

Assessment of vermicomposts as biofertilizers produced with various agro-residues by Asiatic earthworm, *Perionyx excavatus* during three seasons

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Abstract

Growth & yield of crops depend on the quality of soil. The quality refers to physico-chemical factors of soil. Among all factors, presence & availability of plant nutrients play important role in the quantity & quality yield of crop. This can be achieved through by recharging the infertile soil with inorganic & organic fertilizers. The application of organic fertilizer is a better choice over adversely affecting inorganic fertilizer in the soil. Therefore, the present experiment was carried out to prepare compost (by microorganisms) & vermicompost (by earthworms) using various agricultural harvest wastes as their diets, and also to assess & compare the quality of compost & vermicompost on vegetative growth of crop seedlings.

Three sets each of seedling culture pots such as black soil, compost+ soil, and vermicompost + soil in the ratios of 1:5, 1:10 & 1:15 formulations were prepared. Seed germination of Jowar, Blackgram, Greengram & Redgram occurred after 40, 24, 24 & 48 hours respectively, and not shown any significant difference between soil, compost & vermicompost. The assessment of compost & vermicompost as biofertilizer has revealed increased biomass, length of stem, root & leaves, and more number of leaves in the seedling grown in the latter than in the former. Leaves of seedlings grown in vermicompost had deep green coloration than those in other sets. Seedlings had enhanced growth in the formulations of vermicompost followed by compost than in soil alone. Further, the formulations of 1:5 of vermicompost & compost had increased biomass (wet wt.) of seedlings than in 1:10 followed by 1:15, because any decomposed organic matter has its fertile value at certain limits (with respect to alteration in pH) & more than limit results deterioration of soil. In formulations of vermicompost & compost, the biomass of seedlings of all crops was respectively 1.5-10.0 & 1.5 – 5.0 times more than those grown in black soil alone. Hence, among all culture pots, the vermicompost of with 1:5 formulations was found more suitable fertilizer for the vegetative growth (biomass) of all crop seedlings.

Keywords: Soil, Compost, Vermicompost, Earthworm, *Perionyx excavates*, Crop seedlings

1. Introduction

The quality & quantity of the primary production, among the factors, are dependent on the presence of available plant nutrients in soil which are not uniformly distributed everywhere. Hence soil has to be ameliorated with the application of fertilizers, if it has to be used for cultivation. Though inorganic fertilizers have potential to support growth & yield of plants, they adversely affect the soil physico-chemical properties and the biota including earthworms. Their use in agricultural practice has been uneconomical because of the increased cost. Agricultural industry can be made economical & sustainable one through soil conditioning with the application of organic fertilizers. Of the many organic fertilizers (Biofertilizers), Vermicompost appears to be the most valuable soil conditioner as it contains rich amount of available plant nutrients and can be obtained as byproduct in the bio-processing of compostable organic wastes using epigeic earthworms.

Many studies from green house field observations have showed enhanced plant growth in the presence of earthworms (Stockdill, 1982; Hoogerkamp *et al.*, 1983; Edwards & Lofty, 1980; Atlavinyte & Zinkuviene, 1985; Kale & Bano, 1986; Curry & Boyle, 1987; Spain, *et al.*, 1992; Mba, 1996) [24, 8, 5, 1, 11, 3, 22, 16]. Feeding activities of earthworms have been reported (Haimi & Huhta, 1990) [9] to significantly enhance

mineralization of plant litter, provide nutrient availability for the growth of tree seedling (Haimi *et al.*, 1992) [10] and promote the lush growth of plants (Reinecke & Visser, 1980). It is emphasized by many researchers (Edwards & Lofty, 1972; Krishnamoorthy, 1990; Nowak, 1995) [4, 13, 18] that the analysis of worm cast has greater amount of plant nutrients than surrounding non-ingested medium. Application of worm cast to the agricultural fields improves the physico-chemical & biological properties of soil (Kale *et al.*, 1992) [12]. The stimulatory influence of earthworm cast on the germination, growth and yield of barley crop has been reported by Atlavinyte & Zinkuviene (1985) [1]. The presence of growth regulating substances in the worm cast has also been reported (Tomati *et al.*, 1987) [25]. Springett and Syers (1979) [23] have mentioned an increase in net production on application of worm casts. Similar data on improvement in the growth and yield of crops by the inoculation of worms has been shown by Graff & Makeshin (1980) [6].

