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Tests on Vermicomposts for their suitability to vegetable (Abelmoschus esculentus) crops

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ABSTRACT : Vermicomposting is a low cost technology for processing or treatment of organic wastes. It contains N, P, K and micronutrients in forms that are readily taken up by plants. For the present study, six genus of earthworms (Lampito mauritii (T_1A) , Octochetona pattoni (T_1B), Priodocheta pellucida (T_1C), Notoscolex palniensis (T_1D), Lemnoscolex scutarius (T_1E), and Hoplochetella stuarti (T_1F) collected from different ecosystems in Theni District were tried to raise vermicomposts. These six different (T_1A-B-C-D-E-F) treatments (vermicomposts) were applied in different dosages (100,200,300 gm) to Ladies finger plant (Abelmoschus esculentus) to test their efficacy. Treatments along with control (T_1) plants (Ladies finger) were reared. Highest observations were recorded in Notoscolex palniensis (T_1D) on growth and yield in 100 gm of compost application. Soil samples were collected before and after the cultivation of vegetables (Abelmoschus esculentus). These were subjected to physico-chemical analysis of N, P, K pH, EC and micronutrients. These values were compared with the values of plant height, number of fruits, yield, and length of fruit to apply the regression analysis; there is a significant changes in soil parameters after the application of vermicompost compared with control.

Keywords : Notoscolex palniensis, Vermicompost, Abelmoschus esculentus, N, P, K, and Yield.

Introduction

Earthworms are major components of the soil fauna in a wide variety of soils and climates and are involved directly or indirectly in biodegradation, stabilization through humus formation and various soil processes (Lavelle and Spain 2001). The disposal of wastes through the use of earthworms also upgrades the value of original waste materials insitu and allows a final product to be obtained free of chemical or biological pollutants (Divya 2001). Vermicomposting involves bio-oxidation and stabilization of organic material through the interactions between earthworms and microorganisms. Although microorganisms are mainly responsible for the biochemical degradation of organic matter, earthworms play an important role in the process by fragmenting and conditioning the substrate, increasing the surface area for growth of microorganisms, and altering its biological activity (Dominguez 2004; Dominguez and Edwards 2004). Vermicompost contains major and minor nutrients in plant- available forms, enzymes, vitamins and plant growth hormones. It has a more beneficial impact on plants than normal compost (Gajalakshmi and Abbasi, 2004). Earthworms have been described as a keystone species as their activity helps regulate soil fertility, water infiltration and soil detachability in agro ecosystems (Lavelle and Spain, 2001; Shipitalo and LeBayon, 2004). Casts deposited on the soil surface may also be carried away in surface water runoff after rain, leading to increased on-site soil erosion and perhaps also affecting soil properties downstream of the worm’s actual home (Shipitalo and Le Bayon, 2004). Direct effect of plant species on soil organisms are caused by the plant’s inputs of organic matter above and below the ground, while indirect effect of plants on biota include shading, soil protection and uptake of water and nutrients by the root (Neher, 1999). According to Chaudhuri et al. (2003), the quality and quantity of food material influences not only the size but also the species composition, growth rate, fecundity of an earthworm population. They reported differences in the rate of growth and reproduction of three vermicomposting species Perionyx excavates, Eudrilus Eugenia and Eisenia fetida in the Hevea leaf litters used as vermiculture substrate. Earthworms play an important role in maintaining soil fertility, ecosystem function, production and biodiversity conservation (Chaudhuri et al., 2012; Kavdir and Ilay 2011). As global food production is already dependent on intensive agricultural production and demands for food are likely to increase substantially, the future challenge is to match demands for production with forms of soil management that are sensitive to maintaining soil biodiversity(Giller et al., 1997).

In the present study, six genus of earthworm adults [Lampito mauritii (T_1A), Octochetona pattoni (T_1B), Priodocheta pellucida (T_1C), Notoscolex palniensis (T_1D), Lemnoscolex scutarius (T_1E) and Hoplochetella stuarti (T_1F)] collected from various ecosystems of Theni District were selected and inoculated in decompost of vegetable refuses T_1 to identify the suitable genus of earthworm for vermicomposting out of six. Their efficacy was tested with Ladies finger plants (Abelmoschus esculentus) in different dosages (100, 200, 300 gm).

Materials and Methods

Experiments were conducted during 2012-2013 at a farm land of Periyakulam, Theni District, Tamilndu, India, to study the application of vermicompost and thereby to investigate the effect of different dosages of vermicompost on vegetables.

