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Evaluation and promotion of Vermicompost technology for Potato production in Wondogenet, Sidama Region

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Abstract

In vermicompost process energy rich and complex organic substances have been bio-oxidized and transformed into stabilized products by combined action of earthworms and microorganisms, hence earthworms play a considerable role by fragmenting and altering all biological activity of the waste. Therefore the aim of the present study were to explore the suitability and potential use of an epigeic earthworm species, Eisenia Andrei in vermicompost and its effect on cultivation of potato. The experiment were studied for two consecutive year on potato production. A total of six treatments compared for the experiment on farmers field: (1) control (no vermicompost and no chemical fertilizer), (2) NPS(354kg NPS/ha +207kgurea/ha), (3) 3 ton VC/ha, 4.5 ton VC/ha, (4) 1.5 t/ha VC+177kg NPS/ha+103kg urea/ha and (5) 2.25t VC/ha+88.5kg NPS/ha +51.75kg urea/ha. The experiment laid out in RCBD design and replicated three times in each farm. Besides crop data, which were statistically analysed using SAS software economic analysis was also performed to see the feasibility of fertilizer treatments for Potato production in the area. The highest yield (34.16 t/ha) of the crop were recorded at the rate of 3 t/ha. Whereas, the lower yield was measured from the control (no fertilizer). The economic analysis also showed that treatment 3t/ha gave the highest benefit with acceptable MRR suggested by CIMMYT. Therefore partial budget analysis result imply that 3 ton /ha rate vermicompost recommended for farmer use for cultivation of potato.

***Keyword**:* vermicompost, potato, yield

Introduction

Vermicomposting which is alternatively called earthworm vermistabilisation, worm composting, or annelic consumption (Wong *et al*., 1997) is an earthworm based aerobic process which has a unique position in the domain of environmental engineering, as it is the only pollution control that uses a multicellular animal as the main bioagent (Abbasi *et al.*, 2009). In this process energy rich and complex organic substances have been biooxidized and transformed into stabilized products by combined action of earthworms and microorganisms, hence earthworms play a considerable role by fragmenting and altering all biological activity of the waste (Dominguez, 2004).

Being a developing nation, Ethiopian cities and towns are also suffer with the environmental costs of rapid growth and urbanization particularly in the area of solid waste management. Like other developing nations, the municipal solid wastes produced in Ethiopia are also dominated by food, paper and wastes from animal and vegetable origin. Obviously these materials are wholly biodegradable therefore, the organic nature of these wastes offers various biological management options such as vermicomposting instead of disposal to landfill sites, open dumping or any other environmentally risky waste management alternatives (Gezahegn *et al*., 2012).

Despite the fact that vermicomposting is commonly used as a means of managing municipal solid wastes in various corners of the world; it has not been started in Ethiopia yet. However, the current economic growth, industrialization and urbanization throughout the country have led to the generation of large quantities of organic wastes which need marketable, environmentally sound and cost effective management system. It is now time for Ethiopian cities to think about biological waste treatment system like vermitechnology with the intervention of appropriate biological organisms (Gezahegn *et al*., 2012).

In Ethiopian cities, huge amount of market vegetable wastes are dumped indiscriminately or littered on the streets causing environmental deterioration**.** Even the vegetable market waste collected and dumped into the municipal landfills, has cause a nuisance because of high biodegradability. The biological treatment of these wastes appears to be environmentally friendly and cost effective (Gezahegn *et al*., 2012). Therefore the aim of the present study were to explore the suitability and potential use of an epigeic earthworm species, *Eisenia Andrei i*n vermicompost and its effect on cultivation of potato.

Material and method

The experiment was carried out for two consecutive years in 2017 and 2018 main cropping season in wondogent district of Sidama Region. The earthworms were obtained from the breeding site of Ambo in collaboration with ATA project. Vermiculture were carried out at Hawassa center as seed source for the region.

The organic waste material /crop residues, weed biomass, vegetable scarp, leaf litter, biodegradable portion of urban and rural wastes, cow dung and coffee husk/ were collected at selected location for preparation of vermicompost. Mechanical separation of metal, glass, plastics and ceramics were omitted from organic wastes. The earthworms Eisenia andrei (red wiggler) was obtained from the Hawassa center. Earthworm bed was prepared from any environmental material with one meter height. Regarding waste processing, agricultural waste materials used for the experiment was air dried for 48 hours and chopped into small pieces before laying into experimental containers. All the experimental wastes were mixed with powdered cow dung in 3:1 ratio. The waste and worms were set in the following waste/worm mass proportion in each test container (100Kg of waste treated with 1.4kg of worm). Throughout the study period, the moisture content and the temperature of all beddings were maintained 60-70% and 24-27^{0}C respectively, by spraying adequate quantity of water. Vermicomposting takes 1.5 to 2 month. By sieving or exposing to light the earthworm, vermicompost was differentiating and was stored at proper place to maintain moisture.