Peryonix excavates, a tropical epigeic earthworm, has an ability to withstand high temperature, feeds voraciously on variety of organic wastes and breeds prolifically throughout the year. To determine the practical utility of the worm cast has biofertilizer, preliminary laboratory trials were undertaken to assess the status of Vermicompost on the vegetative growth of crop seedlings.

2. Materials & Methods

2.1 Preparation of culture beds

Agricultural wastes [Wheat straw (*Triticum aestivum*), Rice straw (*Oryza sativa*), Jowar straw (*Sorghum ulgare*), Blackgram pod husk (*Phaseolus mungo*), Greengram pod husk (*Phaseolus radiatus*) & Redgram pod husk (*Cajanus cajana*)] were collected from field during harvest season in quantity enough for experimental use. These were reduced to 0.5-1.0" in size. Simultaneously urine free cattle manure was collected from cattle shed, dried, & powdered to get 0.2mm particle size. The powdered cattle manure was mixed with individual agricultural wastes in the ratio of 1:5 (v/v) for maintaining about 1:25-30 C:N ratio to be used for regimen for worm. These were sprayed with required amount of tap water in order to impart 75-80% moisture. These diets were kept for one week for thermal stabilization, microbial initiation of degradation and softening of wastes for easy ingestion by the worms. Culture beds in nine replicates of each diet were prepared by transferring individual diet to round plastic container (481cm³ volumes with 53cm² surface area) with pin-holed lid for ventilation & prevention of predators.

2.2 Inoculation of worms

Five sexually matured (5-week old) worms were inoculated to each culture container in the ratio of 1:5 (worm & dry wt. of diet). Experiments were set up with the onset of each season [monsoon (June-September), winter (October-January) and summer (February- May) seasons & prevailing seasonal environmental conditions of the year (2015) and continued for 3-months. Simultaneously, to know the role of earthworm in composting organic wastes another set of triplicate containers of each diet but without inoculated worms served as controls.

2.3 Formulations of sowing beds (culture pots)

The biofertilizers produced after 90 days, with and without activity of worm from different wastes during different seasons were mixed & designated as 'vermicompost' and 'compost' respectively. To assess the status of these biofertilizers on the growth of seedlings, they were separately mixed with vertisol (black soil) in the ratio of 1:5, 1:10 and 1:15 (v/v). On the onset of monsoon season, about 1.5kg each formulation in triplicate was filled into culture pots (polyethylene bags) of 1750cm³ volumes with 75cm² surface area. Simultaneously a set of culture bags with 1.5kg of onle black soil served as controls for 'soil + compost' sets which further served as control for 'soil + vermicompost' (experimental) sets.

2.4 Inoculation of crop seeds

'Myco- Certified' seeds of hybrid variety of commercial crops such as Jowar, Blackgram, Greengram & Redgram, having 80-90% germination brought from authorized dealer.

These seeds were surface sterilized to remove surface pathogens, if any, by dipping in 0.1% HgCl² for 3 -5 minutes and then in distilled water. The contents of culture pot were saturated with water and next day, five of each type of seeds was planted at 0.5 – 1.0 cm depth and 1.5 inch apart.

2.5 Maintenance of culture pots & observations

Seeded pots were placed in greenhouse to allow sunlight and avoid the leaching effect of rain water. To maintain capillary water in culture pots, tap water was sprinkled on every alternate day up to the 20th day. The time taken for germination of seeds was noted up to 10 days. To avoid overcrowding during subsequent days, three out of the seedlings were removed from culture pots.

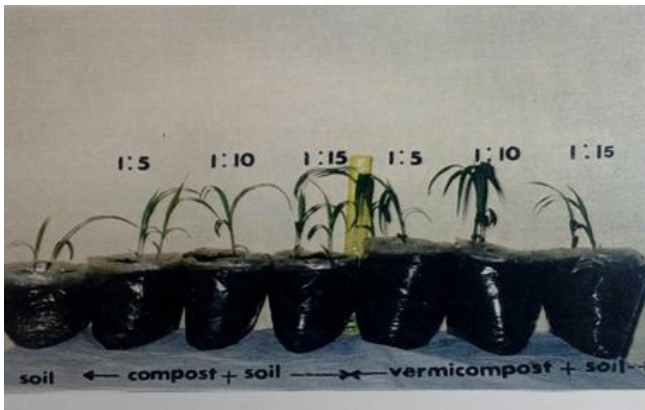
The seedlings retained at the distance of about 6 inches were further allowed to grow for a period of another 10 days. The experiment was terminated on 20th day and the observations with respect to biomass, length of stem & root, number & length of leaves and numbers of branches of seedlings were made. Weight of each seedling was noted after thorough washing and removing adhered soil particles & water droplets. Length of stem (from base to apex of stem), root (from base to tip of the root), and leaves (from base to tip of the leaf) were measured by the help of graph sheets.