Preparation of vermicompost and Germination

From the 6 selected earthworms (Octochetona pattoni, Priodocheta pellucida, Notoscolex palniensis, Lemnoscolex scutarius, Hoplochetella stuarti and Lampito mauritii) were chosen as experimental animal. Pre-composts were prepared with leaf litters of Manilkara zapota (sapota) and Spathodea campanulata (Nandi Flame) separately mixed with cow dung (3:1) at regular interval of 7 days over the soil bed and were used later in the earthworms were allowed to feed on and converted them into vermicompost. It was harvested every 45 days.

Seeds of A. esculentus (Ladies finger) was sowed in the plotted fields and germinated when cotyledons project out through the surface of the soil. Seedlings were planted at a distance of 30 cm between two plants. Lady's Finger (A. esculentus) plants were grown in plots and were applied with different dosages (100g, 200g & 300gm) of vegetable vermicompost raised from leaf litter. All the necessary cultural practices and plant protection measures were followed uniformly for all the treatments during the entire period of experimentation and were replicated four times in a randomized complete block design.

Following treatments were organized

1. Lampito mauritii Vermicompost (T_1A)
2. Octochetona pattoni Vermicompost (T_1B)
3. Priodocheta pellucida Vermicompost (T_1C)
4. Notoscolex palniensis Vermicompost (T_1D)
5. Lemnoscolex scutarius Vermicompost (T_1E)
6. Hoplochetella stuarti Vermicompost (T_1F)
7. Control (Farm soil)

Plant Growth Parameters

Vegetable refuse (T_1A-B-C-D-E- F) vermicompost at the dosage of 100gm, 200gm and 300gm. Time of flowering, Height of the plant (cm), length of the fruit (cm), weight of the fruit (gm), number of fruits per plant, yield of fruit per plant (gm) were recorded on every 10^{th} day from the date of seed germination up to 90 days.

Physico-Chemical Analysis

Soil samples were collected before and after the harvest of vegetables. These were subjected to physico-chemical analysis (pH, electrical conductivity, organic carbon, total Kjeldahl nitrogen) [Jackson, 1958]. Soil and vermicompost pH were measured in deionised water (solids/solution ratio of 1: 2.5) using pH meter. Electrical conductivity (EC) was measured in the effluent and in a saturated solution extract of the vermicompost (Rhoades, et al., 1989). Organic carbon was determined by the Walkley-Black method (Gaudette, et al., 1974). Methods of measuring N, P, and K in soil by Diethen-triamin-penta-acetic acid (DTPA), extractable Zn, Fe, Cu and

Mn were determined in soil samples by atomic absorption spectroscopy (Perkin Elmer, type 3041, series 3000) (Lindsay and Norvell, 1978).

Statistical analysis

Correlation and Regression analysis (SPSS computer version 17.0) was used to evaluate the relationship between plant growth parameters and soil physicochemical parameter.

Result and Discussion

In the present study experiments were conducted to assess the requirements of vermicompost by vegetable crops in bioremediation process to fulfil the needs of the farmers during the transfer of technology at large scale. Among the different dosages (100, 200 & 300 gm) of vegetable refuse vermicompost (T_1A-B-C-D-E-F) applied (Abelmoschus esculentus) in the present investigation, there has been a significant improvement in the soil quality of plots amended with vermicompost @ 100 gm per plant (Table 1, 2, 3 and Fig 1, 2, 3). This is in concordance with the results of the work of Edwards et al., 2000 that application of compost like vermicompost enhances physical and chemical characteristics of soil in Bhendi (Abelmoschus esculentus) cultivation. Vermicompost as an organic input has been applied to grow vegetables and other crops succesfully (Ismail, S.A., 2005). Application of composts like vermicompost could contribute to increased availablity of food (Ouedraogo, et al., 2001). The overall productivity of vegetable crop Ladies finger during the 5 months of the trial was significantly greater in plots treated with vegetable refuse (T_1) @ 100 gm per plant.

Plant Height and Number of Branches

All treatments showed significant increase of plant height when compared to control plant (grown in farm soil). Vegetative growths in all treatments were recorded till 90th day. The tallest lady's finger plant was observed in 100 gm/plant vermicompost of Notoscolex palniensis (T_1D) 60.41 ± 0.064 cm with good foliage and branching numbers 6.120 ± 0.113 (Table 1& Fig.2). Gutierrez et al. (2007) reported that addition of vermicompost increased plant heights and number of leaves in the yield of tomato (Lycopersicum esculentum) significantly which confirms the results of the present study.

