***Original Research Article***

**Effect of Vermicompost on Growth of Avocado (*Persea americana Mill.*) Seedlings in Selected District of Sidama Region and Gedeo Zone, Ethiopia**

***ABSTRACT***

Avocado (*Persea americana Mill*.) is considered the most nutritious of all fruits. The farmers in Sidama region and Gedeo zone usually grow avocado plants from the seeds in their backyards or small gardens without proper use of fertilizers. An experiment was carried out in Wondogenet, Shebedino, Wonago and Dilla zuria districts for two consecutive years from 2020 to 2022 G.C to study the effect of vermicompost for growth of avocado seedlings. Seedlings for root stock were raised on five selected farms in each location and grafted to Hass and Etinger varieties. This experiment was laid out in Randomized Complete Bock Design (RCBD) with three replications. It consists of eight treatments viz; (T1) 0.7 kg/plant vc, (T2) 1.33 kg/plant vc, (T3) 2 kg/plant vc, (T4) 100 kg NPS/ha, (T5) 0.7 kg/plant vc +50 kg NPS/ha, (T6) 1.33 kg/plant vc +50 kg NPS/ha, (T7) 2 kg/plant vc+50 kg NPS/ha and (T8) control (forest soil). All fertilizers were applied at the time of planting as per treatments. Data on germination date, plant height and leaf number, maturity period of seedlings, grafting and grafted date of avocado and trunk diameter were collected and analyzed statistically using SAS software version 9.0. Results indicated that the highest values of seedling height, number of leaves and days to germination were recorded to be 30cm, 32 and 38 dates, treatment 0.7 kg/plant vermicompost, in Dilla zuria and Wonago district. In Shebedino, highest values of seedling height, number of leaves and dates to germination were recorded 36cm, 52 and 13, respectively in treatment 1.33 kg/plant vermicompost application. The maximum values were seedling height (42.7 cm), leaf number (46) and dates to germination (17.5), respectively when treatments 0.7kg/plant vermicompost was applied in Wondogenet. Application of 0.7 kg/plant vermicompost, was found best for growth of avocado seedlings in Dilla zuria, Wonago and Wondogenet districts, whereas 1.33 kg/plant vermicompost was found best for the growth of the seedlings in Shebedino district.

***Keywords: Avocado, Grafting, Organic fertilizer, Seedling, Vermicompost***

**1. INTRODUCTION**

Avocado is native to American and recently introduced to tropical areas including Ethiopia and yet it is contributing a significant role in changing the livelihood of farmers. Ethiopia has suitable agro-ecology for the production and cultivation of avocado (Teklay et al., [2016](https://www.tandfonline.com/doi/full/10.1080/15538362.2023.2178595?scroll=top&needAccess=true&role=tab&aria-labelledby=full-article)) and “the crop covers 17.26 % of the area covered by fruit crops next to banana in Ethiopia. The fruit production of Avocado took up 10.47 % of fruit production and its production is mainly focused in southern part of Ethiopia followed by Oromia, Amhara and Benishan Gul-umuz” (CSA, [2018](https://www.tandfonline.com/doi/full/10.1080/15538362.2023.2178595?scroll=top&needAccess=true&role=tab&aria-labelledby=full-article)).

“The global fruit production was about 8,685,672 metric tons in 2021 and total avocado harvested area was 858,152 hectares. Avocado production in Ethiopia reached 245,336 metric tons in 2021 and total harvested area was 30585.70 hectares. Ethiopia exported 604.5Qt of avocados in 2021. The main avocado destinations in Ethiopia are the United Kingdom (UK), United Arab Emirates (UAE), Singapore, France, Saudi Arabia and Djibouti. Avocados are second only to bananas in total production volume in Ethiopia” (FAO, 2022).

“The Sidama Highland in Southern Ethiopia is known for the traditional coffee- and enset-based agroforestry system” (Abebe et al. 2009; Asfaw and Agren , 2007; Asfaw and Lemenih , 2010; Moges, 2009). “This zone is one of the areas where avocado was first introduced to Ethiopia” (Megersa and Alemu, 2013; Zekarias, 2010). “The Sidama highlands have suitable agro-ecological conditions for rainfed avocado production. It accounts about 36 % of the national annual avocado production” (CSA, 2014). Therefore, the Sidama highlands are important sources of avocado fruits for major cities such as Hawassa and Addis Ababa.

“Agricultural inputs are important elements for production and productivity. As a result the typical inputs utilized for production of the Avocado were seed/seedling, labor, land, and compost/manure. The major sources of inputs for Avocado production in Ethiopia are farmers by, own endeavours, agricultural offices and markets. In general the sources of inputs for Avocado production are agricultural development offices, markets, agricultural research institutes, own stocks, IPMS, and other farmers” (Ayelech, 2011). “The Agricultural research center and self-production by farmers and sources of avocado planting materials Local seed production is the major source of seedlings for distribution” (Berhanu & Dawit, 2016). In addition avocado production is characterized by low inputs with Farm Yard Manure (FYM) the major amendment made to soil to boost productivity and chemical inputs are not used for fertilization or pest treatment.

