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A SIMPLE METHOD FOR IMPROVEMENT OF SOIL FERTILITY THROUGH VERMICOMPOSTING

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Abstract: Managing for soil health is one of the most effective ways for farmers to increase crop productivity and profit-ability while improving the environment. The present study was undertaken for the improvement of soil fertility with the help of garden waste and dung vermicomposting. A free choice experiment on soil, garden waste and dung mixture in different ratios revealed the best culture media was mixture of these three wastes in proportion of 1:1:1. Further study in soil, garden waste and dung mixture followed by release of earthworms and maintained for 60 days resulted the best results were obtained in soil-garden waste-dung ratio (1:4:4) in which maximum increase (3171.07 %) in total bio-number (adults, juveniles and cocoons) and net biomass (743.51 %) was recorded. The maximum amount of nitrogen (1.94%), phosphorus (1.12%) and potassium (1.18%) content were also noticed in this mixture. The study concluded that releasing of *Eudrilus eugeniae* worms in organic waste rich moist soils can be best for in situ recycling of waste biomass and for remediation of soil fertility.

Keywords: Dung; *Eudrilus eugeniae*; Garden waste; Soil; Vermicomposting; Waste recycling.

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INTRODUCTION

Earthworms play important role in soil ecosystem because majority of biomass is handled through them, in collaboration with microorganisms. They improve soil fertility in several ways and act as aerator, crusher, mixer, grinder, chemical degrader and biological stimulator in soil. They mix organic matter with mineral soil, release nutrients and make them available to the plants. They also improve infiltration of water through burrowing and contribute to the formation of stable soil aggregates, producing the crumbly texture of a fertile soil by the intimate mixing of organic matter, microorganisms, mineral soil and secretions from the worm skin and gut (Ramesh, 2000). Earthworms are well known to help the

soil in respiration, nutrition, excretion and stabilization. They cause tunneling, show buffering action, regulate soil temperature and thus stimulate useful activity of aerobic microorganisms.

But in modern agriculture the contribution of earthworms has not been given due consideration and their diversity and density are declining. Earthworms can quickly decompose and stabilize animal manure and in doing so, they increase soil biochemical characteristics making it more suitable for plant growth (Atiyeh *et al.*, 2000a, 2000b). A number of authors have been reported that exchangeable cations such as Ca, Mg, Na, K, available N, P and Mo in earthworms cast was significantly higher than in surrounding soil (Nijhawan and Kanwar, 1952; Nye, 1955; Shinde *et al.*, 1992). Lavelle (1988),

Lee and Foster (1991) pointed out that earthworms breakdown the complex organic matter into available nutrients and help to maintain the physio-chemical and biological properties of the soil.

Vermicomposting is an effective means of composting the decomposable organic wastes using earthworms naturally present in the soil. Vermicomposting is a mixture of worm casts enriched with macro and micronutrients (N, P, K, Mn, Fe, Mo, B, Cu and Zn.), some growth regulating substances (such as gibberellins and auxins) and useful micro flora (Azospirillum, Actinomyces and Phosphobacillus) etc. which naturally helps in improvement of soil fertility or soil quality.

This study has been conducted to showing the reproductive performance of African night crawlers *Eudrilus eugeniae* in Gwalior (MP) soil with the help of dung and garden waste vermicompost, which may be helpful in improving soil fertility in agricultural / horticultural fields with enough inputs of organic matter and moisture or in waste recycling or in garden waste management.

EXPERIMENTAL

For developing a simple method for "improvement of soil fertility" garden waste (included dry leaves and flowers waste) which is generally generated daily in gardens or parks and dung in different ratio with soil were used for vermicomposting. The earthworms for the study were taken from Vermicomposting Centre of School of Study in Zoology, being maintained in Charak Udhyan of Jiwaji University, Gwalior. Firstly a free choice experiment was conducted in a ceramic tank for showing the survivability of African night crawlers *Eudrilus eugeniae*. The sink was divided into four equal size chambers with the help of thermocole sheets arranged around a middle chamber (perforated plastic container). These four chambers were filled with following culture media; (A) Soil + garden waste (1:1), (B) Soil + dung (1:1), (C) Dung + garden waste (1:1) and (D) Soil + garden waste + dung (1:1:1). Thermocole sheets were provided