The experimental design was randomized complete block replicated three times. Potato variety Gudane was planted in rows and other crop management practices were applied as per the recommendation. Prior to this experimental study, nutrient status of different fertilizers and soil characteristics of study site were estimated. Amount of inorganic fertilizer applied was considered /basis/ on each location and the dose of the fertilizer was determined and applied. Effects of these fertilizers on the average yield of potato was recorded.

The trial consisted of six treatments: (1) control (No fertilizer), (2) NPS=354kg+207kg of urea top dressed, (3) 3 t/ha VC, (4) 4.5t/ha, (5) 50% (1.5t/ha) of VC +50% (177kg) of NPS +103kg of urea top dressed and (6) 75% (2.25t/ha) of VC + 25% (88.5kg) of NPS + 51.75kg of urea top dressed. Potato was planted in 30 cm and 75 cm spacing between plants and rows, respectively. The plot size was 3.9 by 3.75m with 1.5 and 1m distances between the blocks and plots within a block respectively. The total area of the experimental field was 404.25m^2. Treatments and treatment combinations were assigned randomly to the experimental units (plots) within blocks. The blended fertilizer was basal applied and urea was applied in two splits, half at planting and the remaining half at 35 days after planting. All other necessary agronomic practices were carried out uniformly for all plots.

Composite soil sample (0-20 cm depth) from experimental site was taken before planting from the surface of ten spots following zigzag sampling pattern. Soil samples were also taken from each plot for analysis of selected chemical properties after harvesting the crop. The soil samples collected were air dried, crushed and passed through a 2 mm sieve for the analysis of selected soil chemical properties following standard procedure. The soil analysis was carried out at the Soil Laboratory of Hawassa Agricultural Research Center.

All soil samples were analyzed for soil pH, OC, TN and available P. Potentiometric method using a glass-calomel combination electrode was used to measure pH of the soils in water suspension in a 1:2.5 soil to water ratio (Barauah and Barthakulh, 1997). The Walkley and Black (1934) wet digestion method was used to determine soil OC content. Total N of the soil was analyzed using the Kjeldahl method as described by Bremner and Mulvaney (1982). Available P was determined using the standard Bray-II extraction method (Bray and Kurtz, 1947).

Table1. Selected physico-chemical properties of surface soil (0-20cm) before planting

Characteristics	***Values***
Texture	*Clay loam*
pH	*6.2*
Organic carbon	*2.13%*
Available phosphorus	*10.92 mg kg^{-1}*

Total N	*0.16%*
C: N ratio	*13.31*
CEC	*27.7 Cmol (+) kg^{-1}*

All crop data such as: plant height, number of plants/hill, number of tuber/hill, biomass yield, Marketable/unmarketable yield, grain yield were collected at the plot level. Five representative plant samples were randomly selected from each plot for determination of plant height, number of plants/hill and number of tuber/hill. Plant height and number of plants/hill and number of tuber/hill were determined at 50% flowering. Plant height measurement was done from the base of the plants to the apex and counting of number of plants/hill and number of tuber/hill. Biomass yield, Marketable/unmarketable yield and grain yield were determined at harvest.

3. Result and Discussion

Chemical properties of the experimental soil before planting

The experimental soil was clay loam in texture, too slightly acidic (pH 6.2) and very low in available phosphorus (Table 1). It also demonstrated low levels of organic carbon and total nitrogen concentrations. This might be due to low input of organic sources such as animal manure, compost and household wastes. To improve soil properties and productivity, organic amendment of soil of the study area is vital. The C: N ratio was indicating that immobilization of inorganic N might not be a concern (Muhammad *et al.*, 2011).

Effect of Vermicompost on the selected chemical properties

Improvement in soil organic matter was observed for the plots which applied vermicompost compared to chemical fertilizer. Abdissa *et al.* (2018) argued that the VC amendment could increase the carbon contents up to 45 g kg^{-1} of the original levels, and thus contributes to improvement of soil structural stability, particularly that of the macro aggregates. The application of OM in the form of VC is expected to increase the OM and TN contents of the soil, because of our VC has rich OM and TN. The available P of the soil varied from 10.8 to 13.8 mg kg^{-1} after application of VC (Table 2). This might be due to the significant increase in soil OM due to the effect of organic fertilizer, which in turn reduced soil P sorption making both the soil native P and the applied P fertilizer available for plant uptake. Similar results were reported by Kisinyo *et al.* (2012).