“Vermicompost could be used as an excellent soil amendment for main fields and nursery beds and has been reported to be useful in raising nursery species plants. In nature, sometime plants follow altered growth patterns such as negative geotropism of roots, stem elongation and dwarfing, shortening of vegetative phase, enhancement of leaf area, photosynthetic rate, flowering and fruiting by matured plants. Vermi-compost has found to effectively enhance the root formation, elongation of stem and production of biomass, vegetables, ornamental plants etc. Earthworms’ casting contains a high percentage of humus. Humus helps in aggregation of soil particles resulting into better porosity, which in turn improve aeration and water holding capacity of the soils” (Ferreras *et al.* 2006). “The application of vermicompost rendered better performance in respect of all round growth of mulberry plants in the lateritic soil of South West Bengal” (Chakraborty et al. 2008).

“Many authors agree that vermicompost act as fertilizers and contribute to the improvement of soil physicochemical characteristics” (Castillo et al. 1999). Hence the need to show vermicompost for avocado cultivars is crucial to boost the production and productivity. As a result the study was conducted to evaluate vermicompost for growth of avocado seedlings in different areas of Sidama region and Southern Ethiopia.

**2. MATERIALS AND METHODS**

**2.1 Description of the study areas**

The field experiment was conducted in Shebedino and Wondogenet of Sidama region and Wonago and Dilla zuria of Gedeo zone for two consecutive years from 2020 to 2022 G.C.

**2.1.1 Shebedino District**

Shebedino district is one of the 36 districts of Sidama region found in Ethiopia which is located at the North-central part of Sidama Region at a distance of 27 km from the capital city of, Hawassa. Astronomically it is situated in the coordinates of 60 46′ to 70 45′ North latitude and 390 34′ to 390 53′ East longitudes. There were around 294179 people in the *Woreda* who live being clustered in 35 peasant associations, out of which 49.2% (145728) were females and the rest 50.8% (148451) were males, as per the 2015 statistics of the *Woreda* Bureau of Finance and Economic Development (BoFED, 2015). Forest soil some nutrient characteristics presented in (Table 1).

**2.1.2 Wondogenet district**

The study area Wondogenet is situated in the Awassa watershed in the East African rift zone southeast of the town Shashemene (7°06'N). The Wondogenet topography is characterized by rolling upland at 1700-2600 m.a.s.l. where a third of the land is over 2200 m.a.s.l. and the major part of the area is steeply sloped (>30 %). The higher altitudes and steep slopes support natural forests, while lower altitudes and gentle terrain consist mainly of farmland where a significant number of diverse natural on-farm trees grow. Most soils of the steep slopes are shallow (<40 cm) but at lower altitudes dark-brown soils of deep alluvial sediments occur (Zewdu and Hogberg 2000). The climate in Wondogenet is characterized by two rainy seasons: a long rainy season from July to September and a short rainy season from February to April. The mean annual rainfall is 1200 mm and means annual temperature is 19 °C. Wondogenet is one of the most densely populated areas in Ethiopia. Six major ethnic groups reside in the area and their main source of livelihood is farming. The Wondogenet environment is agriculturally fertile where irrigation farming dominates in the flat and undulating areas. The dominant type of agriculture is smallholder perennial crop farming on holdings of less than half a hectare, on average. The major crops include enset, khat and sugarcane. Forest soil some nutrient characteristics presented in (Table 1).

**2.1.3 Wonago district**

The research was conducted in Wonago district, Gedeo zone, Southern Ethiopia, 375 km south of the capital city Addis Ababa. The study area is located between 60 12ʹ 30ʺ and 60 22ʹ 30ʺ N latitude and 38015ʹ0ʺ and 38020ʹ0ʺ E longitude. Based on the recent [2020] projection, the study district has a total population of 152,000 with approximately an area of 248 square kilometer giving a population density of 613 persons/km2. The majority of the populations of the study area (90.8 %) live in rural area and the rest (9.2 %) live in small town centers. The study is bordered in the west by Abaya District (Oromiya); in the south by Yirga Cheffie district; in the north by Sidama Zone and in the east by Dilla zuria wereda. The study area has a favorable climate for agroforestry dominated agricultural activities. Rainfall ranges from 799 to 1512 mm while mean annual temperature varies from 12.5 °C to 28 °C. Nitosols are dominant soil types covering highest proportion of the study area. The soils are in general derived from volcanic rocks which are important for coffee growing areas. Forest soil some nutrient characteristics presented in (Table 1).

