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Vemicomposts: A alternative biofertilizers for zayad crops

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With rapid increase in population, the generation of municipal solid wastes, agriculture wastes and other recyclable toxic substances has posing the management problems. Vermicomposting is one of the better recycling technologies which will improve the quality of the products. The aim of the present study was to investigate the potential utilization of vermicomposts of different animal dung, agriculture and kitchen wastes and there effect on the growth (cm), flowering period (days) and productivity (kg/meter^2) of vegetable crops- okra (Ablemoschus esculentus,), lobia (Vigna unquiculata) and bitter gourd (Momordica charantia) . The vermicomposts obtained from different combinations of animal dung, agriculture and kitchen wastes with the help of earthworm Eisenia foetida have significantly increased in total kjeldhal nitrogen (TKN), total potassium (TK), total phashorus (TP) and total calcium (TCa) and significantly decreased in total organic carbon (TOC), C:N ratio, pH and electrical conductivity (EC) in final vermicomposts with compared to initial feed mixture. The vermicomposts of different combinations of animal dung, agriculture and kitchen wastes shows significant effect on the growth and productivity while reduced the flowering periods of crops. The maximum growth observed after 50 days in buffalo dung+ gram bran for okra, lobia and bitter gourd among all combinations of vermicomposts. The significant early flowering period was recorded in cow dung + vegetable wastes for both okra and lobia while buffalo dung + rice bran for bitter gourd. The maximum productivity of okra, lobia and bitter gourd has been recorded in vermicompost prepared from cow dung + vegetables wastes in comparison to control. This study clearly indicates that the vermicomposts of animal dung, agriculture and kitchen wastes not only produce a value added product but also act as a better nutrient source for plants.

Keywords: Organic wastes; *Eisenia foetida*; vermicomposts; crops; growth; and productivity.

Introduction

Modern agricultural practices contribute much deleterious effect in the field disturb the soil texture and their physco-chemical properties, consequently it affect the human health and the environment. Recently, irregular cropping due to change in abiotic and biotic factors resulted in significant decrease in productivity of many crops (Ramamurthy, 2006), increased illness of soil due

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to excessive use of chemical fertilizers, observed that consistent depletion of organic matter and increased availability of acidity result in poor yield and quality (Mall *et al*., 2005). The nitrogenous, phosphorous, calcium and magnesium fertilizers deteriotes the soil nutrient, soil erosion and environmental pollution (Bhattacharya, 2004) and continuously declining of regenerative capacity of soil (Altieri and Resset, 1999). Currently animal wastes and sludeges disposal is a great challenge through world wide and being not fully utilized as organic fertilizers [Abbasy and Ramasamy, 2001]. The many work has been carried out the use of wastes such as cattle dung, municipal sludeges (Dominguez *et al*., 2000), agricultural residue (Bansal and kapoor, 2000) and domestic kitchen wastes (Sinha et al., 2002) etc.

The vermicompost application is one of the most effective methods to rejuvenate the depleted soil fertility and enrich the available pool of nutrients, conserve more water and maintain soil quality (Vashanthy and Kumarasamy, 1999 and Zebrath *et al*., 1999). Vermicomposting is a recycling of wastes in to valuable organic fertilizers (Nagavallemma *et al.*,2004). The vermicomposting process generally neutralizes the pH of substrate because $CaCo_3$ secreted from gut by earthworm (Senapati, 1993). The vermicomposting process generally transforms the nutrients in to a plant available form (Edwards 1998). The mineralization of phosphorous (P), molybdenum (Mo), iron (Fe) and Zinc (Zn) content take place and mineralization rate indirectly related to soil microbial activity over the course of vermicomposting (Buchanan *et al*., 1988).

The use of vermicompost as soil amendments has many positive effects and important components of the bio-organic concepts or sustainable concept of crop cultivation (Masciandro 2000; Ramamoorthy, 2004). Powell *et al.* (1999) reported that manure alone provided sufficient nitrogen for a millet crop. Many researches have found that vermicompost stimulates further plant growth even when the plants are already receiving other type of optimal nutrition [Aranco, 2004; Atiyeh *et al*., 2002; Canellas *et al.*, 2002]. Edwards *et al.* (2004) reported vermicompost applications suppressed the incidence of the disease significantly. Many researchers suggested that vermicompost can be considered as also an alternative of pesticides and as non-toxic method of pest control (Aranco, 2004; Zaller, 2006).

Zayad crops are one of the most promising vegetable crops of summer season in north-east region of India. The objective of this study were evaluate the different chemical parameters and efficiency of a vermicomposts of different animal (viz- cow, buffalo, goat, sheep and horse) dung, agriculture/ kitchen (rice bran, wheat bran, gram bran, barley bran, straw and vegetable) wastes on certain zayad crops. The assessment of growth, flowering period and productivity of okra, lobia and gourd mainly considered.

Materials and methods

Collection of wastes

The different organic wastes, animal dung (cow, buffalo, sheep, goat and horse) were collected from different animal farms, whereas, the agricultural and kitchen waste were collected from garbage and agricultural fields of rural and urban areas of the Gorakhpur district, U.P., India. The Gorakhpur district of Utter Pradesh state has the agriculture based socio-economy of a rural population and is situated in north-east zone of India. The earthworms Eisenia foetida were cultured in Vermiculture Research Centre, Department of Zoology D.D.U. Gorakhpur University Gorakhpur, U.P., India. The cultured adult earthworms were used for the experiments.