with some holes so that earthworms can pass through from one chamber to another, according to their preferential habits. In the middle chamber, 100 adult earthworms were filled and the whole assembly was covered by garden mesh net. The worms had a freedom to migrate and distribute themselves in any one of the media of their own choice. Free choice experiment was repeated three times and the results were recorded after 15 days by counting the number of earthworms and calculating the percent distribution of earthworms in each chamber. For further study the mixture of soil, garden waste (included dry leaves and flowers waste) and dung in different ratios has been used, earthen flower pots were employed as experimental units. Experiments were conducted in two sets (each in triplicate), in first set, the amount of dung was kept constant and that of soil and garden waste was altered and in the second set, the amount of soil was constant and that of dung and garden waste were changed. The experimental pots were filled with 10 kg of equilibrated culture medium in different combination of soil, garden waste and dung mixture. After pre-decomposition period of 10 days and 15 baby worms (weighing 6.23 - 7.89 gm) were introduced in each culture unit or earthen pot for 60 days. The earthworm population and cocoons were estimated by hand sorting and counted at the completion of 60 days through washing over a sieve (Kale and Krishnamoorthy, 1982). The observations on the number and weight of adult, baby worms, juveniles and cocoons, worm population growth and biomass production were recorded.

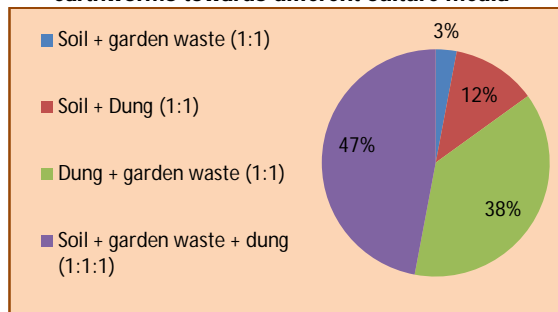
The quality of compost was assessed by determining the values of nitrogen (N), phosphorus (P) and potassium (K). The followings chemical parameters of vermicompost were analyzed: Total Kjeldahl nitrogen (N) was determined as per method of (Bremner and Mulvaney, 1982). Available phosphorus was analyzed by employing method (Olsen et al. 1954) and Potassium was determined by ammonium acetate extractable method (Simard,

1993). The pH of the composts was determined using glass electrode pH meter (Jackson, 1973).

RESULTS AND DISCUSSION

The number and weight of adult earthworms are the indicators of growth and biomass production, whereas the number and weight of cocoons and juveniles are the parameters of reproductive performance. Observations of the free choice experiment of soil, garden waste and dung mixture in different ratios revealed that highest percentage of earthworms (47%) was found in mixture of soil (S), garden waste(GW) and dung (D) (1:1:1) are depicted in figure 1.

Figure 1. Showing the relative preference of earthworms towards different culture media



Therefore further study has been conducted in mixture of soil, garden waste (included dry leaves and flowers waste) and dung in different ratios. All the experimental culture media were not

found to be equally suitable for survival, growth and reproduction of *E. eugeniae*. The results on average number of adults, cocoons and juveniles, dealing with two sets of experiments, are depicted in Table 1.

Table 1. Showing average number of adults, juveniles and cocoons of *E. eugeniae* in first and second set of experiment using different combinations of soil, garden waste and dung mixture

Organic matter	Initial no. of worms	No. of adult worms (Mean±S.E)	No. of juveniles (Mean±S.E.)	No. of cocoons (Mean ± S.E.)
Garden waste alone (GW)	15	0.0	0.0	0.0
Soil (S)	15	5.00 ± 0.58	1.67±0.33	0.0
S+GW+D (4:4:1)	15	8.67 ± 0.82	65 ± 2.88	45 ± 2.88
S+GW+D (3:3:1)	15	9.67± 0.88	75 ± 2.88	65 ± 2.88
S+GW+D (2:2:1)	15	13.00±1.15	138.34± 7.26	100 ± 5.77
S+GW+D (1:1:1)	15	15.333±0.88	181.67±2.88	200.66 ± 2.88
Dung (D)	15	18.34±0.88	213.34 ± 7.26	205 ± 2.96