**2.1.4 Dilla zuria district**

Dilla zuria woreda is located between 6º15’05’’ N and 6º26’35’’N latitude and 38º 15’ 55’’ and 38º 24’ 02’’ E longitudes. Woreda is the second-lowest administrative unit in current Ethiopia. It is bounded by Oromia region in the South and the West, Bule woreda in the East, and Sidama region in the North (Figure 1). It is divided into 19 kebeles (lowest administrative units). The altitudinal range of the Woreda ranges from 1350 m to 2550 m with a slope between 39.4 % and 51.5 %. The mean monthly rainfall of the study area ranges from 83.7 mm-310 mm with an average RF of 172.9 mm. The Rainfall is bimodally occurring between March up to June and September to October with the highest amount of rainfall occurring between May and September and the lower between October and February. The mean monthly temperature ranges from 15.4 °C to 17.9 °C. January and February are the hottest months of the year with the maximum temperature record. Forest soil some nutrient characteristics presented in (Table 1).

**Table 1: composite forest soil analysis before planting of experimental area**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Location**  | **Sample type**  | **pH** | **OC** | **OM**  | **TN** | **C:N** | **P** | **CEC**  | **Textural class** |
| Wondogenet | Forest soil | 7.2 | 5.66 | 9.7 | 0.3 | 15.0 | 24.0 | 33.0 | Loamy Sand |
| Shebedino | 7.16 | 7.0 | 12.0 | 0.4 | 17.0 | 28.0 | 36.0 | Clay Loam |
| Dilla zuria and Wonago | 6.8 | 6.8 | 11.0 | 0.4 | 16.0 | 30.0 | 35.0 | Clay Loam |

**2.2 Vermi-compost preparation and analysis**

Organic waste materials which include crop residues, weed biomass, vegetables scrap, and leaf litter, biodegradable portion of urban and rural wastes, cow dung and coffee husk were used for preparation of vermicompost. Mechanical separation of metal, glass, plastics and ceramics from organic wastes were conducted before mixing all the materials. All the waste materials were air dried for 48 hours and chopped into small pieces and mixed together. The mixture was then mixed again with powdered cow dung in 3:1 ratio (three hand wastes and one hand cow dung). Eisenia fetidia earthworms from Hawassa Agricultural Research Center were mixed with the aforementioned mixture in the proportion of 100 kg wastes with 1.4 kg worms to form a one meter high earthworm bed. Throughout the vermicomposting process, the moisture content and the temperature of all beddings were maintained to 60-70% and 24-270C, respectively, by spraying adequate quantity of water. Vermicomposting took 2.5 months to mature. By sieving or exposing earthworms to sunlight the vermicomposting were differentiated from the worms and stored in under shade, dry with ventilation for use. The vermicompost was analyzed for pH, organic carbon (OC), total nitrogen (TN), available phosphorus (avP) and cation exchange capacity (CEC). The values are 8.7, 13.68, 0.953%, 39.9 mg/kg and 35.52 cmol (+)/kg, respectively (Table 1).

**2.3 Experimental Design and Treatments**

The experiment was laid out in Randomized Complete Bock Design (RCBD) with eight treatments and three replications on each farm making a total number of 24 seedlings per farm. The treatments were (T1) 0.7 kg/plant vermicompost, (T2) 1.33 kg/plant vermicompost, (T3) 2 kg/plant vermicompost, (T4) 100 kg NPS/ha, (T5) 0.7 kg/plant vermicompost +50 kg NPS/ha, (T6) 1.33 kg/plant vermicompost +50 kg NPS/ha, (T7) 2 kg/plant Vermicompost +50 kg NPS/ha and (T8) control (forest soil, without fertilizers).

**2.4 Production of avocado seedlings**

Five farmers in each location were selected for the experiment and trained on avocado production and vermicompost technology. Avocado seedlings for were raised on each farmer's field from locally available avocado variety using polythene bags. The root stalks were grafted with Hass and Fruit varieties of avocado when seedling reaches for grafting. The soil mix was in the ratio of two hands top soil, one hand sand and one hand vermicompost according to the treatments. All the fertilizers were applied during planting as per the treatments.

**2.5 Data collection and analysis**

The vermicompost used in this study was supplied from Hawassa Agricultural Research Center (Hawassa, Ethiopia). Vermicompost analyses were conducted in HARC Soil laboratory (SARI compound). When the seedlings reached to transplanting stage, soil samples were taken from the upper, middle and bottom part of the polythene bag, mixed and analyzed for pH, OC, TN, avP and CEC. Soil particle distribution was measured by hydrometer method (Estefan. G, 2012). About 250 g soil was saturated with distilled water for determining pH of soil. The paste was allowed to stand for one hour and pH was recorded by pH meter with glass electrodes using buffer of pH 4.0 and 9.0 as standard. Soil organic carbon (SOC) content was estimated following the method as described by Ryan et al. (2001), and available phosphorus was estimated by Olsen’s method , Total nitrogen was determined by Kjeldhal method (Jackson, 1973).

Crop data such as plant height, number of leaves, trunk diameter, growth rate of seed, and maturity period of seedlings for grafting were collected and analysed using SAS version 9.0 and mean separation was done with LSD at 5 % probability level(P = 0.05).

**3. RESULTS AND DISCUSSION**

The values in vermicompost were for pH, organic carbon (OC), total nitrogen (TN), available phosphorus (avP) and cation exchange capacity (CEC) 8.7, 13.68, 0.953%, 39.9 mg/kg and 35.52 cmol (+)/kg, respectively . Also vermicompost were used in this experiment have high nutrient content and pH value. This means Vermicompost has high nutrient contents and as a result can enhance soil fertility physically, chemically and biologically.