Experimental design

The vermicomposting were conducted on a cemented earth surface. Each vermibed formed of different combinations from animal dung with agricultural/ kitchen wastes in the 1:1 ratio in size of the 3m x 1m x 9cm as shown in Figure 1. After formation of vermibed moistened 2kg of cultured adult Eisenia foetida were inoculated in each bed. The beds were covered with jute pockets and moisten the bed daily up to 40 to 50 days for maintaining the moisture content (40-60 per cent) and temperature (25-35 ^{0}C). After one week interval, mixture of bed was manually turned up to 3 weeks. After 50 to 60 days granular tea like vermicompost appeared on the upper surface of beds. The earthworms was separated from prepared vermicomposts. The final prepared vermicompost were used for chemical analysis and experimental field crop.

Fig. 1. View of vermicomposting beds

Chemical analysis

The chemical analysis of water extract of initial feed mixture (mixture of organic wastes just after inoculation of earthworms) and final vermicomposts, soil and mixture of soil with vermicomposts were performed by standard methods. Total organic carbon (TOC) were determined by the method of (Nelson and Somer, 1982), total Kjeldahl nitrogen by (Bremner and Mulveny, 1982) procedure, total available phosphorus (TAP) by colorimetric method (Bansal and Kapoor, 2000), total Potassium and Calcium were determined by flame photometer Bansal and Kapoor (2000), The pH and electrical conductivity (EC) were determined by the method of (Garg *et al.*,2006).

Measurement of growth, flowering and productivity

Following crops and their variety were selected for experiment field.

Okra (Ablemoschus esculentus)- Punjab Padamni; Bitter gourd (Momordica charantia)- Phalguni; Lobia (Vigna unguiculata)- Pusa phalguni

Measurement of growth, flowering period and productivity of crops were performed in the experimental field of the Vermiculture Research Center. The different varieties of crops were sowed according to their season. They were sowed directly in the cultivated soil. In the cultivated field, each grid having the size of $1m^2$ (1m x 1m) area seeded with different crops were sowed with the same seed density. 2 kg/m^2 vermicomposts were mixed with soil in each experimental fields. Growth of plants was observed at 20, 35 and 50 days by auxanometer. Flowering period (days) was observed when flower appear in adults plants. After harvesting of each crops, productivity were calculated in the kg/ $meter^2$.

Statistical Analysis

The data given as the mean ± standard error (SE) of six replicates. Two way analysis of variance (ANOVA) were applied to between time and different combinations of animal dung and agriculture/kitchen wastes between initial feed mixture and final vermicomposts chemical parameter as well as growth of plants. Student ‘t’ test were applied between control and different combinations of soil with different vermicompost for flowering period and productivity (Sokal and Rohlf, 1973).

Results

There was significant increased in total kjeldhal-nitrogen (TKN), total potassium (TK), total available phosphorus (TP), total calcium (TCa) and decrease in pH, electrical conductivity (EC), total organic (TOC) and a C:N ratio was observed in final vermicomposts of all the combinations of organic wastes compared to the initial feed mixture and soil mixed with different final vermicomposts.

Maximum significant ($P<0.05$) decrease in TOC was observed in vermicompost prepared from sheep dung+ straw (208.0 gm/kg). Whereas, highest TOC was obtained in buffalo dung singly and their different combinations with agriculture/ kitchen wastes was at initial stage (Tables 1and 2). TOC level in soil increase after mixing of vermicompost of different animal dung+ agriculture/ kitchen wastes. The vermicompost of horse dung+ wheat bran (215.00gm/kg) shows maximum significant increase of TOC followed by sheep dung+ wheat bran (212.66 gm/kg), goat dung + wheat bran (205.20) and buffalo dung gram bran (200.8 gm/kg) after mixed with soil (Tables 3).

The total kjeldahl-nitrogen was significantly increased in all the vermicompost of different combinations of organic wastes when compared to initial feed mixture. The maximum significant ($P<0.05$) increased of nitrogen was recorded in the vermicompost of goat dung +wheat bran (27.4 gm/kg) in the final stage. The highest TKN was observed in soil (3.21gm/kg) after mixing of vermicompost of goat dung+ wheat bran (Table 3). The highest calcium level was observed in the final vermicomposts of buffalo dung+ rice bran (5.9gm /kg). The vermicompost of buffalo dung+ rice bran (1.92gm/kg) caused highest calcium in soil (Table 3 and 4). There was significant increase in TK was observed in all combinations of the vermicompost of different animal dung and agriculture/kitchen wastes. The highest potassium was observed in the final vermicompost of buffalo dung+ rice bran (9.8 gm/kg) (Table 1 and 2). After mixing of different vermicomposts caused significant increased of potassium in the soil, the vermicompost of buffalo dung+ rice bran (1.58gm/kg) shows highest increased (Table 3).

C:N ratio was significantly decreased in all the vermicomposts of different animal dung and agriculture/kitchen wastes. The lowest C:N ratio was recorded in vermicompost obtained from cow dung+ vegetable wastes (9.6) (Table 3).The lowest pH (6.5) was noticed in the vermicompost of goat dung+ vegetable wastes. There was significant decrease in electrical conductivity was observed in all vermicomposts obtained from sheep dung+ wheat bran (0.59 ds/m) (Table 3).