Organic matter	Initial no. of worms	Final no. of worms (Mean± S.E.)	No. of juveniles (Mean ± S.E.)	No. of cocoons (Mean ± S.E.)
Garden waste alone (GW)	15	0.0	0.0	0.0
Soil (S)	15	5.50 ± 0.33	1.74 ± 0.33	0.0
S+GW+D (1:1:1)	15	15.33± 0.88	178.95 ± 2.88	196.92 ± 2.96
S+GW+D (1:2:2)	15	18.66± 0.88	215.00 ± 2.88	216.66±12.01
S+GW+D (1:3:3)	15	23.00± 0.88	235.00 ± 2.88	220.00±5.77
S+GW+D (1:4:4)	15	26.33± 0.88	241.00 ± 5.19	223.33±8.81
Dung (D)	15	18.33± 0.88	212.82 ± 7.26	204.92 ± 2.88

Table 2. Showing average weight of adults, juveniles and cocoons of *E. eugeniae* in first and second set of experiment using different combinations of soil, garden waste and dung mixture

Organic matter	Initial wt. of worms (gm)	Final wt. of worms (gm) (Mean ± S.E.)	Wt. of juveniles (gm) (Mean ± S.E.)	Wt. of cocoons (gm) (Mean ± S.E.)
Garden waste alone (GW)	7.48±0.09	0.0	0.0	0.0
Soil (S)	6.46±0.44	9.00 ± 0.99	0.13 ± 0.03	0.0
S+GW+D (4:4:1)	7.39±0.42	15.40±1.86	4.10 ± 0.11	1.50 ± 0.05
S+GW+D (3:3:1)	7.33±0.81	17.99±1.93	4.56 ± 0.12	1.83 ± 0.05
S+GW+D (2:2:1)	7.89±0.96	24.61±1.86	6.46 ± 0.08	2.00 ± 0.05
S+GW+D (1:1:1)	7.33±0.47	28.85±1.14	6.80 ± 0.05	3.93 ± 0.06
Dung (D)	6.23±0.31	34.42±1.95	6.93 ± 0.08	4.00 ± 0.05

Organic matter	Initial wt. of worms (gm)	Final wt. of worms (gm) (Mean ± S.E.)	Wt. of juveniles (gm) (Mean ± S.E.)	Wt. of cocoons (gm) (Mean ± S.E.)
Garden waste alone (GW)	7.43±0.05	0.0	0.0	0.0
Soil (S)	6.46±0.44	9.64 ± 0.31	0.16 ± 0.03	0.0
S+GW+D (1:1:1)	7.33±0.47	28.85±1.14	6.94 ± 0.08	4.01 ± 0.05
S+GW+D (1:2:2)	7.46±0.85	33.42±1.79	7.80 ± 0.05	4.13 ± 0.14
S+GW+D (1:3:3)	6.91±0.54	41.09±0.69	7.90 ± 0.05	4.20 ± 0.05
S+GW+D (1:4:4)	8.02±0.84	55.44±1.19	7.96 ± 0.12	4.26 ± 0.12
Dung (D)	6.23±0.31	34.17±1.95	6.89 ± 0.05	3.945 ± 0.06

Similarly the average results on the weight of adults, cocoons and juveniles are depicted in Table 2. It was observed that in all combinations of substrates, the earthworms showed variable degree of growth and reproduction with minimum performance in soil alone and zero degree of growth and reproduction performance in garden waste alone. The numbers of *E. eugeniae* varied from 15.00 to 26.33 in combinations of soil, garden waste and dung mixtures. In first series of experiment, the number of worms decreased only in soil alone from 15 to 5.0 (-66.67 %) and in second series from 15 to 5.5 (-63.34%) decrease was found. During 60 day period of experiment, the pre-mature worms became fully mature and increase in adult worms and the presence of significant number of cocoons and baby worms indicate their reproductive activity. The number of adult worms could not survive in soil alone and garden waste alone.