According to (Lim *et al.*, 2015). “Physically, vermicompost supplemented soils have better aeration, porosity, lower bulk density and higher water retention capacity. Soil chemical properties such as pH, electrical conductivity, organic matter and nutrient status improved significantly and led to better plant growth and yield owing to vermicompost application” (Lim *et al.,* 2015). “Moreover, earthworms secrete several hormones, enzymes and vitamins during casting that promote the activity of other beneficial microbes in the soil, thereby improving soil health. Also addition of vermicompost to plant potting media causes significant changes in the physical properties, altering water and air availability in the substrates and conditioning root growth” (Marinari et al., 2000). Application of vermicompost resulted in higher values of soil pH, OC, TN, available P and CEC compared to chemical fertilizers in experimented area locations such as ( Wondogenet ,Shebedino ,Dilla zuria and Wonago) (Table 2). However, the values are not significantly different among the different rates of vermicompost (Table 2).

The pH, value of soil after grafting avocado seedling in different district treated with 0.7 kg/plant, 1.33 kg/plant and 2 kg/plant vermicompost showed improvement than chemical fertilizer (100 kg/ha) that is 7.56, 7.23 and 7.5 and 6.22, respectively in Wondogenet ,whereas in Shebedino 7.58, 7.22, 7.52 and 5.2, respectively and also in Dilla zuria and Wonago districts 7.32, 7.15 and 7.2 and 5.2, respectively by above treatment combinations (Table 2). from this result using vermicompost for pot amendment is better and vermicompost is ex-pressed not only in plant growth but also in regulating soil pH and increasing electrical conductivity without causing salinity problems (Argüello et al., 2006), Shi-wei and Fu-zhen, 1991, Ali et al., 2015)

Similarly, Gopinath et al. (2008) reported “a significant increase in soil pH and total organic carbon after application of vermicompost in two consecutive growing seasons, at a rate equivalent to 60 kg/ ha of N. Together these changes in soil properties improve the availability of air and water, thus encouraging seedling emergence and root growth”.

Organic carbon content of soil after grafting avocado seedling in different woreda treated with 0.7 kg/plant, 1.33 kg/plant and 2 kg/plant, forest soil vermicompost showed improvement than chemical fertilizer (100 kg/ha) that is 5.82, 5.50, 5.65, 5.70, and 3.93, respectively in Wondogenet ,whereas in Shebedino 6.63, 7.16, 6.59, 7.1 and 4.86, respectively and also in Dilla zuria and Wonago districts 6.8, 6.72, 6.53, 6.92 and 4.85, respectively by above treatment combinations (Table 2). This is due to vermicompost had high organic carbon and the nature of forest soil. Similarly “Earthworm casts ingested soils often have much higher content of soil organic carbon and nutrients availability as compared to surrounding soils” (Lee, 1985). The studies undertaken by Maheswarappa, (1999) revealed that “vermicompost addition in soil enhanced organic carbon status, decreased bulk density, improved soil porosities and water holding capacities, increased microbial populations and dehydrogenase activity in the soils. It has been documented that organic matter content in worm casts was about four times more than in surface soil with average values of 48.2 and 11.9 g kg-1 soil, respectively” (Khang, 1994). “While the joint activities of soil worms and microorganisms in the vermicompost provide biooxidation of the resulting organic matter. Another point that makes vermicompost special is the degradation is mesophilic. This is the main reason why vermicompost products increase microbial activity and diversity” (Fracchia et al., 2006).

“As soil analyzed result show in Table 2 in Wondogenet ,Shebedino Dilla zuria, and Wonago district, CEC and total nitrogen content higher than chemical fertilizer only treatment. This is due to earthworm casts are chemically and biologically rich, hence, soils imbedded with vermicompost show higher cation exchange capacity and have a higher rate of plant growth hormones and humic acids, higher microbial population and activity, and less root pathogens or soil borne diseases” (Atiyeh et al., 2002; Arancon et al., 2003a; Postma et al., 2003; Perner et al., 2006) and overall improvement in plant growth and yield (Arancon et al., 2003b, 2004a). Lee (1992) reported that “microorganisms in the worm casts might fix atmospheric N in such quantities that are significant for the earthworm metabolism and as a source of nitrogen for plant growth”.

“Amounts of soil N and P significantly after incorporating vermicompost into soils”(Venkatesh et al., 1998, Sreenivas et al., 2000). In line with this study (Table 2) there were more orthophosphates in those soils that received vermicompost treatments than in soils treated with inorganic fertilizers. Maheswarappa et al. (1999) reported “increased amounts organic carbon, improvements in pH, decreased bulk density, improved soil porosities and water-holding capacities, increased microbial populations and dehydrogenase activity of soils in response to vermicompost treatments”.

