Research Journal of Recent Sciences _____ ISSN 2277 - 2502
Vol. **1(ISC-2011),** 289-296 **(2012)** *Res.J.Recent.Sci.*

Management of Agriculture Waste from Market yard Through Vermicomposting

Mane T.T.[1] and Raskar Smita S.[2]
[1]Department of Botany, Baburaoji Gholap College, Sangvi, Pune, Maharashtra, INDIA
[2]Lonkar Madhamik Vidhyalaya Mundhawa,Pune, Maharashtra, INDIA

Available online at: www.isca.in
(Received 8th August 2011, accepted 27th february 2012)

Abstract

Solid waste management has become one of the major problems we are facing today. The rapid increase in the generation of huge quantity of waste is one aspect of the environmental crisis. This is accompanying with recent global development with respect to rapid urbanization and population growth which has resulted into generation of large quantity of organic solid waste. The Agriculture Produce Marketing Committees (APMC's) are generating large quantity of organic waste from cereals, pulses, fruits, vegetables and in some markets from cattle. The farmers bring the produce to the market from farms without grading and cleaning it. Most of the produce is sold on weight basis, in order to make more profit. Hence the organic waste in the market area increases and puts pressure on the e system of agricultural solid waste collection and management. Due to these increased volume and weight, most of the waste remain uncollected and starts decaying at the site. As a result the foul odour is spread thought vicinity of towns and cities. The solid waste collection and disposal system is not efficient. The APMCs are usually located in the centres of town which creates sanitation, problems and hygiene hazards to the common people. This research paper is concentrated on handling this problem in simplest, scientific, economical and environmental friendly way to transform waste materials into compost through vermicomposting by using an exotic species of earthworm - Eisenia Foetida and Eudrilus euginiae.

Keywords: Agriculture produces market committee, vermicomposting, and agro waste.

Introduction

It is estimated that in India nearly 700 million tonnes of organic waste is generated annually which is either burned or land filled[1]. The large amount of the agro waste generated from the market area has created major environmental problems. Vermicomposting is the best biotechnology to reduce the load on the treatment and disposal of biodegradable agro waste. Earthworms have ability to convert organic waste into valuable resources containing plant nutrients and organic matter, which are essential for maintaining soil productivity. Vermicompost is the microbial composting of organic wastes through earthworm activity to form organic fertilizer which contains higher level of organic matter, organic carbon, total and available N, P, K and micronutrients. It also promotes microbial and enzyme activities, in the soil. In the present investigation, the study is carried out on the proper utilization of agriculture waste from market yard through vermicomposting and obtaining the nutrient rich organic manure.

Material and Methods

In the present study, the area chosen was 'Agriculture Produce Marketing Committee (APMC), Baramati, Dist: Pune, Maharashtra. In market yard, large amount of agro waste (biodegradable) are available such as- Sorghum and jowar straw (after feeding cattle), dry leaves of crops and trees, pigeon pea (Cajanus cajan) stalks, groundnut (Arachis hypogaea) husk, soybean (Glycine max) residues, vegetable wastes, weed (Parthenium), fibre from coconut (Cocos nucifera) and sugarcane (Saccharum officinarum) trash and waste generated from the onion (Allium cepa) market.

Selection of earthworm species for vermicomposting process: For composting we selected the African species of earthworms i.e. Eisenia fetida (photo plate1) and Eudrilus eugenae (photo plate 2) which are efficient to maintain vermicomposting process in India. Eisenia fetida has a wide range of temperature tolerance and has very high reproductive potential. It is less sensitive to density pressure and Eudrilus eugeniae is found to be a very efficient species for culture maintenance in India [2].

Methodology used for vermicomposting: The agro waste was collected from APMC area with the help of labours and transported at the vermicompost project site by local vehicles.