3. Results

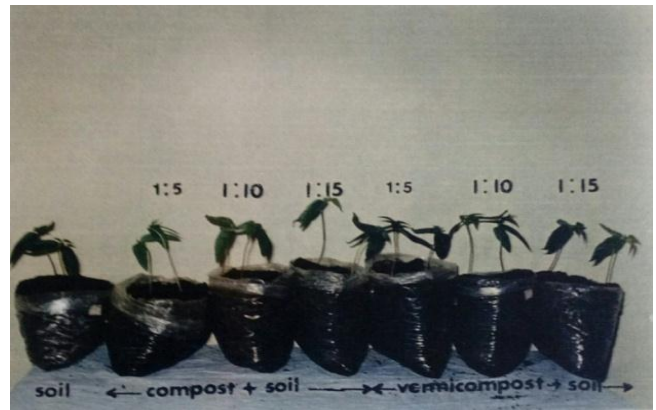
Germination of seeds of Jowar, Blackgram, Greengram & Redgram occurred after 40, 24, 24 & 48 hours respectively, and did not show any difference between soil, compost & vermicompost culture sets as well as among different formulations (ratios) of compost & vermicompost.

The assessment of compost & vermicompost as biofertilizer has revealed increased biomass, length of stem, root & leaves, and more number of leaves in the seedling grown in the latter than in the former (table-1). Leaves of seedlings grown in vermicompost had deep green coloration than those in other sets. Further, seedlings in general, had enhanced growth in the formulations of vermicompost followed by compost than in soil alone. Further, it was seen that, in the formulations of 1:5 of vermicompost & compost has enhanced amount of biomass of seedlings (wet wt.) than in 1:10 followed by 1:15 (figs.3, 4, 5 & 6), and in formulations of vermicompost & compost, the biomass of seedlings of Jowar, Blackgram, Greengram & Redgram were respectively 1.5-10.0 & 1.5 – 5.0 times more than those grown in black soil alone (table-1).

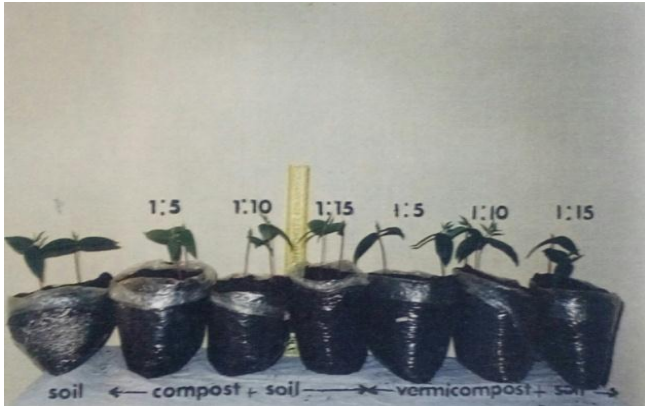
In all formulations, up to 10 days, there was no notable difference in growth of seedlings (figs. 1-4), whereas increase in difference occurred from 10th day onwards up to the end of 20th day of their growth (figs.5-8). Seedlings grown in vermicompost formulation revealed increased length of root only in Greengram, Blackgram & Redgram, and more number of branches was noticed only in Blackgram & Redgram than in soil and formulations of control set.



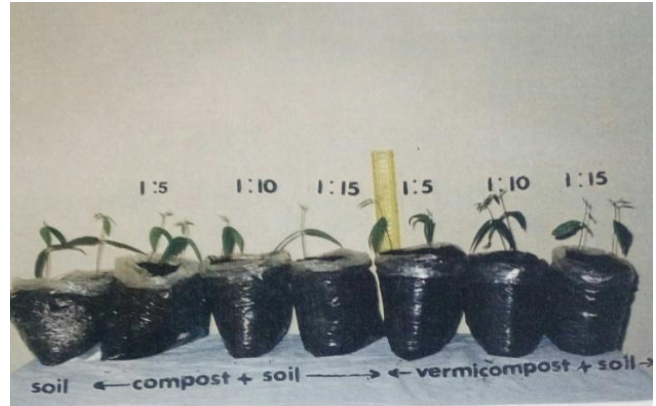
(A)