C: N ratio of vermicompost in all treatments were in wondogenet district between (13-20, shebedin b/n (16-20) and Dila zuria and Wonago(14-16) in this study ( Table 2). Which indicates According to Yadav et al. (2017), “a C: N ratio of less than 15 indicates maturated compost which is highly regarded as good plant growth. Similar to this finding (Table 2) decline in C: N ratio marks its utility as fertilizer in agro ecosystems”. Morais and Queda (2003) indicated the maturity of vermicompost depends upon C: N ratio. C: N ratios below 20 are good as plant growth promoters. How-ever, a ratio of 15 or lower marks its utility in agronomic uses.

**Table 2: Soil analysis after grafting in Wondogenet, Shebedino and Dilla zuria and Wonago districts**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Location** | **No**  | **Treatments** | **pH(1:2.5 , soil:water)** | **%OC** | **%OM** | **%TN(kjeldhal)** | **C/N** | **P(mg/kg soil), olsen method** | **CEC(meq/100g soil)** | **%Sand** | **%Clay** | **%Silt** | **Textural class** |
| **Wondogenet** | 1 | 0.7 kg/plant vc | 7.56 | 5.828 | 10.0475 | 0.4284 | 13.60412 | 27.8 | 35.35 | 82 | 11 | 7 | **Loamy Sand** |
| 2 | 1.33 kg/plant vc | 7.23 | 5.50368 | 9.48834 | 0.3612 | 15.23721 | 25.4 | 34.15 |
| 3 | 2 kg/plant vc | 7.5 | 5.6511 | 9.7425 | 0.3892 | 14.51978 | 26.5 | 34.68 |
| 4 | 100 kg NPS/ha | 6.22 | 3.9312 | 6.77739 | 0.2604 | 15.09677 | 18.8 | 28.6 |
| 5 | 0.7 kg/plant vc +50 kg NPS/ha | 6.18 | 3.94103 | 6.79433 | 0.2688 | 14.66156 | 17.5 | 27.45 |
| 6 | 1.33 kg/plant vc +50 kg NPS/ha | 6.15 | 4.18673 | 7.21792 | 0.2996 | 13.97439 | 16.8 | 28.8 |
| 7 | 2 kg/plant vc +50 kg NPS/ha | 6.48 | 5.94594 | 10.2508 | 0.2884 | 20.61699 | 19.4 | 30.4 |
| 8 | Control(forest soil) | 7.35 | 5.79852 | 9.99665 | 0.3724 | 15.57068 | 25.2 | 33.48 |
| **Shebedino** | 1 | 0.7 kg/plant vc | 7.58 | 6.6339 | 11.4368 | 0.3976 | 16.6849 | 29.9 | 36.45 | 50 | 23 | 27 |  **Sandy Clay Loam** |
| 2 | 1.33 kg/plant vc | 7.22 | 7.16461 | 12.3518 | 0.4032 | 17.7694 | 30.2 | 31.52 |
| 3 | 2 kg/plant vc | 7.52 | 6.59459 | 11.3691 | 0.392 | 16.8229 | 28.5 | 35.56 |
| 4 | 100 kg NPS /ha | 6.22 | 4.8452 | 8.35313 | 0.2968 | 16.3248 | 18.5 | 28.44 |
| 5 | 0.7 kg/plant vc +50 kg NPS/ha | 6.15 | 4.86486 | 8.38702 | 0.2576 | 18.8853 | 17.2 | 26.42 |
| 6 | 1.33 kg/plant vc +50 kg NPS/ha | 6.06 | 5.16953 | 8.91227 | 0.252 | 20.514 | 19.5 | 29.5 |
| 7 | 2 kg/plant vc +50 kg NPS/ha | 6.33 | 5.06142 | 10.4202 | 0.2968 | 17.0533 | 22.4 | 31.22 |
| 8 | Control (forest soil and sand) | 7.27 | 7.1941 | 12.4026 | 0.4088 | 17.5981 | 29.6 | 36.82 |
| **Dilla zuria and wonago** | 1 | 0.7 kg/plant vc | 7.32 | 6.899256 | 11.89432 | 0.4564 | 15.11669 | 32.4 | 37.35 | 50 | 23 | 27 | **Sandy Clay Loam** |
| 2 | 1.33 kg/plant vc | 7.15 | 6.722352 | 11.58933 | 0.4368 | 15.39 | 31.4 | 34.42 |
| 3 | 2 kg/plant vc | 7.2 | 6.53562 | 11.26741 | 0.4144 | 15.77128 | 33.8 | 35.78 |
| 4 | 100 kg NPS/ha | 5.2 | 4.855032 | 8.370075 | 0.3164 | 15.3446 | 20.2 | 29.34 |
| 5 | 0.7 kg/plant vc +50 kg NPS/ha | 5.44 | 4.796064 | 8.268414 | 0.3136 | 15.29357 | 19.5 | 27.12 |
| 6 | 1.33 kg/plant vc +50 kg NPS/ha | 5.6 | 4.737096 | 8.166754 | 0.3248 | 14.58466 | 21.8 | 29.25 |
| 7 | 2 kg/plant vc +50 kg NPS/ha | 5.7 | 4.727268 | 8.14981 | 0.3304 | 14.30771 | 24.3 | 28.21 |
| 8 | Control (forest soil and sand) | 6.96 | 6.92874 | 11.94515 | 0.4284 | 16.17353 | 31.5 | 35.55 |