There was significant time dependent effect of vermicomposts obtained from different combinations of organic wastes on the growth, flowering and productivity of okra, lobia and bitter gourd **(**Figure, 2 to 10). The plant growth is the major important parameter of crops which directly influence the yield. The significant ($P<0.05$) plant growth (cm) was recorded in the all combinations of vermicompost at different growth periods i.e. 20, 35 and 50 days after sowing of seeds. At 20 days, the highest growth of okra, lobia and bitter gourd has recorded in the vermicomposts of cow dung +vegetable wastes (21.33 cm), buffalo dung+ vegetable wastes (28.33 cm) and cow dung +vegetable wastes (16.16 cm) respectively with respect to control of okra(13.00 cm), lobia(18.00 cm) and bitter gourd (8.16 cm) (Figure, 2,3 and 4). The highest significant plant growth has been recorded 31.13 cm for okra, 135.00 cm for lobia and 102.00cm for bitter gourd in horse, buffalo and cow dung +vegetables wastes respectively after 35 days of observation with respect to control. The control value of okra (19.60 cm), lobia (80.00 cm) and bitter gourd (39.33 cm) was observed at 35 days (Figure, 2,3 and 4). At 50 days, there was significant plant growth was recorded in different treatments of vermicomposts. The maximum significant growth was observed in the buffalo dung + gram bran (50.50 cm) followed by cow dung +gram bran (47.80 cm) and buffalo dung + vegetable wastes (47.00 cm) with respect to control (30.00 cm) of okra (Figure-2). For lobia, the maximum growth has been recorded in the buffalo dung + gram bran (142.82 cm) with respect to control (92.26 cm) of 50 days of observation (Figure-3). The maximum significant growth of bitter gourd was observed in the buffalo dung + gram bran (150.00 cm) with respect to control (68.00 cm).

Figure, 5 to7 shows that the early flowering of okra, lobia and bitter gourd which was observed in vermicomposts of different animal dung and agriculture/kitchen wastes. There was significant early flowering period was observed in the all combinations of vermicompost when mixed with soil. The vermicompost of cow dung + vegetable wastes for both okra (44.40 days) and lobia (59.52 days) caused significant early flowering period where as, early flowering period of bitter gourd in buffalo dung +rice bran(54.18 days). These are highly significant with respect to control. The control values of okra was 60.14 days, of lobia was 78.18±2.16 days and bitter gourd was 68.28 days (Figure 5, 6 and 7).

There was significant ($P<0.05$) productivity of okra, lobia and bitter gourd was observed in all combinations of vermicomposts when mixed with soil (Figure, 8 to10). The maximum significant productivity of okra was recorded in the vermicompost prepared from cow dung+ vegetable wastes with the value of 1.80 kg/meter^2 with respect to control (0.09 kg/meter^2) (Figure 8). The maximum significant yield have been observed in cow dung +vegetable wastes (4.62 kg/meter^2) among all combinations for lobia. The productivity in control for lobia was 1.20 kg/meter^2. Figure 10 shows that the maximum significant productivity of bitter gourd was observed in the vermicomposts prepared from cow dung+ vegetable wastes (4.15 kg/meter^2) among all combinations with respect to control (1.30 kg/meter$^{2)}$ (Figure 10).

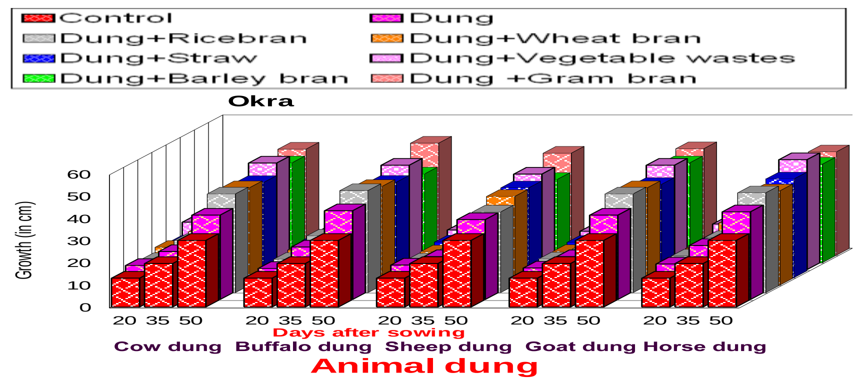


Fig. 2.

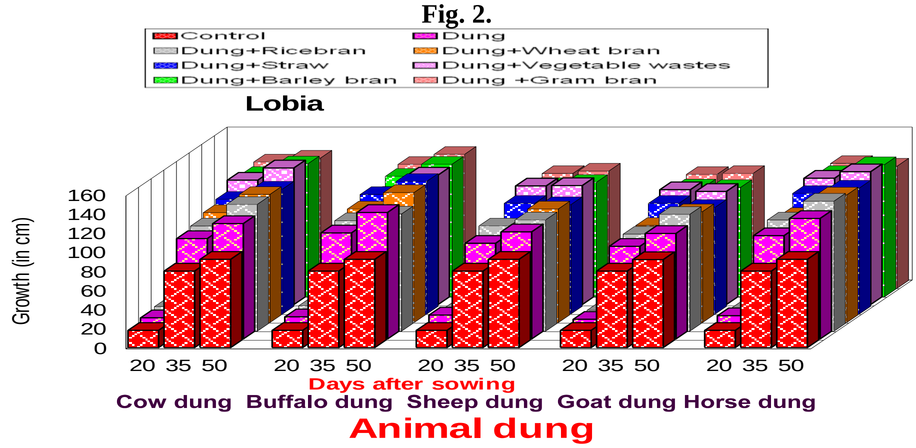


Fig. 3.