Parameters considered for Selection of site: Accessibility to regular supply of raw materials, less population density, site is elevated than the surrounding land, free from soil born diseases and free flies, slightly sloped land (for drainage of leachate) with a firm soil type, convenient utilities like good roads for transport, availability of labours, Communication facilities etc. While designing, all necessary precautions has

been taken to minimize nuisance of odour, flies, rodent, bird and fire hazard. The site selection of the project has been done with due care on account of the environment care.

Construction of vermicomposting production unit Erection of Shade house for each bed: Dimensions: 20' length X 15' width X 10' height with sloping roof. Water proof shade net was used. Roof framework made in steel angle channel. At the roof, there was provision for the sprinkler for water supply and aerator for fulfilled the oxygen demand during the composting.

Erection of Beds or the reactor: The 6 beds have been constructed for study the composting process, having dimension of 20' x 15' x 5'.The distance between each bed - 10''. Each bed has been a slope and drainage at one end to collect the vermiwash. The bed has capacity to decompose the 1 ton agro waste by vermicomposting process.

Figure -1
Earthworms (Eisenia Foeitida)
used as culture for decomposition

Figure -2
Earthworms (Eudrtilus eugeniae)
Used as Culture for decomposition

Photoplate-3
Construction of vermicomposting
Production unit at the production site

Initial steps for vermicomposting: Agro waste from APMC area is transported at the vermicompost project site. The waste is then segregated as biodegradable and non-biodegradable. Biodegradable agro waste material is cut into small pieces by means of cutter machine (photo plate-3).

The biodegradable agro waste is allowed to its partial decomposition for 10 to15 days for achieving better activity of earthworm and nutrient enriched vermicompost production (photo plate-4).

Partially decomposed agro waste material is arranged in layers at the vermicompost project site (Photo plate-5).

Figure - 4
Cutter machine used to cu agro waste

Manufacturing process Preparation method of vermicompost bed: 6" layer of partially biodegradable agro waste was made which is finely chopped by cutter machine. 1" layer of cow dung slurry is applied on it to further decomposing of the agro waste for 15 to 20 days.

Figure -5
Pre-Digestion of the agro waste
With cow dung slurry

After partial decomposition, cow dung slurry is covered by the 4" layer of Farm Yard Manure which contains leaf litter and cattle dung. The lignite powder, which is carrier material for the bacterial culture of PSB bacteria having CFU minimum 5x107 Cell/g, is sprinkled on it. It helps in improving nutritional quality of compost. When the heat evolved during the decomposition of the materials has subsided (15–20 days after heaping), Selected earthworm sps. (Photo plate no. 5 and 6) were released through the cracks developed. Water was sprinkled every three days to maintain adequate moisture. After every ten days, the vermicompost excreta were removed manually.

Then this vermicompost was kept in heap to separate the very minute earthworms. In 24 hours these earthworms comes to the bottom part of vermicompost, which are then removed and placed on the partially decomposed organic matter. The vermicompost is sieved by use of one mm sieve and spread in thin layer for air drying. Matter which could not be sieved is placed back on partially decomposed organic matter for breakdown by earthworms. Within one month all the partially decomposed organic matter gets converted into vermicompost. After 10 days of drying, vermicompost is collected and put in a heap.

Physico- chemical analysis of vermicompost: matured vermicompost samples were collected from each vermicompost bed about 500 gm and kept in the polythene bag which is free from adventitious contaminations. Each sample bags was labelled and sealed air tightly. The Physico-chemical analysis of vermicompost was conducted in laboratory of 'Krishi Vidynan Kendra, Sharadanagar, Baramati. The object of study is to analyse the physico-chemical characteristics of matured vermicompost by standard methods as per the fertiliser (control) order 1985.