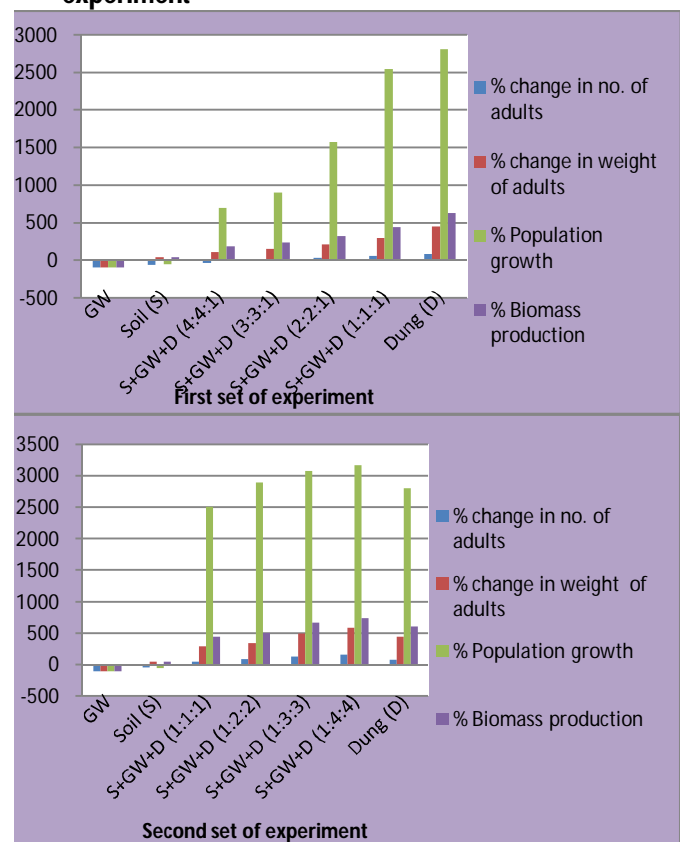
The number of cocoons was found to be increased with decreasing amount of soil and garden waste, i.e. 45.00 in S+GW+D (4:4:1), 65.00 in S+GW +D (3:3:1), 100.00 in S+GW+D (2:2:1), 205.00 in S+GW+D (1:1:1) and 200.66 in dung alone. Maximum number of cocoons (205.0) was recorded in S+GW+D (1:1:1). Similar to the number of cocoons, minimum cocoon weight (1.5gm) was also observed in S+GW+D (4:4:1) and an increasing trend was noticed with decreasing amount of soil and garden waste, i.e., 1.833 gm in S+GW+D (3:3:1), 2.0 gm in S+GW+D (2:2:1), 4.0 gm in S+GW+D (1:1:1) and 3.933 gm in dung alone. Maximum weight of cocoons (4.0 gm) was recorded in S+GW+D (1:1:1) shown in Table 2.

In first series of experiment, in which ratio of soil and garden waste was altered and dung was constant the weight of adult worms increased as 39.36 % in soil alone, in S+GW+ D (4:4:1)108.28%, S +GW+ D (3:3:1) 145.42 %, in S+GW+ D(2:2:1) 212.62 %, in S +GW+ D (1:1:1) 293.62% and in dung alone 445.40 % increased. In second series of experiment where ratio of soil was remain constant, dung and garden waste ratio were altered, higher values of both

parameters (number and weight of adult worms) were reported viz. the weight of adult worms increased as in soil alone 49.15%, in S+ GW + D (1:1:1) 293.62%, in S+ GW + D (1:2:2) 347.66%, in S+ GW + D (1:3:3) 494.64%, S + GW + D (1:4:4) 591.05% and in dung alone 448.25% increased. The best results were obtained in soil-garden waste-dung ratio (1:4:4) in which maximum increase (3171.07%) in total bio-number (adults, juveniles and cocoons) and net biomass (743.51 %) was recorded and shown in figure 2.