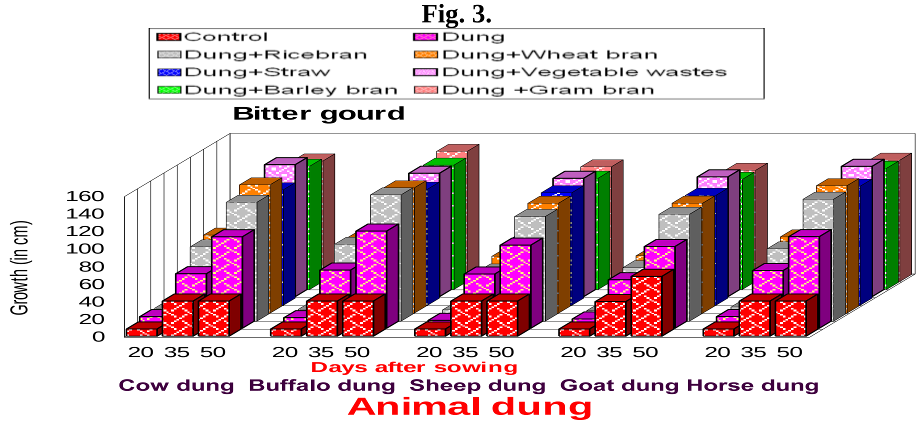


Fig. 4. Figure shows the effect of vermicomposts of different animal dung and agriculture/kitchen wastes on the growth (cm) of okra, lobia and bitter gourd.

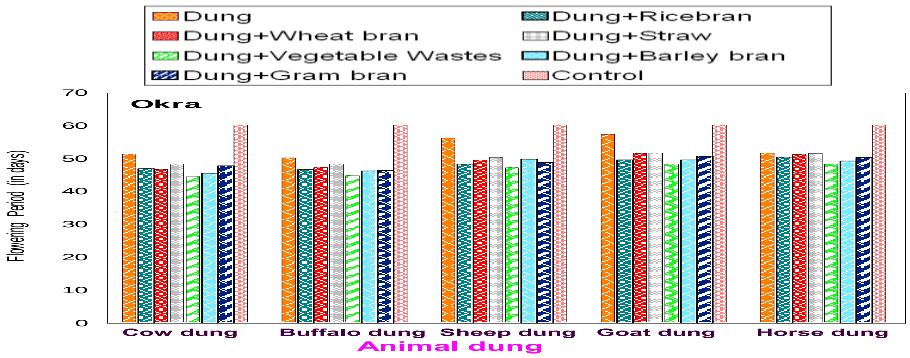
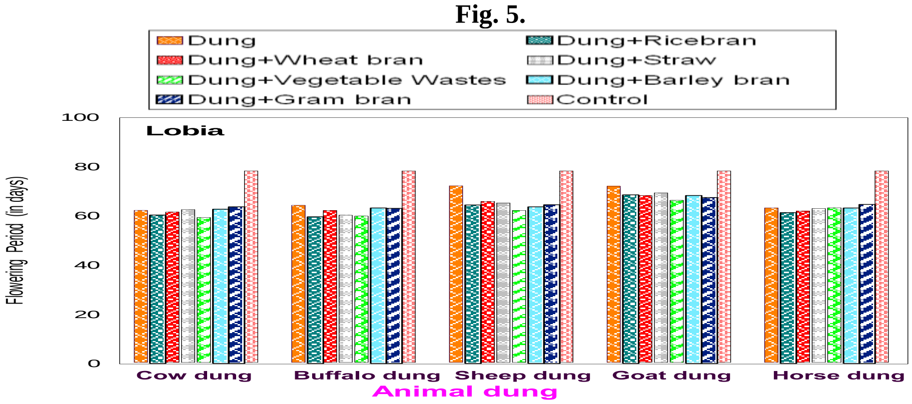


Fig. 5.



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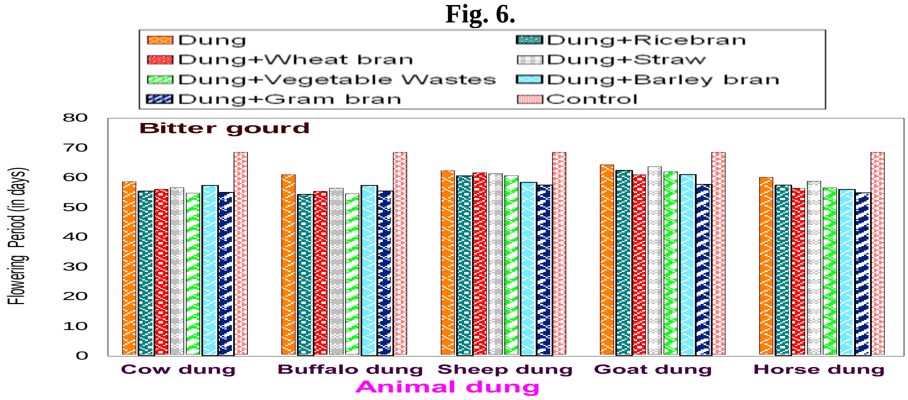

Fig. 7. Figure shows effect of vermicomposts of different animal dung and agro/kitchen wastes on the flowering period (days) of okra, lobia and bitter gourd.