Figure - 6
Agro Waste arranged in racks with
Earthworm species for decomposition

Figure - 7
Vermicompost ready for marketing

Physical Parameters of vermicompost: Particle size- Particle size of sample was 94.87% which passed through the 4.0 mm IS sieve. Colour- The colour of vermicompost samples collected from the set (1) and set (2) were dark black. Odor- The foul odour were absent in vermicompost samples collected from set (1) and set (2). Bulk density (g/cm^3) – The bulk density ranged from the 0.8 to o.9. Moisture, percent by weight – 23.0

Chemical Parameters of vermicompost Total Nitrogen (as-N): The standard method of analysis of total nitrogen used as per fertilizer control order 1985**.** We estimated the amount of nitrogen in sample by using Kjeldahl's assembly.
PH: The pH meter was used to determine pH. **Moisture:** 5 gm sample was taken in a weighed clean, dry Petri dish. Then allowed to heat in an oven for about 5 hours at 65^0 $\pm 1^0$C to constant weight and cool in desiccators and weigh.

Percentage loss in weigh indicated as moisture content. **Bulk density:** To estimate the bulk density, standard method as per fertilizer (control) order 1985was used. **Conductivity:** The conductivity was measured with the help of conductivity meter which calibrated by using 0.01 M potassium chloride solution. **Organic carbon:** Analysis of organic carbon was done as per fertilizer (control) order 1985. 10gm of sample was dried at 105^0 C for 6 hrs and put in pre weighed crucible and allowed to ignite the material in a Maffle furnace. **C: N** Ratio: C: N ratio was calculated by the dividing the carbon value with the total nitrogen value. **Phosphorus (P_2O_5)** – The amount of phosphorus was analysed by gravimetric Quinoline molybdate method as described under Schedule-II, Part B, and 4(ii) of fertilizer (control) order 1985. **Potassium**-The potassium was analysed by flame photometrically to measure the total potassium as described under Schedule-II, Part B, and 4(ii) of FCO 1985. **Calcium and Magnesium:** The Calcium was analysed by EDTA method and magnesium analysed by method given Indian Standard Institution (IS: 3025, 1965). Sulphur: The sulphur was analysed by standard method recommended by the FCO 1985.

Results and Discussion

Physico-chemical characteristics of vermicompost produced form the agro waste generated at APMC of Baramati: Bhattacharjee etc. Al (2001) reported that application of vermicompost reduces the loss of nutrients through leaching from the soil by changing the soil's physico-chemical properties.

Colour: Dark black colour of vermicompost indicated that the decomposition of agro waste successfully**.**

Odour: Absence of foul odour indicated that all parameters required for composting process were present in optimum condition.

Bulk density: Vasanthi and Kumaraswamy (1999) reported that bulk density of the soil increases when the vermicompost supplemented with NPK. Vermicompost increased the porosity and bulk density of soil and improve the avaibility of nutrients to crop growth.

Moisture content: vermicompost addition caused a significant increase of moisture content due to the more porosity addition to the soil reported Bazzoffi et. al (1998).

Particle Size/porosity: The total porosity was improved by the use of vermicompost. Greater porosity in the soil treated with vermicompost was due to an increase in the amount of pores reported by Marinari ET. Al (2000).

Table - 1
Physico-chemical Characteristics of vermicompost set No.1. (Bed No.1, 2 and 3 and their average)

Sr.No.	Parameters	Bed no.1	Bed no.2	Bed no.3	Average value in %
A	**Physical Characteristics**				
1	Colour (dark brown to black)	Black	Black	Black	Black
2	Odour	No Odour	No Odour	No Odour	No Odour
3	Particle size (4 mm IS Sieve)	93.70	94.10	94.70	94.16
4	Moisture	20.50	22.80	19.50	20.94
5	Bulk Density(g/cm^3)	0.88	0.89	0.90	0.89
B	**Chemical Characteristics**				
1	pH	6.9	7.0	6.9	6.93
2	Conductivity($ms\ cm^{-1}$)	3.50	3.45	3.37	3.44
3	Organic Carbon	18.5	19.4	20.2	19.37
4	Total Nitrogen	0.95	0.9	1.0	0.95
5	C/N ratio	19.47	21.55	20.2	20.40
6	Total Phosphorus (as P_2O_5)	0.7	0.8	0.9	0.8
7	Potassium (K_2O)	0.7	0.9	0.8	0.8
8	Calcium	5.4	5.9	5.7	5.67
9	Magnesium	0.2	0.3	0.25	0.25
10	Sulphur	0.4	0.5	0.45	0.45