These ratios were also not found suitable for survival and growth of earthworms in garden waste alone. In combinations containing low amount of soil, high amount of dung and garden waste i.e., 1:1:1, 1:2:2, 1:3:3, 1:4:4 and in dung alone, population growth and biomass production of *E. eugeniae* were higher (shown in figure 2).

Figure 2. Percent change in number, weight of adults, Population growth rate and % biomass production in different combinations of soil, garden waste and dung in first and second set of experiment



Data of experiments were converted into percentile of parameters (% growth rate and biomass production) and average of these values indicates the net percentile rank of a particular medium. Medium showing highest rank should be considered to be the best suitable medium for *E. eugeniae*. Two types of culture media can be recognized according to their percentile scores: (a) Highly suitable with percentile score of 100-80, (b) Moderately suitable (80-60 percentile), (c) Suitable (60-40 percentile) and (d) Un-suitable (40-0 percentile) were depicted in Table 3.

Table-3. Accordingly different substrate combinations may be grouped in the following manner

Suitability range	Substrate combinations
Highly suitable	S+GW+D (1:4:4), (1:3:3), (1:2:2), (1:1:1) and Dung
Moderately suitable	S+GW +D (2:2:1)
Suitable	S +GW+D (3:3:1), S+GW+D (4:4:1)
Un-suitable	S (soil alone) and GW (Garden waste alone)

Vermicomposting is an effective means of composting the decomposable organic wastes using earthworms naturally present in the soil. Vermicomposting is a mixture of worm casts enriched with macro and micronutrients (N, P, K, Mn, Fe, Mo, B, Cu and Zn.), some growth regulating substances (such as gibberellins and auxins) and useful micro flora (*Azospirillum*, *Actinomyces* and *Phosphobacillus*) etc. In the present study an attempt has also been made to demonstrate the quality of the vermicompost by estimation of pH, Nitrogen (N), Phosphorus (P) and Potassium (K) values were shown in figure - 3, 4, 5 and 6 respectively.

According to Shweta *et al.* (2006) flower waste in combination with dung gave faster multiplication but when mixed with dung was best substrate in to increase the biomass production. pH was neutral being around 7 and increased gradually from substrate to compost to vermicompost (Mitchell and Alter, 1993 and Nagavallema *et al.*, 2006). The near-neutral pH of vermicompost may be attributed by the secretion of NH_4^+ ions that

reduce the pool of H^+ ions (Haimi and Huhta, 1987) and the activity of calciferous glands in earthworms containing carbonic anhydrase that catalyze the fixation of CO_2 as $CaCO_3$, thereby preventing the fall in pH (Kale and Krishnamoorthy, 1982). The increased trend of pH in the vermicompost and compost samples is in consistence with the findings of (Tripathi and Bhardwaj, 2004 and Loh *et al.*, 2005), which was due to higher mineralization whereas the present findings (shown in figure-3) are in contradiction to the that of Haimi and Huhta (1987), Ndegwa, *et al.* (2000) and Suthar and Singh (2008), who reported lower pH.