(C)



(B)



(D)

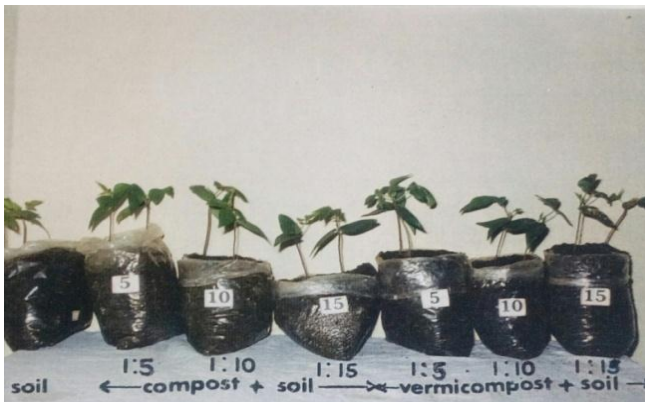
Fig 1: a) Jowar, b) Blackgram, c) Greengram, and d) Redgram seedlings growth on 10th day in soil & different formulations of compost & vermicompost amended soil.



(A)



(C)



(B)



(4)

Fig 2: a) Jowar, b) Blackgram, c) Greengram, and d) Redgram seedlings growth on 20th day in soil & different formulations of compost & vermicompost amended soil.

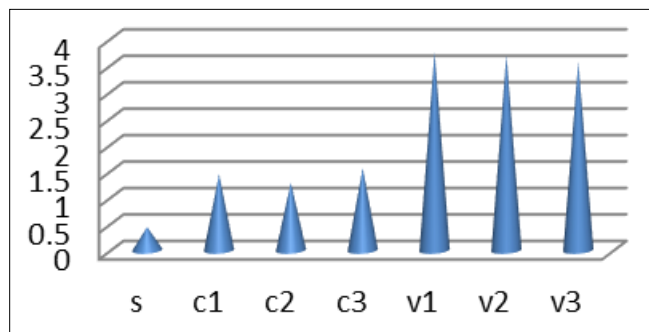


Fig 3: Jowar seedling biomass on 20th day in different formulations.

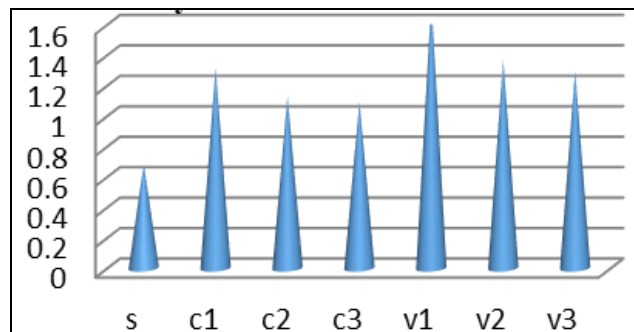


Fig 5: Greengram seedling biomass on 20th day in different formulations.

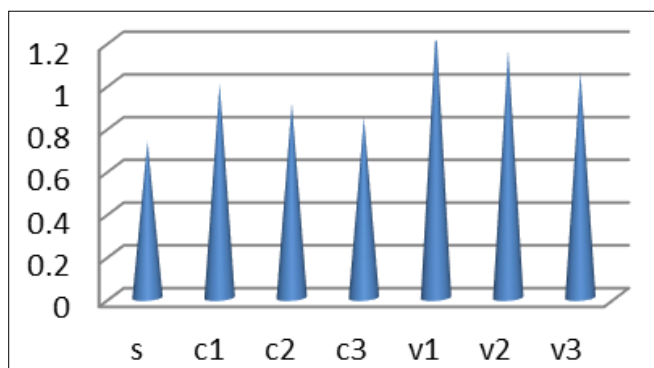


Fig 4: Blackgram seedling biomass on 20th day in different formulations.

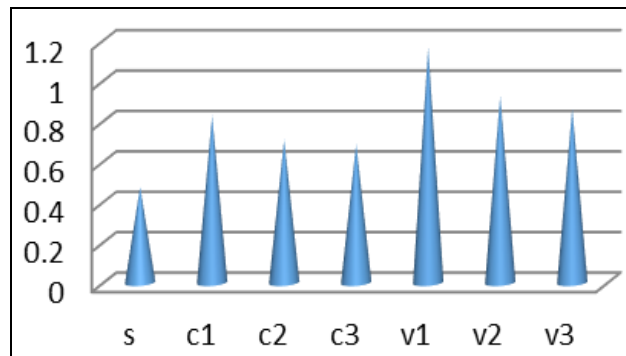


Fig 6: Redgram seedling biomass on 20th day in different formulations.