All parameter values are presented in percentage (%); except the electrical conductivity, pH and bulk density

pH and Conductivity: Edwards and Bohlen (1996) reported that the pH range between 6-7 promotes the availability of plant nutrients like NPK, so vermicompost should be applied in soil. Chemical parameters like pH and electrical conductivity (EC) were determined by ISI Bulletin (1982) by using digital pH and conductivity meters. Vermicompost improves the pH of soil and make available the nutrient for the crop yield reported by Srikanth et. al (2000).

Organic Carbon: The deficiency in organic carbon reduces the storage capacity of soil nutrients and reduction in soil fertility reported by Kale et al. (1992). Vasanthi and Kumaraswamy (1999) and Srikanth et al. (2000) reported that the incorporation of vermicompost with farm yard manure have been shown to increase organic carbon content in the soil.

Nitrogen: Atiyeh (1998) reported that the conventional compost was higher 'ammonium', while the vermicompost tended to be higher in 'nitrates', which is the more available form of nitrogen.

Using vermiwash and vermicompost may attribute the significant increase in nitrogen of the soil by using vermiwash and vermicompost due to the presence of nitrogen fixing bacteria, which increase the nitrogen content of the soil reported by Lalitha et al (2000) and Ansari (2008 a; b).

Total Phosphorus (as P_2O_5): Kale and Bano (2001) reported that the vermicompost shows the high values of NPK as high as 7.37% nitrogen (N) and 19.58% phosphorus as P2O5 in worm's vermicast. Lee (2002) suggested that the passage of organic matter through the gut of worm results in phosphorus (P) converted to forms which are more bio-available to plants.

Total Potassium: Suhane (1998) showed that exchangeable potassium (K) was over 95% higher in vermicompost. The nutrients N and P and the intestinal mucus excreted by worms are further used by the microbes for multiplication and vigorous soil remediation and fertility improvement action reported by Teotia (2002).

Table- 2
Physico-chemical Characteristics of vermicompost set No.2. (Bed No.1, 2 and 3 and their average).

Sr.No.	Parameters	Bed no.1	Bed no.2	Bed no.3	Average value in %
A	**Physical Characteristics**				
1	Colour (dark brown to black)	Black	Black	Black	Black
2	Odour	No Odour	No Odour	No Odour	No Odour
3	Particle size (4 mm IS Seive)	94.87	94.10	93.97	94.31
4	Moisture	24.30	22.80	23.50	23.53
5	Bulk Density(g/cm^3)	0.88	0.87	0.90	0.88
B	**Chemical Characteristics**				
1	pH	6.8	7.1	6.9	6.94
2	Conductivity($ms\ cm^{-1}$)	3.27	3.57	3.45	3.43
3	Organic Carbon	23.0	21.2	20.50	21.56
4	Total Nitrogen	0.95	0.9	0.98	0.94
5	C/N ratio	24.21	23.55	20.91	22.89
6	Total Phosphorus (as P_2O_5)	0.72	0.9	0.8	0.80
7	Potassium (K_2O)	0.75	0.82	0.89	0.82
8	Calcium	5.7	5.8	5.4	5.64
9	Magnesium	0.3	0.28	0.25	0.27
10	Sulphur	0.4	0.45	0.5	0.45

All parameter values are presented in percentage (%); except the electrical conductivity, pH and bulk density

Conclusion

Vermicomposting appears to be the most promising as high value bio-fertilizer which not only increases the plant growth and productivity by nutrient supply but is also cost effective and pollution free. Use of vermicompost promotes soil aggregation and stabilizes soil structure. This improves the air- water relationship of soil, thus increasing the water retention capacity and encourages extensive development of root system of plants.