The number of branches shows a significant (6.120 ± 0.113) variation over that of control (2.115 ± 0.163) in all the treated plants (Table 3). According to Forde and Lorenzo (2001) root growth and branching is favored in nutrient-rich environment and in the presence of hormones like auxins that enable the plant to optimize the exploitation of the available resources which are in turn transformed into photo assimilates and transported again to the root consequently influencing plant growth and morphology.

Yield

The weight and length of fruit and number of fruits / Bhendi plant is one of the most important yield contributing traits in lady's finger and was found maximum when treated with 100 gm vegetable refuse (T_1) vermicompost of Priodocheta pellucida 270.44 ± 0.134 kg fruit/plant (T_1C), Notoscolex palniensis 250.4 ± 0.163 (T_1D) followed by Lampito mauritii 150.6 ± 0.219 (T_1A) and Octochetona pattoni 200.75 ± 0.176 (T_1B) vermicompost (Fig.1&3). Average number of fruits/plant was Lemnoscolex scutarius 150.5 ± 0.141 (T_1E) and Hoplochetella stuarti 100.8 ± 0.134 (T_1F) (Fig.1). Azarmi et al., (2008) studied on tomato (Lycopersicum esculentum var. Super Beta) and the results of their study supported the findings of our study that vermicompost has positive effect on growth, yield and elemental contents of plant as compared to control. In the present study, number of fruits per plant was greatly influenced by the treatment T_1. Chand et al. (2008) experimented on tomato plants to find out the effect of natural fertilizers on their yield and quality. They found that significantly highest yield was recorded in the treatment receiving enriched vermicompost along with 3 sprays of liquid manure. Similar trend was observed in development of fruit length and fruit girth. They also confirmed that earthworms significantly improve plant growth.

Different doses of vermicompost produced different responses in A. esculentus and showed maximum positive effect on growth parameters. The results corroborate the findings that different doses of vermicompost caused different responses in growth parameters of L. esculentum plant (Azarmi et al. 2008). Joshi and Vig (2010) reported significant increase in growth parameters with application of vermicompost in L. esculentum. Vermicompost has influenced the plant growth parameters like plant length, number of branches, number of flowers per plant, number of fruits per plant, yield of fruit per plant, length of fruits were significantly influenced in plots receiving different doses of different genus of vermicompost. According to Gonzalez et al. (1996) and Tien et al. (2000) tree plantations may influence earthworm abundance by altering the physico-chemical properties of soils viz. temperature, moisture regime, pH, organic matter content and litter inputs. Overall plant growth with vermicompost application has been reported in different studies (Arancon et al., 2006; Zaller 2007; Bachman and Metzger 2008; Singh et al. 2008). Arancon et al. (2004, 2006);Bachman and Metzger (2008) also reported growth and yield improvement in different crops with vermicompost application. The results clearly indicated that the plants receiving vermicompost had produced more fruits/branches, branches/plant, large sized fruits with higher total yield than those of control.

Plot soil tests for physico chemical parameters (N, P, K, pH, EC and micronutrients) was done before and after cultivation and the results were statistically correlated (Table 4).The vermicompost prepared by all the three earthworm species showed a substantial difference in total N content, which could be attributed directly to the species specific feeding preference of individual earthworm species and indirectly to mutualistic relationship between ingested microorganisms and intestinal mucus (Suthar and singh 2008). The worms during vermicomposting converted the insoluable P into soluable forms with the help of P-solublizing microorganisms through phosphates present in the gut, making it more available to plants (Suthar and singh 2008, Padmavathiamma et al., 2008). Vermicomposting proved to be an efficient process for recovering higher K from organic waste (Suthar and singh 2008). The present findings corroborated to those of Delgado et al., 1995, who demonstrated that higher K concentration in the end product prepared from sewage sludge. pH was neutral being around 7 and and increased gradually from substrate to compost to vermicompost (Nagavallemma et al., 2006,). Fares et al., 2005, found the increased pH at the end of the composting process, which was attributed to progressive utilization of organic acids and increase in mineral constituents of waste. The increased EC during the period of the composting and vermicomposting processes is in consistence with that of earlier workers (Jadia and Fulekar 2008), which was probably due to the degradation of organic matter releasing minerals such as exchangeable Ca, Mg, K and P in the available forms, that is, in the form of cations in the vermicompost and compost (Tognetti et al., 2005).