Number of leaves counted at forty five days, seventy five days, and one hundred five days after planting showed significant difference between treatments in Dilla zuria district (Table 3). The 0.7 kg/plant of vermicompost (3.8 leaves/ plant, 13.0 leaves/plant and 32.0 leaves /plant) showed higher value in number of leaves, but it was not statistically superior to treatment 2, 3, 5, 6,and 7 treatments ; it only exceeded the control and T4(100 kg NPS/ha of 5.6 leaves/plant ,9.0 leaves /plant and 23.2 leaves /plant respectively in three of rounds data taken(Table 3). vermicompost use improves crop plant morphology, such as leaf area (Lazcano et al., 2009), stimulated flowering, increased flower number and biomass (Arancon et al., 2008), and increased overall fruit yield (Arancon et al., 2004; Arancon et al., 2004; Atiyeh etal., 2000; Singh et al., 2008).

Germination date is not significantly different between treatments in Dilla zuria district even though 0.7 kg/plant vermicompot treated pot germinated at 38 date than chemical fertilizer treated pot 42 date i.e. 100 kg NPS /ha/400 seedlings /ha (Table 3).

In Dilla zuria district seedling heights at 45, 75 and 105 dates after planting were significantly different between treatments. Vermicompost application at a rate of 0.7 kg/plant resulted in significantly taller plants than application of chemical fertilizers at 75 and 105 dates after planting. However, at 45 date after planting there is no significant difference between treatments (Table 3).

Despite the above-mentioned physical and chemical mechanisms, there is much experimental evidence showing that vermicompost enhances plant growth further than expected because of nutrient supply and improvements in the physical condition of substrates. This was first suggested by Scott (1988) and Edwards and Burrows (1988), who observed that “small doses of vermicompost added to the potting media of several ornamental species, produced a much larger increase in plant growth than the equivalent dose of nutrients. These effects were maintained even when vermicompost was diluted 1:20 with other potting media, resulting in a dose of vermicompost would be expected to have negligible physical effects” (Edwards and Burrows, 1988).

“Using organic matter acts as a slow-release fertilizer, gradually making essential nutrients available to the seedling” (Brady and Wei, 1996).Nutrients in vermicompost initiate maturity of avocado seedlings in few months**.**

Nevertheless, some authors suggest that earthworms, and not microorganisms, are responsible for the production of PGRs. Nielson (1965) reported “the first evidence of the presence of indole compounds in the tissues of *Aporrectodeacaliginosa*, *Lumbricusrubellus, and Eiseniafetida”.*

More recently, El Harti et al. (2001a, 2001b) showed that a crude extract of the earthworm Lumbricusterrestris was able to stimulate rooting in bean seeds due to the presence of indole compounds of endogenous origin.

Therefore 0.7 kg/plant is better for seedling growth in Dilla zuria and Wonago districts, so farmers apply always in this rate for their seedling growth in their seedling site/home garden**.** Accordingly, Mistry (2015) found that vermicompost can have dramatic effects upon the germination, growth, flowering, Fruiting and yields of crops. Similar results were gained at Cornell University lab in trials, where they have applying the solid vermicompost and saw a definite impact on leaf growth and weight gain (Dunn, 2011).

**Table 3: Effect of vermicompost on growth status of avocado at Dilla zuria district**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  **No** | **Treatment**  | **Germination****Date** | **Seedling height at 45th date** | **Seedling height at 75th date/cm** | **Seedling height at 105th date/cm** | **Leaf no at 45th date** | **Leaf no at 75th date** | **Leaf no at 105th date** |
| 1 | 0.7 kg/plant vc | 38a | 8.2a | 30.2a | 30.0a | 3.8a | 13.0ab | 32.0a |
| 2 | 1.33 kg/plant vc | 38a | 11.3a | 24.2ab | 33.6a | 6.2a | 14.6a | 31.2a |
| 3 | 2 kg/plant vc | 43a | 7.8a | 31.0a | 33.8a | 4.8a | 15.2a | 30.8a |
| 4 | 100 kg NPS /ha | 42a | 9.8a | 18.6b | 19.0b | 5.6a | 9.0b | 23.2b |
| 5 | 0.7 kg/plant vc +50 kg NPS /ha | 46a | 7.3a | 25.0ab | 33.8a | 2.2a | 9.4b | 30.6a |
| 6 | 1.33 kg/plant vc +50 kg NPS/ha | 40a | 12.1a | 20.4ab | 29.4a | 7.6a | 12.8ab | 28.6ab |
| 7 | 2 kg/plant vc +50 kg NPS/ha | 36a | 11.1a | 18.8b | 29.2a | 4.6a | 11.2ab | 32.9a |
| 8 | control (forest soil) | 42a | 13.1a | 19.2b | 25.4a | 6.8a | 12.6ab | 16.4b |
|  | LSD(0.05) | 12.0 | 7.9 | 10.9 | 10.2 | 5.58 | 4.7 | 9.0 |
|  | CV (%) | 22.9 | 60.6 | 35.9 | 26.8 | 82 | 35.9 | 36.9 |
|  | Mean  | 40.7 | 10.01 | 12.2 | 29.2 | 5.2 | 23.4 | 28.8 |
|  | Significance | Ns | Ns | \*\*\* | \*\*\* | ns | \*\* | \*\* |