The mineralization of nutrients is observed to be enhanced, therefore results into boosting up of crop productivity. Vermicompost produced from the farm wastes is not only having beneficial effects on soil health and growth, quality and yield of crop but also playing vital role in eradication of pollution hazards. It helped to reduce volume of agro waste and to generate additional revenue for the Baramati APMC. The Problem of disposing the agro waste may be solved by constructing such the vermicomposting production unit.

The agro waste converted in vermicompost which will earn economic benefits.No hazardous effluents are generated from a compost production unit using agro wastes.

There are no pesticide residues, weed seeds, heavy metals, sand, termite or wax, plant root diseases, etc. Vermicompost can be used for all crops agricultural, horticultural, and ornamental and vegetables at any stage of the crop.

It will reduce the requirement of more land for disposal of fruits and vegetable wastes in near future. It helps to create better environments, thus reduce ecological risk.

Table - 3
Table showing average value of set 1 and 2 (i.e. average value of six beds)

Sr.No	Parameters	Average value of set 1in percentage.	Average value of set 1 percentage.	Total Average value. (%)
A	**Physical Characteristics**	Composition as per Analysis (in %)		
1	Colour (dark brown to black)	Black	Black	Black
2	Odour	No Odour	No Odour	No Odour
3	Particle size (4 mm IS Seive)	94.16	94.31	94.23
4	Moisture	20.94	23.53	22.23
5	Bulk Density(g/cm^3)	0.89	0.88	0.88
B	**Chemical Characteristics**			
1	pH	6.93	6.94	6.93
2	Conductivity ($ms\ cm^{-1}$)	3.44	3.43	3.43
3	Organic Carbon	19.37	21.56	20.46
4	Total Nitrogen	0.95	0.94	0.94
5	C/N ratio	20.40	22.89	21.64
6	Total Phosphorus (as P_2O_5)	0.80	0.80	0.80
7	Potassium (K_2O)	0.80	0.82	0.81
8	Calcium	5.67	5.64	5.65
9	Magnesium	0.25	0.27	0.26
10	Sulphur	0.45	0.45	0.45

All parameter values are presented in percentage (%); except the electrical conductivity, pH and bulk density

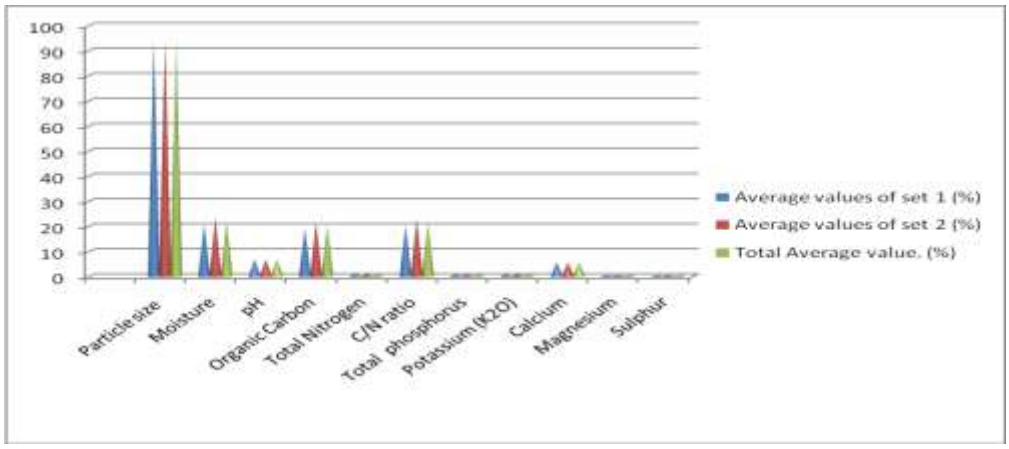

Figure- 1
Shows the average values of parameters from set1 and set2 and Mean average of both sets