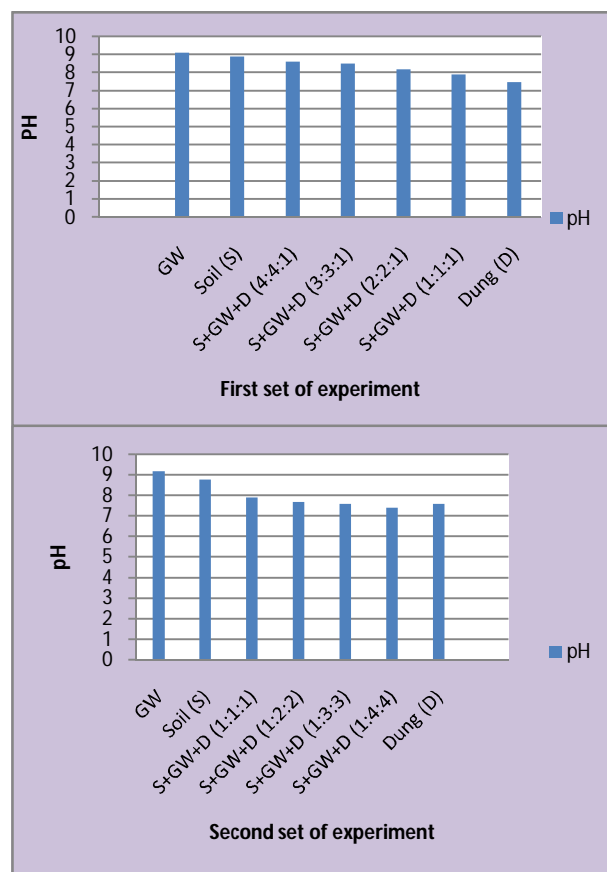


Figure 3. Showing variation of pH in different culture media (organic ratio) in first set of experiment and second set of experiment

Nitrogen is the chief constituent of all kinds of fertilizers including chemical and bio-fertilizers followed by potash (potassium) and phosphorus. In the first set of experiment it was observed that the quantity of total nitrogen was highest (1.91%)

in vermicompost obtained from dung and in the second set of experiment the quantity of total nitrogen was maximum (1.94 %) in the vermicompost prepared from soil, garden waste and dung (1:4:4) are depicted in figure 4. Whereas, the nitrogen content was lowest (0.29 %) in the vermicompost produced from soil alone. The values of nitrogen in other combinations of soil, garden waste and dung mixture were observed to stand in between the lowest and highest recorded values (figure 4).

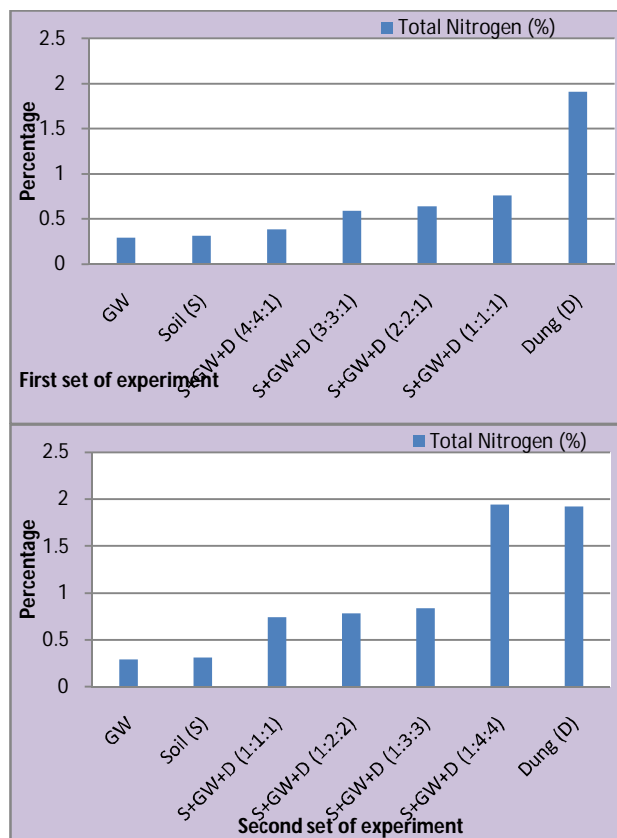


Figure 4. Showing variation of Total Nitrogen in different culture media (organic ratio) in first set of experiment and second set of experiment

The values of phosphorus content showed a range of variations from 0.18 – 1.12 % in both sets of experiment (shown in figure 5).