Table 1: Observations of variables of crop seedlings after 20 days.

Seedlings Biomass (g) & length (cm)	Soil	Compost + Soil			Vermicpost + Soil			Ratios								
	S	1:5 C ₁	1:10 C ₂	1:15 C ₃	1:5 V ₁	1:10 V ₂	1:15 V ₃	S:C ₁	S:C ₂	S:C ₃	S:V ₁	S:V ₂	S:V ₃	C ₁ :V ₁	C ₂ :V ₂	C ₃ :V ₃
Jowar																
Biomass	0.442	1.440	1.279	1.557	3.751	3.694	3.569	4.8	1.5	1.3	9.8	4.5	2.0	2.0	2.9	1.6
Number of leaves	04	06	05	04	07	06	05	1.5	1.2	1.0	1.7	1.5	1.2	1.2	1.2	1.2
Max. leaf length	18.5	30	21	21	38	30	25	1.4	1.0	1.1	2.0	1.6	1.3	1.3	1.4	1.2
Shoot length	27	42.5	27.5	27	50	34.5	29	1.6	1.0	1.0	1.8	1.3	1.1	1.2	1.2	1.1
Root length	11.5	13	12.5	11.5	14	13	12.4	1.1	1.1	1.0	1.2	1.1	1.1	1.1	1.0	1.1
No. of branches	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Blackgram																
Biomass	0.731	1.004	0.910	0.846	1.279	1.158	1.057	1.4	1.4	1.2	1.7	1.5	1.4	1.3	1.3	1.2
Number of leaves	04	06	06	05	10	09	08	1.5	1.5	1.2	2.5	2.2	2.0	1.7	1.5	1.6
Max. leaf length	05.2	06.5	06	05.7	07	06.4	06	1.2	1.2	1.1	1.3	1.2	1.1	1.1	1.1	1.0
Shoot length	09	11	10	09.7	12.5	12	10.2	1.2	1.2	1.1	1.4	1.3	1.3	1.1	1.2	1.0
Root length	06	10.5	08.5	08.4	10.8	10	9.5	1.7	1.7	1.4	1.8	1.7	1.6	1.0	1.2	1.1
No. of branches	01	02	02	02	03	03	02	1.0	1.0	2.0	3.0	3.0	2.0	1.5	1.5	1.0
Greengram																
Biomass	0.684	1.317	1.130	1.093	1.759	1.307	1.298	1.9	1.6	1.6	2.6	1.9	1.9	1.3	1.2	1.2
Number of leaves	04	08	07	05	09	08	08	2.0	1.4	1.2	2.2	2.0	2.0	1.1	1.1	1.6
Max. leaf length	05	06.6	06.2	05	06.9	06.5	05.4	1.3	1.2	1.0	1.4	1.3	1.1	1.0	1.0	1.1
Shoot length	09	12	11.5	10	13	12.2	11.5	1.3	1.3	1.1	1.4	1.3	1.3	1.1	1.1	1.1
Root length	05	06.5	05.5	05	08.5	07.5	06	1.3	1.1	1.0	1.7	1.5	1.2	1.3	1.4	1.2
No. of branches	01	02	02	01	02	02	02	2.0	2.0	1.0	2.0	2.0	2.0	1.0	1.0	2.0
Redgram																
Biomass	0.473	0.827	0.708	0.686	1.165	0.925	0.861	1.7	1.5	1.4	2.5	1.9	1.8	1.4	1.3	1.2
Number of leaves	05	08	08	07	12	11	10	1.6	1.6	1.4	2.4	2.2	2.0	1.5	1.4	1.4
Max. leaf length	06	07.2	07	06	08.5	07.6	07.4	1.2	1.2	1.0	1.4	1.3	1.2	1.2	1.1	1.2
Shoot length	10.5	15.4	14	12	22	17	16	1.5	1.3	1.1	2.1	1.6	1.5	1.4	1.2	1.3
Root length	05	09.8	09.5	05.2	14	10	08.5	2.0	1.9	1.0	2.8	2.0	1.7	1.4	1.1	1.6
No. of branches	02	03	03	02	04	04	03	1.5	1.5	1.0	2.0	2.0	1.5	1.3	1.3	1.5

Root length of Jowar & number of branches in Greengram seedlings were almost same in experimental, control & soil sets. Whereas, no difference was found in number of branches of all seedlings indifferent formulations of experimental & control sets. All growth parameters of seedlings were higher in control set than seedlings grown in soil.