Scope for Improvement: The production of agro waste in market area from various sectors such as vegetables market, fruit market and onion market is about 1.5 mt per day. The agro waste contained about 95 to 96 % of biodegradable waste only 5 to 6 % is non biodegradable wastes. To reduce the load on treatment and existing system of disposal of such biodegradable waste, we have undertaken the project study entitled "The study of compost production unit based on the agro waste produced from APMC, Baramati", Dist- Pune (Maharashtra). During the project, we faced some problems and recognized that the various factors affecting on the manufacturing process of vermicompost. There will be some changes for improvement in production of vermicomposting process run at Agriculture Produce Marketing Committee, Baramati as follows, Collection of agro waste: - Before the manufacturing process of vermicompost, the collection and transportation of agro waste from various sectors such as fruit market, vegetables market and onion market is not done effectively. There should be provision for effective collection and transportation of agro waste at the site from various sectors to vermicompost site, this will reduce the cost that can be used for farmers.

Segregations of waste the labour should be trained for the effective segregation of agro waste. The non biodegradable waste such as plastic wrappers, wooden particles, metals and other materials should be removed before vermicomposting process. For this the labour should be trained for manufacturing process of vermicomposting. They should followe the standard process to maintain all parameters such as temperature, moisture, humidity at optimum condition for better avaibility of nutrients after vermicomposting process. Space available for the collection of daily agro waste -Large convenient space should be available for the collection. Manufacturing / construction of vermicomposting unit - vermicomposting unit should have facilities such as outlets of vermiwash and the possible to collect the vermiwash periodically while the vermicomposting unit the quality of material should be good. The above improvements are essential for vermicomposting that will help to farmers and society.

Acknowledgment

Firstly, I would like to thank Mr. Bhoite V.M. who inspired me for constant encouragement and efforts throughout the project. It was really a pleasure and privilege to work under him. I feel deeply obliged to Mr. D.S Vadak (Chairman - Agriculture Produce Market Committee, Baramati) for giving me the privilege to be associated with such an esteemed organization. I offer my whole thanks and regards to the entire members of Agriculture Produce Market Committee, Baramati, and Dist. Pune. For their co-operation and assistance during the course of my project.

References

1. Bhiday M.R., Earthworms in agriculture, *Indian Farming*, **43(12),** 31–34, **(1994)**
2. Kale R. D. and Bano K., Laboratory studies on age specific fecundity and mortality of earthworm *Eudrilus eugeniae. Mitteilungen aus dem Hamber gischen museum and Institut. Ferganzurgsband*. **(89),** 139-148(**1994)**
3. Bhattacharjee G., Chaudhuri P.S. and Datta M., Response of paddy (Var.Trc- 87-251) crop on amendment of the field with different levels of vermicompost, Asian *J. Microbial. Biotech. Environ. Sci*., **(3),** 191-196**(2001)**
4. Vasanthi D., Kumarasamy K., Efficacy of vermicompost to improve soil fertility and rice yield, *Journal Indian Society of Soil Sciences*, **42** (2), 268-272 (1999)
5. Albiach R., Canet R., Pomares F. and Ingelmo F., Microbial biomass contentand enzymatic activities after the application of organicamendments to a horticulturalsoil, Bioresour, *Technol.*, **(75),** 43-48 *Soil Biol. Ecol.*, **(27)** *25-27,* **(2000)**
6. Atiyeh R.M., Dominguez J., Sobler S. and Edwards C.A., Changes in biochemical properties of cow manure during

processing by earthworms (Eisenia andrei) and the effects on seedling growth, *Pedobiologia*, **(44),** 709-724, **(1998)**

7. Atiyeh R.M., Arancon, N., Edwards C.A., and Metzger J.D., Influence of earthworm-processed pig manure on the growth and yield of greenhouse tomatoes, Bioresource Technology, **(75),** 175-180 **(2000)**

8. Atiyeh R.M., Subler S., Edwards C.A., Bachman G., Metzger J.D. and Shuster W., Effects of Vermicomposts and Composts on Plant Growth in Horticultural Container Media and Soil; In *Pedobiologia*, **(44),** 579-590 **(2000)**