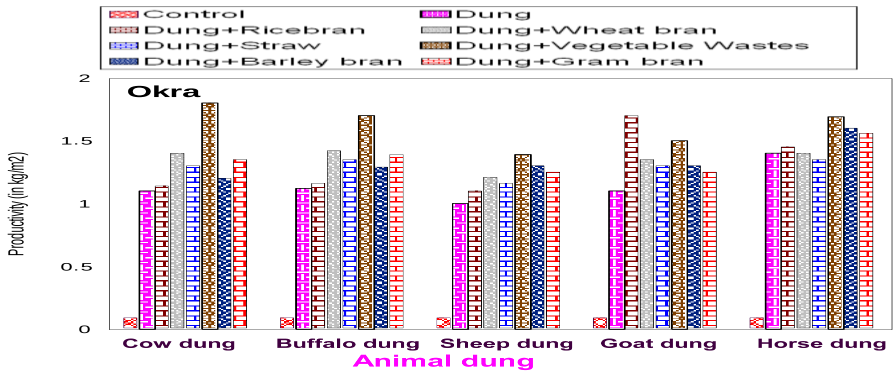

Fig. 8.

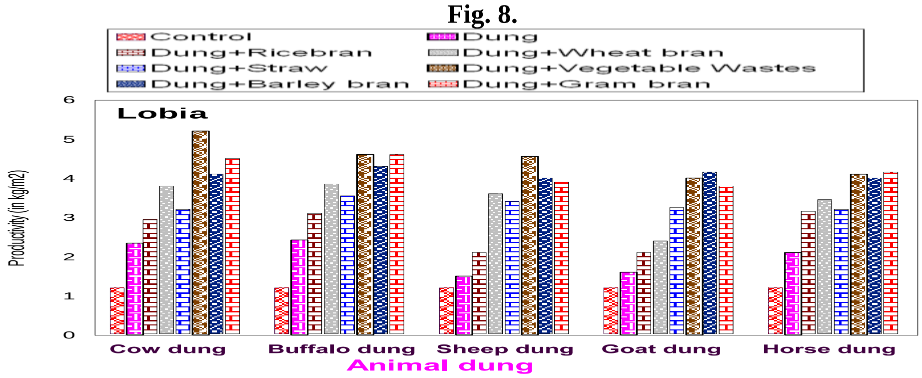

Fig . 9.

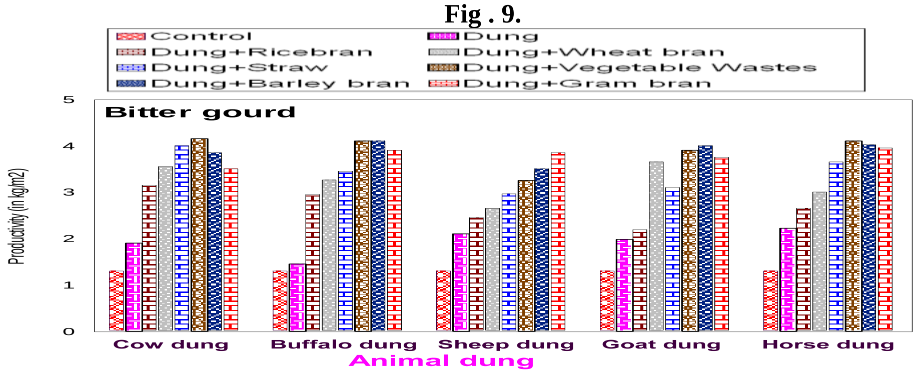

Fig. 10. Figure shows effect of vermicomposts of different animal dung and agro/kitchen wastes on the productivity (kg/m^2) of okra, lobia and bitter gourd.

Discussion

It is evident from results that there was a significant decrease in total organic carbon (TOC), pH, C:N ratio and electrical conductivity (EC) and increase in total kjeldahl nitrogen (TKN), total available phosphorus (TAP), total exchangeable potassium (TK) and total calcium (TCa) in final vermicomposts than of initial feed mixture. Furthure, the C:N ratio, pH and electrical conductivity were decreased whereas, TOC, TKN, TP and TCa were significantly increased in the soil after mixing of vermicomposts of different animal dung and agriculture/kitchen wastes It indicates that inoculated earthworms Eisenia foeitda in the vermibed alter the physico-chemical properties of vermicomposts. The vermicomposting of organic matter stabilization gives chelating and phyto-hormonal elements, which have a high content of microbial matter that stabilized the humic substance (Venkatesh and Evera, 2008).

Maximum significant ($P<0.05$) decrease in TOC was observed in vermicompost prepared from sheep dung+ straw. It is because the significant decrease in TOC is due to the feedings of earthworm as well as simultaneous microbial degradation of organic matter. Elvira *et al*. (1996) stated that a large fraction of organic matter in initial substrate was lost as CO_2 during vermicomposting. Micro-organisms that use the carbon as source of energy and nitrogen for building cell structure bring about decomposition of organic matter (Suthar, 2007; Suthar, 2008; Venkatesh and Evera, 2008). Maximum significant decrease in TOC was observed in vermicompost obtained from sheep dung + straw. Straw have a content of nitrogen, ash, lignin, cellulose, hemicelluloses, residual ash, calcium, magnesium, sodium, potassium and phosphorus (You *et al*., 1982).

The total kjeldahl-nitrogen was significantly increased in all the vermicompost of different combinations of organic wastes when compared to the initial feed mixture The maximum significant increase of TKN was observed in vermicomposts obtained from goat dung +wheat bran (27.40gm/kg) followed by cow dung+ wheat bran (26.50gm/kg). The decay of organic carbon might be responsible for nitrogen addition in the form of micro-nutrient, excretory substance, growth hormone, resume from the earthworm gut (Tripathi and Bhardwaj, 2004). Decreased in pH may also be an important factor in nitrogen retentions, as this is lost as volatile ammonia at higher pH volume (Hartenstien and Hartenstien, 1981).