In Shebedino district avocado local fruit which collected from trial farmer home garden germinate at in short at 52 date and in long time 68 date and have no significant between treatments. So farmers in Shebedino woreda should apply 1.33 kg/plant /pot for early germination of seedlings of avocado (Table 4). The addition of vermicompost improves seed germination, seedling growth, and plant yield; Similarly, Gutierrez-Miceli et al. (2007) found that vermicompost application increased germination more than other amendments.

Plant height of avocado seedlings highly significant between treatments in different round of data taken in Shebedino woreda. In round 52, 82, 112 dates 1.33 kg/plant application of vermicompost show high growth than (7.2, 23.6 and 36.0cm) and 100 kg NPS/ha gave (2.6, 16.4 and 27.2cm), respectively . These shows in month interval vermicompost treated pot show visual difference in respect of growth (Table 5). Hormones added to
vermicompost improveplant growth and production while also enriching the soil with nutrients. It improves root length, biomass, plant growth, and plant physiology in general (Grapelli et al., 1985).

Number of leaves also significantly different in different date of interval data taken between treatments. That means 1.33 kg /plant gives 7.8, 11.8 and 13.4 leaves at 52, 82 and 112 dates than 100 kg NPS/ha show 3.4, 6.4 and 8.2 leaves, respectively (Table 4). Furthermore, during casting, earthworms secrete a number of hormones, enzymes, and vitamins that encourage the activity of other beneficial microbes in the soil, enhancing soil health.

Therefor in Shebedino woreda farmers must use 1.33 kg/plant for seedling growth of avocado for time effective growth of avocado Since it contains humic acid and plant growth hormones, vermicompost helps crop plants grow and produce more (Atiyeh et al., 2002). Earthworms increase crop yield by excreting beneficial soil organisms and secreting polysaccharides, proteins, and various nitrogen compounds into the soil (Hatti et al., 2010; Rekha et al., 2013).

**Relative Growth Rate in Plant Height Dilla Zuria and Wonago district**

Plant height growth in Dilla zuria district in ascending rate in different treatments except 100 kg NPS alone (Figure 1). Similarly trunk diameter of NPS fertilizer and control (forest soil) is too small in size than vermicompost treated treatments. Vermicompost increase water holding capacity of the soil and save irrigation. Further, it also reduces the expenditure on costly chemical fertilizer inputs thus, reducing overall cost of cultivation. Therefore during grafting both treatments is not reach for grafting.

In line with this study, the speed of maturation increased, relative to the control without vermicompost, in three out of the six pine progenies, decreased in two of the progenies and was unaffected in the other. It may be expected that different hybrids or plant genotypes will respond differently to vermicompost, considering that plant genotype determines important differences in nutrient uptake capacity, nutrient use efficiency and resource allocation within the plant. In light of this evidence, it is clear that vermicompost constitutes a promising alternative to inorganic fertilizers in promoting plant growth.

**Figure 1: Relative growth and trunk diameter of avocado seedling at Dilla zuria and Wonago**

**Table 4: Effect of vermicompost on growth status of avocado at Shebedino woreda**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No**  | **Treatment**  | **Germination****date** | **Seedling height at 52 date**  | **Seedling height at 82 date/cm** | **Seedling height at 112 date/cm** | **Leaf no at 52 date**  | **Leaf no at 82 date** | **Leaf no at 112 date** |
| 1 | 0.7 kg/plant vc | 59a | 6.32abc | 28.0a | 43.0ab | 3.4a | 10.6ab | 12.2ab |
| 2 | 1.33 kg/plant vc | 52.a | 7.2abc | 23.6ab | 36.0bc | 7.8a | 11.8a | 13.4a |
| 3 | 2 kg/plant vc | 52.a | 8.2abc | 26.2ab | 49.2a | 3.6a | 13.2a | 16.0a |
| 4 | 100 kg NPS /ha | 64a | 2.6bc | 16.4b | 27.2d | 3.4a | 6.4b | 8.2b |
| 5 | 0.7 kg/plant vc +50 kg NPS /ha | 69a | 1.4c | 24.2ab | 38.0bc | 3.4a | 10.4ab | 11.8ab |
| 6 | 1.33 kg/plant vc +50 kg NPS/ha | 60a | 11.2ab | 22.0ab | 36.6bc | 7.6a | 12.4a | 13.8a |
| 7 | 2 kg/plant vc +50 kg NPS/ha | 58a | 13.7a | 27.6a | 40.6bc | 6.8a | 11.6a | 13.4a |
| 8 | control (forest soil) | 63a | 2.16bc | 27.6a | 34.0cd | 2.4a | 10.8 | 12.6ab |
|  | LSD(0.05) | 19.09 | 9.6 | 10.5 | 8.6 | 6.05 | 4.8 | 4.8 |
|  | CV (%) | 24.8 | 112.8 | 33.2 | 17.4 | 97.3 | 34.5 | 29.3 |
|  | Mean  | 59.3 | 6.5 | 24.4 | 38.0 | 4.8 | 10.9 | 12.6 |
|  | Significance | **ns** | \*\* | \*\* | \*\*\* | ns | \*\* | \*\* |