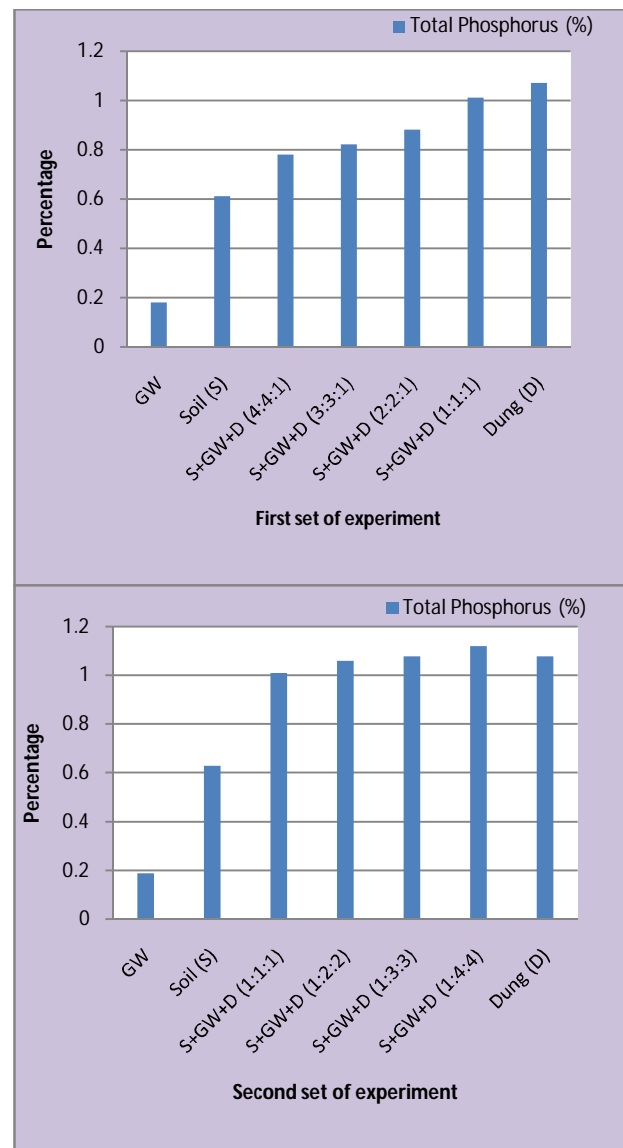


Figure 5. Showing variation of Total Phosphorus in different culture media (organic ratio) in first set of experiment and second set of experiment

The potassium content varied from 0.13 – 1.18 % in different combinations of the substrate media used in both sets of experiments and the difference between them was not significant (figure 6).

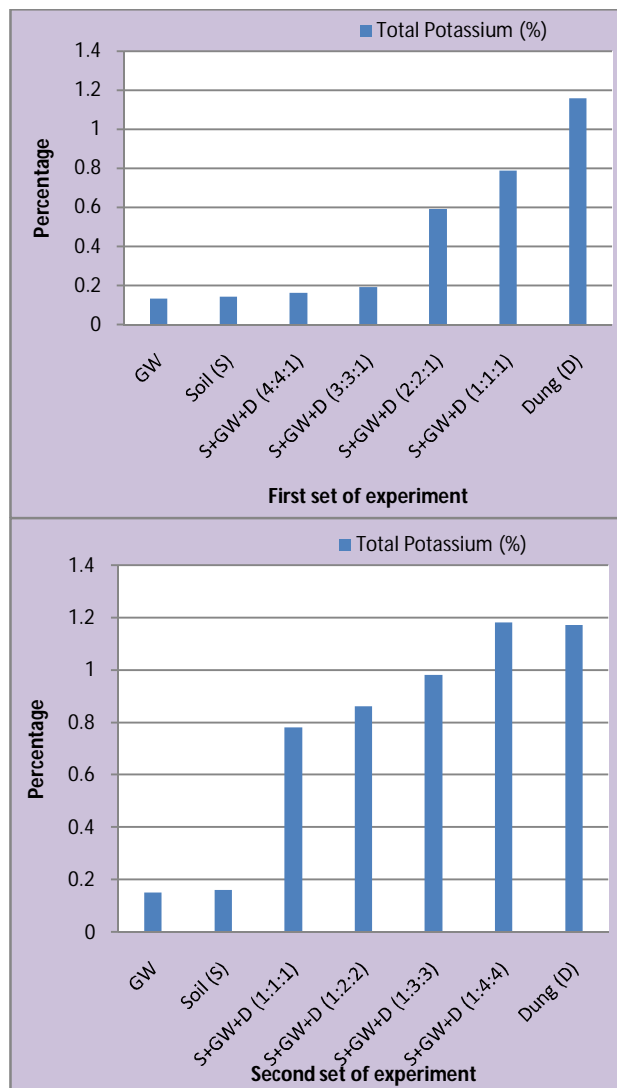


Figure 6. Showing variation of Total Potassium in different culture media (organic ratio) in first set of experiment and second set of experiment