C:N ratio was significantly decrease in all the vermicomposts of organic wastes. The lowest C:N ratio was recorded in vermicompost obtained from cow dung+ vegetable wastes (9.6). The lowest C:N ratio was obtained in soil with vermicompost of horse dung+ straw (79.72). Microbial decomposition is one of the major factor that caused a significant decrease in the C:N ratio of vermiwash obtained from the vermicomposts of different animal dung + agriculture/kitchen wastes (Senapati *et al.*, 1980) The lowest (8.8) C:N ratio in the combination of cow dung +vegetable wastes may be due to the acceleration of organic matter mineralization, stabilization and maturity of organic wastes (Suthar, 2008).

A significant increase in TK was observed in all combinations. The highest potassium was observed in buffalo dung+ gram bran (9.8 gm/kg), whereas, vermicompost obtained from buffalo dung+ rice bran caused highest TK (1.58gm.kg). Microbial activity during vermicomposting enhanced the rate of exchangeable K^+ mineralization (Suthar, 2007). The earthworms prime its symbiotic gut micro flora with secreted mucous and water to increase degradation of ingested organic matter and release of metabolites (Suthar, 2008).

Significant highest TP was observed in vermicompost of horse dung+ vegetable wastes (12.6gm/kg) followed by buffalo dung+ wheat bran (12.2gm/kg). The significant increase in the level of total phosphorus is due to the physical breakdown of feed mixture through earthworms as well as due to vermic activity attributed to the phosphorus-solubilizing and stabilizing micro-organism present in earthworm guts (Suthar, 2008). The highest level of TP in the combination of horse dung + vegetable wasted and followed by buffalo dung +wheat bran because wheat bran has organic phosphorus compound, it is possible that the break down of these organic compounds in vermicactivity enhanced the total phosphorus (Suthar, 2008).

The lowest pH (6.5) was noticed in the vermicompost of goat dung+ vegetable wastes. It is because microbial decomposition during the process of vermicomposting lowers the pH of vermicompost in acidic condition was attributed to mineralization of nitrogen and phosphorus in to nitrates / nitrites and orthophosphates. The lowest pH was noticed in combination of goat dung + vegetable waste, buffalo dung + rice bran, sheep dung + wheat bran and horse dung + rice bran. Hartenstien and Hartenstien (1981) has reported that decrease in pH may be due to the nitrogen retention as this element lost as volatile ammonia at higher pH value during vermicomposting.

There was significant decrease in electrical conductivity was observed in all vermicomposts obtained from sheep dung+ wheat bran (0.59 ds/m). The soil mixed with vermicompost of horse dung+ barley bran (0.81 ds/m) caused lowest electrical conductivity. The decrease in EC might have been due to the loss of organic matter and release of different minerals salts in available forms. Lowest electrical conductivity in combination of sheep dung + wheat bran may be due to the increased rate of loss of organic matter, consequently there is release of different minerals salts (Kaviraj and Sharma, 2003). The highest calcium level was observed in the vermicomposts of buffalo dung+ rice bran because it was possible that the gut process associated with Ca^{++} metabolism was primarily responsible for enhanced content of inorganic Ca^{++} in worm cast. Highest Ca^{++} level was noticed in combination of buffalo dung + rice bran is due to the higher rate of Ca^{++} mineralization (Garg *et al.*, 2006; Suthar, 2008).

There was a significant time dependent effect of vermicomposts prepared from different combinations of organic wastes on the growth, flowering and productivity of okra, lobia and bitter gourd. The highest significant growth of okra (21.33 cm), lobia (28.33 cm) and bitter gourd was (16.16 cm) was recorded in the vermicomposts of cow dung+ vegetable wastes and buffalo dung+ vegetable wastes after 20 days of measurement. The highest (31.13 cm) growth in okra was observed after 35 days in horse dung + vegetable wastes. After 50 days of observation, the vermicomposts of cow dung+ vegetable wastes followed by cow dung+ gram bran and buffalo dung+ vegetable wastes was highly effective for okra, lobia and bitter gourd. It may be due to the increased amount of Ca^{++} in cow dung + vegetable wastes and TKN in cow dung+ gram bran which affects the growth of plants. Vermicomposts of different organic wastes are a rich source of enzymes, vitamins, plant growth hormones such as IAA, gibberellins, cytokinins, biocontrol agents, phosphorus, potassium and calcium (Phatak and Ram, 2004). These micronutrients, hormones etc. are beneficial for growth of different plants. The essential nutrients which are present in the combination of cow dung + vegetable wastes give better growth of okra, lobia and bitter gourd. It indicates that the synthesis of hormones, enzymes, vitamins and microorganism like nitrogen fixing bacteria are present in sufficient amount, which affect the growth of okra, lobia and bitter gourd plants. Supplementation of NPK and humic acid productions during vermicomposting process have positive effect on plant growth (Bansal and Kapoor, 2000; Ramamoorthy, 2004).

