in T₂ treatment (Table 5). The mean individual biomass of *P. excavatus* in T₂ treatment was about 17 % and 35 % more ($p<0.05$) than the T₁ and T₃ treatment, respectively. Similarly *P. excavatus* exhibited greater mean cocoon production 106.83 4.91 with mean reproduction rate (cocoon worm⁻¹) of 5.32 0.25 in T₂ treatment (Table 5). The mean cocoon production in T₂ treatment was 21.9 % and 645.5 % more ($p<0.05$) than the T₁ and T₃ treatment, respectively. The reproduction rate in T₃ treatment was statistically different ($p<0.05$) from that of T₁ and T₂ treatment. Nevertheless, the reproduction rate of *P. excavatus* for T₁ and T₂ treatment did not show statistically significant difference. ($P = 0.181$). Similarly total earthworm mortality in T₃ treatment was



statistically different ($p < 0.01$) from T1 and T2 treatments. No statistically significant difference ($P = 0.418$) in mortality for T1 and T2 treatment was recorded, after 150 days of experimentation. (Table 5).

The success of vermicomposting is considered in terms of Physiochemical properties of composting material. The survival, biomass production and reproduction is the best indicator to evaluate the composting process. In T3 treatment the greater mortality 31.7 3.60% of the initial population was recorded and it was statistically significant ($p < 0.05$). Studies revealed that the kind, availability and quality of food directly affects the survival growth rate and reproduction potential of earthworms (Graf, 1974, Hartenstein et al., 1979, Nauhauser et al. 1979, Kale et al. 1982). Frederickson and Knight (1983) observed that factors relating to the growth of *E.fetida* may also be considered in terms of physiochemical and nutrient characteristics of waste feed stock. Abbott and Parker (1981) strongly recommended the concepts that a N-poor diet led to a decrease in earthworm biomass. Neuhauser et al., (1980) stated that weight gain in *E.fetida* strongly correlated to the C-to-N ratio of the feeding material. The food palatability directly related to its chemical quality (Satchell and Lowe, 1967). In present study the drastic variation in earthworm biomass and cocoon production rate in different treatments probably related to chemical nature of the feeding stuff.

Suitable combination for waste treatment As our data indicates, the earthworm species showed good results in the term of increasing NPK in T2 bedding having the proportions of 60 : 20 : 20 of guar gum industrial waste, cow dung and saw dust, respectively. As compared to other two combinations, this combination was found to be the ideal combination for the highest fold increase in NPK and times decrease in C/N and C/P ratio. It can be hypothesized that nitrogen and, organic matter content as well as microbial population in this bedding provides better condition for earthworm as compared to other two. Since guar gum industrial waste contains high quantity of lignin and cellulose and the enzymes to digest these plant component are mainly produced by symbiotic bacteria in earthworm gut. Lignin materials are decomposed by soil *basidio-mycetes* and *lignolytic* bacteria that are slow degraders. However these groups are found to establish well on worm cast and hence, the decomposition of lignin and cellulose not a major cause (Kale et al., 1988). The vermicombed T2 has good proportions of cow dung and saw dust in compare to other two that act as an ideal bedding for worm growth. Since, guar gum industrial waste have very high quality of nitrogen, so high proportions of nitrogen in bedding caused lethal effects on worm by producing toxic ammonia and it can be minimized by using materials having less amount of nitrogen like saw dust. Senappa et al., (1995) studied the vermicomposting of distillery waste by using the different proportions of wastes with other supplements like cattle dung and leaf litter. They concluded that more of the distillery sludge and less of cattle dung affected the worm drastically and it was observed that total volume of cow dung and leaf litter should be proportional to the total volume of distillery sludge and press mud that consequently have positive effect on growth and production of earthworms. Hartenstein (1978) suggested that *E.Fetida* derives a considerable amount of cellulose and that it many selectively remove larger proportions of microbes cellulosic matrix. In contrast to cellulose the ligneous components must be microbially or enzymatically separated from the cellulose. Kaviani et. al., (1998) studied the conversion of coir pith by using *Lurnbricus mbellus*. They found that bedding material incorporated with 25% of the coir pith showed higher fold increase in N, P and K as well as higher population of bacteria, actin-mycetes and cellulose degraders.

Conclusion

Vermicomposting of guar-gum industrial waste not only accelerates the microbial mineralization of complex plant nutrients, but also acted as good growth media for earthworm biomass production. Mixing of certain organic supplements in vermicombeds creates suitable microclimates as well as chemical environment that consequently affect the biological potential of earthworms in waste reduction. So, Vermicomposting process transfer energy



rich and complex organic substances into a product with a relatively high content of humus like compounds.

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