The observations from this study revealed that the number and weight of adult earthworms, and number and weight of cocoons and juveniles were increased in all waste combinations containing high or low amount of dung. The soil alone, garden waste alone and the media containing high proportions of soil and garden waste were not much suitable for the survival and reproduction of adult worms. The number of adult worms was found to slightly reduce in soil alone and not found in garden waste alone as compared to the initial value. Such a reduction in

the number of worms might be due to escape or migration or natural death of the worms on account of lack of nutrients, proper aeration, hostile environment etc. The conditions in soil-enriched media were observed to be unfavorable not only for the survival of the adult worms and also for reproductive performance of the surviving worms while with increasing percentage of dung, the conditions became favorable.

The best results were obtained in soil-garden waste-dung ratio (1:4:4) in which maximum increase (3171.07%) in total bio-number (adults, juveniles and cocoons) and net biomass (743.51 %) was recorded.

The increased trend of NPK in the vermicompost and compost samples (shown in figure 4, 5 and 6 respectively) is in consistence with the findings of Kale (1995) described composition of the vermicompost as: total nitrogen - 0.5 to 1.5%, available phosphorus - 0.1 to 0.3%, available potassium - 0.15 to 0.56%. The vermicompost acts as an excellent base for the establishment and multiplication of beneficial / symbiotic microbes. It being a natural means of soil fertility management fits well into integrated plant nutrient management strategy for sustainable agriculture. Similar nutrient pattern was reported by Krishna Murthy *et al.* (2010) in different weed species, Patnaik and Reddy (2010) in vegetable wastes, Shweta *et al.* (2010) in sugarcane trash and byproducts of sugarcane and Laxmi *et al.* (2013) in vegetable market waste, paddy straw, weeds, and sugarcane trash. Wani *et al.* (2013) showed high nutrient content in the dung followed by garden waste and kitchen waste using *Eisenia fetida*.

Development of a simple method of vermicomposting of garden waste and dung with soil should be a welcome event as it will help in solving problems of soil fertility in gardens or in agriculture lands or farm lands or in nurseries. It is also helps in solid waste management, environmental conservation and in improving community health by avoiding the incineration of garden or agriculture waste.

CONCLUSION

Chemical fertilizers were the major tools for 'green revolution' during 1950-60s. The green revolution was need of that time, since increasing human population was struggling for availability of food. The chemical agents were considered as boon, but in fact they brought 'mixed blessings' for mankind. They boosted food productivity, but at the cost of environmental pollution, deteriorating crop quality and increasing health hazards. In conclusion, it may be stated that: (a) soil - garden waste - dung mixture can be a good additive for preparation vermicompost and biomass production using *E. eugeniae*, (b) the soil alone and garden waste is not a very suitable medium even on mixing with dung in large amount, (c) soil, garden waste and dung mixed in (1:4:4) ratio to get satisfactory results of waste management and production of vermicompost and to develop a simple method of vermicomposting of garden waste and dung with soil should be a welcome event as it will help in solving problems of soil fertility using earthworms so that the practice of vermicomposting could be promoted among general public using container units for agricultural and horticultural fields. It is also helps in solid waste management, environmental conservation and in improving community health by avoiding the incineration of garden or agriculture waste. This practice of vermiculture with waste recycling of garden waste and cattle dung naturally helps in improvement of soil fertility or soil quality. The large scale practice of vermicomposting may have far reaching effect in environmental conservation, sustainable development and improving community health. Moreover, this waste management technology mediated by earthworms could also be utilized for self employment, resource generation in rural areas and a big income generation resource especially in urban cities.

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