The significant early flowering of okra (44.40 days) was observed in the vermicompost obtained from cow dung + vegetable wastes (Figure-5). Early flowering of lobia was observed in vermicompost of cow dung + vegetable wastes. The treatment of vermicompost of buffalo dung + rice bran caused early flowering of bitter gourd. Vermicompost and its extract have consistently improved the early start of the flowering period much more than could be possible from more conversion of mineral nutrients in to more plant available forms (Atiyeh *et al.,* 2002). It has been suggested that the dramatic increase in microbial action in the organic matter by earthworms could result in the production of significant quantities of plant growth regulators such as Indol acetic acid, gibberellins and cytokinines and hormone like activity in the vermicompost. The highly significant concentration of TKN and TP stimulate the starting of early flowering period in wheat (Atiyeh *et al.*, 2002). It may be possible that the growth hormones (gibberellins) present in significant amounts in vermicompost of buffalo dung+ rice bran stimulated the early flowering of the plant. The nitrogen, phosphorus, sulphur and hormones are the important factors which stimulate the starting of early flowering and yield of grains (Farahbakhsh *et al*., 2006).

There was significant productivity of okra, lobia and bitter gourd was observed among all combinations of vermicompost mixed with soil. The combinations of cow dung +vegetable wastes caused highest productivity of all these crops. It indicates that the increased productivity of plants may be due to the presence of essential nutrients in vermicomposts which enhanced the productivity of crops. Large amount of humic acid was produced during vermicomposting which increase the productivity (Ramamoorthy, 2004; Gupta, 2005). Gibberellins, auxine increase the bio availability of phosphorus and more exchangeable nutrients by the organic inputs (Erich *et al.*, 2002).

Conclusion

From the present study it is clear that the vermicomposts of animal dung and agriculture/ kitchen wastes have sufficient amount of TKN, TP, TCa and TK, that means during vermicomposting there was significant increased of total kjedhal nitrogen, phosohorus, calacium, exchangeable potassium whereas, accountable decreased in TOC, pH, C:N ratio and EC. Inoculation of earthworm Eisenia foetida improve the quality of vermicompost prepared from different combinations of animal dung and agriculture/kitchen wastes. These vermicompost have efficient potential for the growth, flowering as well as productivity of crops. Among all these combinations, the cow dung+ vegetable wastes and buffalo dung+ rice bran has preferable combination of organic wastes for better growth and production of okra, lobia and bitter gourd. Thus, preparation of particular type of vermicompost from different combinations of organic wastes can be used for better growth and productivity of crops. These vermicomposts will be easily biodegradable, less expensive and more natural than synthetic fertilizers. The small industry of vermicomposting will also improve the socio-economic condition of the farmers. It can be concluded that vermicomposting is a biotechnological tool which is ecologically sound and most acceptable among farmers.

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References

Abbasi, S.A. and Ramasamy, E.V. (2001). Solid Wastes Management with earthworms. Discovery publishing house, New Delhi, pp. 78.

Altieri, M. and Resset, P. (1999). Ten reasons why biotechnology will not ensure food security protect the environment and reduce poverty in the development world. Ag. Biol. Forum 2:155-162.

Arancon, N. (2004) An Interview with Dr. Norman Arancon". In casting call, a (2), August.

Atiyh, R.M., Arancon, N.Q., Edwards, C.A. and Metzger, J.D. (2002) The influence of earthworms processed organic wastes on plant growth. Bioresource Technology 81:103-108.

Bansal, S. and Kapoor, K.K. (2000). Vermicomposting of the crop residues and cattle dung with Esenia foetida. Biores, Technol. 67:155-161.

Bhattacharya, P. (2004) Organic food production in India. Agrobios (India), Jodhpur.

Bremner, J.M. and Mulvaney, R.G. (1982). Nitrogen Total in Method of Soil Analysis (A.L. Page, R.H. Millar and D.R. Keeney, eds.), American Society of agronomy, Madison, pp. 575-624.

Buchanan, M.A, Russed, G. and Block, S.D. (1988). Chemical characterization and nitrogen mineralization potentials of vermicomposts derived from differing organic wastes. Inc. A. Edwards and E.F. Neuhauser (eds.). Earthworms in waste and environmental management. SPB Academic Publishing, The Hague, pp. 231-239.

Canellas, L.P., Olivares, F.L., Okorokova, A.L., Facanha and Facanda, A.R. (2002). "Humic Acids isolated from earthworm compost enhance root Elongation, lateral root emergence, and Plasma membrane H+ - ATPase Activity in Maize Root". In plant physiology, 1(130):1951-1957.

Dominguez, J., Edwards, C.A. and Webster, M. (2000). Vermicomposting of sewage sludge: effect of bulking materials on the growth and reproduction of the earthworms Esenia Andrei. Pedobiologia 44:24-32.

Edwards, C.A. (1998). The use of earthworms in the breakdown and management of organic wastes. In C. A. Edwards (ed). Earthworm Ecology, CRC Press, Boca Ratan, FL, pp. 327-354.

Edwards, C.A., Dominguez, J. and Arancon, N.Q. (2004). The influence of vermicomposts on plant growth and & pest incidence. In soil Zoology for sustainable Development in the 21st Century (S.H. Shakir and W.Z.A. Mikhail, eds), pp.397-420, self- publisher, Cairo, Egypt.

Erich, M.S., Fitzgerald, C.B. and Porter, G.A. (2002). The effect of organic amendments on phosphorus chemistry in a potato cropping system. Agric. Ecosys. Environ., 88:79-88.

Elvira, C., Sampendro, L., Benitez, E. and Nogales, R. (1998). Vermicomposting of sludges from paper mill and dairy industries with Eisenia andrei. Biores. Technol., 63:205-211.