9. Ansari Abdullah A., Effect of Vermicompost on the Productivity of Potato (Solanum tuberosum) Spinach (Spinacia oleracea) and Turnip (Brassica campestris) *World Journal of Agricultural Sciences,* **4 (3),** 333-336 **(2008)**

10. Barley K.P. and Jennings A.C., Earthworms and Soil Fertility III; the Influence of Earthworms on the Availability of Nitrogen, *Australian Journal of Agricultural Research*, **(10),** 364-370 **(1959)**

11. Edwards C.A. and P.J. Bohlen, Biology and Ecology of Earthworms, 3rd Edn., Chapman and Hall, London **(1996)**

12. Hartenstein R., Neuhauser E. F. and Kaplan D. L., Reproductive potential of the earthworm *Eisenia fetida Oecologia (Berl*), **(43),** 329-340**(1979)**

13. ISI Bulletin Manak Bhavan, Bhadur Shah Zafar Marg, New Delhi **(1982)**

14. Kale R. D., Vermicomposting technology in India An answer to shortages in nutrient supplies. In: Earthworms in the processing and utilization of organic wastes (Ed. C. A. Edwards), Publ, J. G. Press, PA, Chapter, 22**(2002)**

15. Krishnamoorthy R.V. and Vajranabhaiah S.N., Biological activity of earthworm casts A assessment of plant growth promoter levels in the casts, *Proc. Indian Acad. Sci. (Anim. Sci.).*, **(95),** 341-351 **(1986)**

16. Lalitha R, Fathima K, Ismail S.A., The impact of biopesticide and microbial fertilizers on productivity and growth of *Abelmoschus esculentus, Vasundara the Earth* **(1-2),** 4-9, **(2000)**

17. Lee K. E. Earthworms, Their ecology and relationship with soils and land use, Publ, Hartcourt Brace Jovanorich, Academic Press, Sydney, 411(**1985)**

18. Orozco F.M., J. Cegarra, L.M. Trujillo and A. Roig, Vermicomposting of coffee pulp using the earthworm Eisenia fetida, Effect on C and N contents and the availability of nutrient, *Biol. Fertil, Soils*, **(22),** 162-166 **(1996)**

19. Maheswarappa HP, Nanjappa HV and Hegde M.R., Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as intercrop in coconut garden, Annals of Agricultural Research, **20(3),** 318–323 **(1999)**

19. Parthasarathi K., Vermicomposts produced by four species of earthworms from sugar mill wastes (pressmud), *Ind. J. Life Sci.,* **(1),** 41-46 **(2004)**

20. Parthasarathi K. and L.S. Ranganathan, Supplementation of pressmud vermicasts with NPK enhances growth and yield in leguminous crops (Vigno mungo and Arachis hypogaea), *J. Curr. Sci.,* **(2),** 35-41 **(2002)**

21. Parthasarathi K., Vermicomposts produced by four species of earthworms from sugar mill wastes (pressmud), *Ind. J. Life Sci.,* **(1),** 41-46 **(2004) ,**Ranganathan L.S., Vermibiotechnology - From Soil Health to Human Health, Agrobios., India **(2006)**

22. Reinecke A. J. and Kriel J. R., Influence of temperature on the reproduction of the earthworm *Eisenia fetida* (Oligochaeta), *S. Afr. J. Zool.* **(16),** 96-100 **(1981)**

23. Sreenivas C, Muralidhar S and Rao M.S., Vermicompost, a viable component of IPNSS in nitrogennutrition of ridge gourd, Annals of Agricultural Research, **21(1),** 108–113 **(2000)**

25. Watanabe H. and Tsukamoto J., Seasonal change in size and stage structure of Lumbricid *Eisenia foetida* population in a field compost and its practical application as the decomposer of organic waste matter, *Rev. Ecol. Biol. Sol.,* **(13),** 141-146 **(1976)**