4. Discussions

The germination of seeds appeared to be influenced by the presence of sufficient moisture rather than availability of nutrient as the time taken for it was same in soil as well as in all formulations of control & experimental sets. There were no notable differences in vegetative growth of seedlings between soils, control and experimental sets up to 10 days growth, except that the leaves of seedlings in experimental sets had deep green coloration which might be due to the presence of more amount of iron in it. These seedlings during the initial period of development appear to take up only a few required nutrients though plenty of others are present in available form in culture medium.

Higher growth of seedlings, after initial 10 days, in vermicompost sets than in compost sets may be due to more nutrients especially the available nitrogen which helps in building the biomass of seedlings. Increased growth of Birch seedlings with the absorption of all available nitrogen (Haimi *et al.*, 1992) ^[10] and increase in the protein synthesis of *Agaricus bisporous* & *Raphanes sativam* when grown in the presence of worm casts (Galli *et al.*, 1990; Tomati *et al.*, 1990) ^[7, 26] have also been documented. In addition, presence of growth promoting substances in vermicompost (Krishnamoorthy & Vajranadhaiah, 1986) ^[14] may also boost the growth of seedlings in experimental sets as it is known that the microflora living in the gut of the earthworms have been reported to decompose phenolic compounds (Neuhauser *et al.*, 1978) ^[17] which are known (Sembdner, *et al.* 1980) ^[21] to inhibit the functions of plant growth hormones. Krishnamoorthy & Vajranadhaiah (1986) ^[14] have shown that the activities of worms (*Perionyx excavates*) in leaf compost amended soils reduced phenol levels and release plant growth promoters through their castings. Higher growth of Birch seedlings with long stem and large and green leaves in the presence of earthworm activities have been reported by Haimi *et al.* (1992) ^[10], and Rasool *et al.*, (2008) also reported the addition of vermicompost of 15 tons ha⁻¹ increased growth & yield of tomato. Our findings corroborate those of Krishnamoorthy (1990) ^[13] who reported the increase in shoot length & biomass of Birch seedlings with casts of *Perionyx excavates* due to higher NPK ratio than garden soil amended medium. Further, higher growth in 1:5 ratio than their other formulations (1:10 & 1:15) of both compost & vermicompost may be due to more organic load in the soil might have reduced pH, & availability of other micronutrients present in the soil. Because, organic matter in the form of plant litter, compost & manure will decrease soil pH through decomposition process (Brady & Weil, 2002), and if the soil solution (mixture of water & nutrients) is too acidic or basic, some nutrients won't dissolve easily, so they won't be available for uptake by roots. Plants take nutrients in pH ranges from 6.0 to 7.5 below this some nutrients such as N, P & K are less available, when exceeds 7.5, then Fe, Mn & P are less available (Martin, 2011) ^[15]. Hence,

vermicompost produced by the activity of *Perionyx excavates* had higher fertilizer value due to the presence of more available, all plant nutrients than compost produced by microbial activity alone. Further, any decomposed organic matter has its fertile value at certain limits & more than limit results deterioration of soil.

5. Conclusions

Germination of seeds appeared to be influenced by the presence of sufficient moisture rather than availability of nutrients; as the time taken for it was same in soil as well as in all formulations of compost & vermicompost amended soils. The assessment of compost and vermicompost as biofertilizer has revealed increased biomass, length of stem, root & leaves, and more number of leaves, deep green colorations in the seedlings grown in the latter than in the former may be due to more available plant nutrients in it. Further, in the formulations of 1:5 of vermicompost & compost has increased biomass of seedlings (wet wt.) than in 1:10 followed by 1:15. In the formulations of vermicompost & compost, the biomass of seedlings of all crops was respectively 1.5-10.0 & 1.5 – 5.0 times more than those grown in black soil alone. Hence, among all culture pots, the vermicompost with 1:5 formulations was found more suitable fertilizer for the vegetative growth (biomass) of all crop seedlings. Hence, overall, vermicompost produced by the activity of *Perionyx excavates* had high fertilizer value due to the presence of more available plant nutrients than compost & black soil alone. Any decomposed organic matter has its fertile value at certain limits & more than limit results deterioration of soil.

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