Farahbakhsh, H., Pakgohar, N. and Karimi, A. (2006). Effect of nitrogen and sulphur fertilizers on yield, yield components and oil contents of oil seed Rape (Brassica napus L.). Asian J. of Plant Sciences 5(1):112-115.

Garg, V.K., Yadav, Y.K., Sheoran, A., Chand, S. and Kaushik, P. (2006). Live stocks excreta management through vermicomposting using an epigeic earthworm Eisenia foetida, Environmentalist 26:269-276.

Gupta, P.K. (2005). Vermicomposting for sustainable agriculture. Bharat Printing Press, Jodhpur, India, pp.11-14.

Hartenstein, R. and Hartenstein, F. (1981). Physico- chemical changes affected in activated sludge by the earthworm Eisenia foetida . J. Environ. Quality, 10, 377-382. Gunadi, B., Blount, C. and Edward, C. A. 2002. The growth and fecundity of Eisenia foetida (Savigny) in cattle solids pre-composted for different periods. Pedobiologia 46:15-23.

Kaviraj and Sharma, S. (2003). Municipal solid waste management through vermicomposting employing exotic and local species of earthworms. Bioresource Technol., 90:169-173.

Mall, A.K., Dubey, A. and Prasad, S. (2005). Vermicompost: An inevitable tool of organic farming for sustainable agriculture. Agrobios Newsletter 3(8):10-11.

Masciandaro, G.B. (2000). "In situ" vermicomposting of biological sludeges and impacts on soil quality. Soil Biology and Biochemistry 32:1015-1024.

Nagavallemma, K.P., Wani, S.P., Lacroix, S., Padmaja, V.V., Vineela, C., Babu Rao, M. and Sahrawat, K.L. (2004). Vermicomposting: Recycling wastes in to valuable organic fertilizers. Global Theme on Agroecosystems Report no. 8. Potacheru 502324. Andhra Pradesh, India: International Crops Research Institute for the Semi- Arid Tropics. pp. 20.

Nelson, D.W. and Sommers, L.E. (1982). Total organic carbon and organic matter. (In: A.L. Page, R.H. Miller and D.R. Keeney eds. Method of Soil Analysis) American Society of Agronomy, Medison, pp. 539-579.

Pathak, R.K. and Ram, R.A. (2004). Manual on Jaivik Krishi, Central Institute for Subtropical Horticulture, Rehmankhera, P.O. Kokari, Lucknow-227107, 24:31-32.

Powell, J.M., Piker, F.N. and Somda, Z.C. (1999). Crop yield and the fate of nitrogen and phosphorus following application of plant material and feces to soil. Nutrient cycling in Agro- Ecosystems 54:215-226.

Ramamoorthy, P. (2004). Standardization and nutrient analysis of vermicomposting sugarcane wastes, press-mud trash, bagasse by Eudrilus eugeniae (Kinberg) and Eisenia foetida (Savigny) and the effect of vermicompost on soil fertility and crop productivity. Ph.D. Thesis, Anna. Univ., India.

Ramamurthy, V. (2006). Vermicompost application improves the productivity and quality of Nagpur mandarin (Cipus reticulate Blanco). Organic News.

Senapati, B.K. (1993). Earthworm guts contents and its significance. In A.K. ghosh (ed) Earthworm Resources and Vermiculture, Zoological Survey of India, Calcutta, pp. 97-99.

Senapati, B.K., Dash, M.C., Rane, A.K. and Panda, B.K. (1980). Observation on the effect of earthworms in the decomposition process in soil under laboratory conditions. Com. Physiol. Ecol. 5:140-142.

Sokal, R. and Rohlf, J. (1973). Introduction to Biostatistics W.H. Freeman and Co. San Fransisco.

Suthar, S. (2007). Nutrient changes and biodynamics of epigeic earthworm Perionyx excavatus (Perrier) during recycling of some agriculture wastes. Bioresour Technol., 98:1608–1614.

Suthar, S. (2008). Feasibility of vermicomposting in bio-stabilization of sludge from a distillery industry. Science of total Environment, 394:237-243.

Sinha, R.K., Heart, S., Agarwal, S.M., Asadi, R. and Carretero, E. (2002). Vermiculture and waste management: Study of action of earthworm Esenia foetida, Eudrilus eugenae and Perionyx excavatus on biodegradation of some Community wastes in India and Australia. Environmentalist 22:261-268.

Tripathi, G. and Bharatdwaj, P. (2004). Comparative studies on biomass production, life cycles and composting efficiency of Eisenia foetida (Savigny) and Lampito mauritii (Kinberg), Biores. Technol. 95:77-83.

Vasanthi, D. and Kumaraswamy, K. (1999). Efficacy of vermicompost to improve soil fertility and rice yield. J. Indian Soc. Soil. Sci. 47:268-272.

Venkatesh, R.M. and Eevera, T. (2008). Mass reduction and recovery of nutrients through vermicomposting of fly ash. Appl. Ecol. and Environ. Res., 6(1):77-84.

You, I.S., Jones, R.A. and Bortha, R. (1982). Evaluation of chemically defined for attachment of 3, 4 dichloroaniline to humans. Bull. Env. Contam. Toxicol. 29:476-482.

Zaller, J.G. (2006). Vermicompost as a substitute for peat in organic potting media: effects on germination, biomass allocation, yields and fruit quality of three tomato varieties. In review.

Zebrath, B.J., Neilsen G.H., Hogue E. and Neilsen, D. (1999). Influence des amendments fait de dechets organiques surcertains properties physiques et chemiques due Sol. Canadian J. Soil Sci., 79:501-504.

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