**Relative Growth Rate in Plant Height Shebedino district**

Plant height growth in Shebedino district in ascending rate in different treatments except 100 kg NPS alone (Figure 2)

**Figure 2**: Relative growth and trunk diameter of avocado seedling at Shebedino district

In Wondogenet woreda 2 kg/plant vermicompost germinated at 48 date reach for grafting at 50.5 cm and 18.5 number of leaves which is significantly different from 100 kg NPS /ha germinated 54, seedling height is 35.2 cm and 14.5 number of leaves but is not significantly different from treatment 1 and 2 (Table 6). Therefore 0.7 kg/plant vermicompost rate important for seedling growth of in Wondogenet woreda.

**Table 5: Effect of vermicompost on growth status of avocado at Wondogenet district**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No**  | **Treatment**  | **Germination****date** | **Seedling height at 41date/cm** | **Seedling height at 71 date/cm** |  **Seedling height at 101 date/cm** | **Leaf no at 41 date**  | **Leaf no at 71 date** | **Leaf no at 101 date** |
| 1 | 0.7 kg/plant vc | 46ab | 0.85b | 31.5a | 42.7bc | 0 | 16.7a | 17.5ab |
| 2 | 1.33kg/plant vc | 41b | 2.65a | 32.7a | 43.7b | 0 | 14.5a | 15.5ab |
| 3 | 2 kg/plant vc | 48ab | 1.25ab | 34.2a | 50.5a | 0 | 17.0a | 18.5a |
| 4 | 100 kg NPS /ha | 54a | 0.2b | 23.0a | 35.2d | 0 | 14.0a | 14.5ab |
| 5 | 0.7 kg/plant vc +50 kg NPS /ha | 44ab | 0.3b | 28.2a | 40.7bcd | 0 | 13.5a | 14.0b |
| 6 | 1.33 kg/plant vc +50 kg NPS/ha | 49ab | 0.7b | 31.0a | 45.7ab | 0 | 15.7a | 16.5ab |
| 7 | 2 kg/plant vc +50 kg NPS/ha | 47ab | 0.15b | 22.0a | 39.5bcd | 0 | 13.2a | 14.5ab |
| 8 | control (forest soil) | 51.0ab | 0.15b | 25.5a | 37.0cd | 0 | 14.5a | 15.2ab |
|  | LSD(0.05) | 10.3 | 1.46 | 12.8 | 6.3 | 0 | 4.7 | 4.01 |
|  | CV (%) | 14.9 | 127.3 | 30.6 | 10.2 | 0 | 21.7 | 17.3 |
|  | Mean  | 46.9 | 0.78 | 28.5 | 41.9 | 0 | 14.9 | 15.7 |
|  | Significance | \*\* | \*\* | Ns | \*\* | Ns | ns | \*\* |

**Relative Growth Rate in Plant Height Wondogenet district**

“Plant height growth in Wondogenet district in ascending rate in different treatments except 100 kg NPS alone (Figure 3).The weather also affected the growth rate of trunk diameter. Similar to this study the temperatures of 7th month (May 2013) and one month before (April 2013) were the highest (26.2 - 26.40C) compared to other months on experimental location. Climatic conditions influenced nutrients absorption for growth rate of avocado”(Lahay.E and Whiley.W. 2002).

**Figure 3: Relative growth and trunk diameter of avocado seedling at Wondogenet**

**4. CONCLUSION AND RECOMMENDATION**

Vermicomposting is the safest practice for managing all types of waste because it is an environmentally safe, commercially effective, and socially appropriate method of converting trash into black gold, also known as vermi-fertilizer. Farmers in studied area recycle residues that pollute their environment to vermicompost easily. The results marked the rapid mineralization of agricultural waste by inoculating *Eisenia Fetida*. Earth- worm inoculation led to the marked decrease in C: N ratio, thereby enhancing its nutrient content. Upon observing the nutritional status of vermicompost in this experiment it becomes very clear that vermicomposting is a low input efficient technique that finds its potential in converting biodegradable waste into value added fertilizer. Based on the experiment, farmers are recommended to apply 0.7 kg/plant of vermicompost in Wondogenet, Dilla zuria, and Wonago districts, while in Shebedino district, 1.33 kg/plant is optimal for avocado seedling production. With these application rates, avocado seedlings can reach grafting stage within five months across all study locations

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of the manuscript.

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