Table 2. Some soil properties as affected by application of vermicompost after potato harvest

Treatment	*pH*	*OC (%)*	*T N (%)*	*CEC mg/100g*	*Available P(mg kg^{-1})*
1. Control	*6.28*	*2.02*	*0.15*	*27.4*	*10.8*
2. Recommended NPS(354 kg/ha)+207kg/ha urea	*6.21*	*2.03*	*0.15*	*24.2*	*11.5*
3. 3t/ha of VC	*6.81*	*2.42*	*0.21*	*30.4*	*12.6*
4. 4.5t/ha	*6.99*	*2.81*	*0.23*	*36.2*	*16.4*
5. 1.5t/ha VC + 177kg/ha of NPS+103kg/ha urea	*6.60*	*2.60*	*0.24*	*27.6*	*13.0*
6. 2.25t/ha of VC +88.5kg/ha of NPS+51.75kg/ha	*6.62*	*2.69*	*0.25*	*25.4*	*13.8*

Effect of treatments on the yield of potato

Applications rates of Vermicompost and blended NPS fertilizers significantly ($P< 0.05$) affected marketable and total yield of potato compared to the control treatments (Table 3). Comparison of means among application levels showed that the highest mean total yield was recorded at the application of 3 t ha^{-1} VC, whereas the lowest total yield was recorded at the control treatment. This is maybe due to Vermicompost is rich in all essential plant nutrients and Provides excellent effect on overall plant growth and improves the quality and shelf life of the produce. Significance in respect of tuber yield were in the reason that vermicompost improves soil structure, texture, aeration, and water holding capacity and increased amounts of organic carbon and increased microbial populations. The application of VC favorably affects soil physical and microbial population and soil enzyme activities and consequently improves crop production (Maheswarappa *et al*., 1999).

Table 3: Vermicompost effect on yield and yield parameter of potato at wondogent district.

Treatments	*PH (cm)*	*branch Plant^{-1}*	*TNo Plant^{-1}*	*NMY kg/ha*	*MY kg/ha*	*TY kg/ha*
1. Control	*64.9a*	*3.4a*	*10.7a*	*418.5a*	*16798b*	*17198.9b*
2. Recommended NPS(354 kg/ha)+urea	*96.9a*	*5.0a*	*14.4a*	*744.4a*	*30329.6ab*	*31074.0ab*
3. 3t/ha of VC	*93.6a*	*5.3a*	*16.4a*	*859.3a*	*33303.6a*	*34162.9a*
4. 4.5t/ha	*94.2a*	*5.2a*	*14.6a*	*685.2a*	*31281.5ab*	*31966.7ab*
5. 1.5t/ha VC + 177kg/ha of NPS+ urea	*94.4a*	*4.8a*	*15.6a*	*781.5a*	*31688.9ab*	*32470.4ab*
6. 2.25t/ha of VC +88.5kg/ha of NPS+ urea	*91.3a*	*5.4*	*14.0a*	*679.6a*	*29203.7ab*	*29833.3ab*
CV (%)	28.7	34.6	26.6	40	30.7	32.0
LSD at 0.05	NS	NS	NS	NS	15542	16581

PH=Plant height, branch plant^{-1} =branch per plant, TNo=tuber number per plant, NMY=unmarketable yield, and MY= Marketable yield and TY = total yield.

Table 4 : partial budget analysis of potato at wondogenet district

Treatments	*average yield*	*adjusted yield*	*field benefit*	*Fertilizer cost*	*Labor cost*	*Variable cost*	*Net benefit birr/ha*	*MRR %*
T1	17198.9	15479.0	77395.05	0	0	0	77395.1	0
T2	31074	27966.6	139833	7098.6	200	7298.6	132534.4	7.6
T3	34162.9	30746.6	153733.1	0	200	400	153333.1	189.8
T4	31966.7	28770.0	143850.2	0	200	400	143450.2	165.1
T5	32470.4	29223.4	146116.8	3571.3	200	3871.3	142245.5	16.8
T6	29833.3	26850.0	134249.9	1788.5	200	2138.5	132111.4	25.5

Conclusion and Recommendation

In conclusion, the experiment revealed that application of vermicompost has an advantage in improving the physicochemical properties of the soil and increases total yield of potato. The economic analysis also clearly showed the benefits of *VC* compared to inorganic fertilizer alone and the control plot. Therefore, 3t/ha VC could be recommended for Potato producers at Wondogenet district, for farmers in respect of cost minimization, easy handling and preparation of vermicompost by farmers and climate smart technology. However, similar undertakings should be carried out over years and at different region to determine the long-term effect of Vermicompost on the soil and the crop.

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