The values of plant height, number of fruits, yield, and length of fruit with the soil parameters were statistically analysed using regression 'B' value is positive for all parameters, because of the application of vermicompost, height, fruit length and yield of fruit also (positive result) increased. The low earthworm diversity observed is consistent with other studies on invertebrate ecology in urban areas (Paul and Meyer, 2001). According to Paoletti (1999) and Curry et al. (2002), earthworm populations in cultivated land are generally lower than those found in undisturbed habitats. Agricultural activities such as ploughing, several tillage operations, fertilizing and application of chemical pesticides have dramatical effect on invertebrate animals. Any management practices applied to soil are likely to have some (positive or negative) effects on earthworm abundance and diversity. These effects are primarily the result of changes in soil temperature, soil moisture and organic matter quantity or quality (Hendrix and Edwards, 2004). The abundance of earthworms may increase due to some agricultural activities like liming, organic fertilizing etc. (Kõlli, Lemetti, 1999). Lavelle and Spain (2001) admit that the regional abundance of earthworms and the relative importance of the different ecological categories are determined by large scale climatic factors (mainly temperature and rainfall) as well as by their phylogenetic and bio geographical histories together with regional parameters such as vegetation type and soil characteristics. According to Hole et al (2005) the evidence from comparative studies under arable regimes indicates a general trend for higher earthworm abundance under organic management.

Vermicompost contains more nutrients in plant available forms such as phosphates, exchangeable calcium, soluble potassium and other macronutrients with huge quantity of beneficial microorganisms, vitamins and hormones which have influence on the growth and yield of plants (Theunissen et al. 2010). Kumari and Ushakumari (2002) reported that enriched vermicompost was a superior treatment for enhancing uptake of N, P, K, Ca and Mg by cowpea.

Vermicompost have been recognized as having considerable potentials as soil amendments. Vermicomposts are products of depredated organic matter through interactions of earthworms and microorganisms. The process accelerates the rete of decomposition of the organic matter, alters the physical and chemical properties of the material and lowers the C: N ratio leading to a rapid humification process in which the unstable organic matter is fully oxidised and stabilized (Albanell et al., 1998). The application of organic manures brings about structural improvement regeneration of soil structures and increasing the aeration within. It may cause the roots to extend into a large volume of soil in addition to the increase of water retention in the soil profile (Agarwal et al., 1995). The analysis of soil applied with fertilizer showed that it has all kinds of nutrients needed for the better growth of the crop. The soil properties such as pH, EC, available nitrogen, phosphorus, potassium, iron zinc, copper and manganese were found to vary in the soils treated with vermicompost application (Chidambaram et al., 2013). This is also in concordance with the present investigation that the soil nature differs entirely on the application of vermicompost of various treatments. The results of this study indicate that incorporation of vermicompost of plant origin into a traditional base medium of farm soil and sand enhanced growth of bhendi plant through, at least in part, improved mineral nutrition.

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Table : 1 Height of the Ladies finger plant (in cm) in different dosages and different treatments

Treatments	Three different dosages		
	100 gm	200 gm	300 gm
Lampito *mauritii* (T_1A)	58.42 ± 0.1344	50.45 ± 0.021	43.48 ± 0.035
Octochetona *pattoni* (T_1B)	60.29 ± 0.071	51.46 ± 0.205	39.99 ± 0.141
Priodocheta *pellucida* (T_1C)	53.59 ± 0.163	55.49 ± 6.371	43.77 ± 0.325
Notoscolex *palniensis* (T_1D)	60.41 ± 0.064	45.95 ± 0.070	40.88 ± 0.169
Lemnoscolex *scutarius* (T_1E)	50.33 ± 0.297	45.34 ± 0.148	30.23 ± 0.106
Hoplochetella *stuarti* (T_1F)	40.60 ± 0.0566	37.66 ± 0.070	35.36 ± 6.561
Control (T_1)	21.58 ± 0.085		

Table : 2 Fruit length (in cm) of the Ladies finger plant in different dosages and different treatments

Treatments	Three different dosages		
	100 gm	200 gm	300 gm
Lampito *mauritii* (T_1A)	20.11 ± 0.148	18.94 ± 0.092	9.865 ± 0.148
Octochetona *pattoni* (T_1B)	21.49 ± 0.077	19.26 ± 0.085	10.15 ± 0.078
Priodocheta *pellucida* (T_1C)	20.99 ± 0.014	19.14 ± 0.155	11.495 ± 0.219
Notoscolex *palniensis* (T_1D)	22.12 ± 0.162	20.63 ± 0.255	12.19 ± 0.233
Lemnoscolex *scutarius* (T_1E)	19.77 ± 0.332	17.71 ± 0.297	7.740 ± 0.297
Hoplochetella *stuarti* (T_1F)	13.37 ± 0.120	10.44 ± 0.297	6.93 ± 0.0989
Control (T_1)	11.15 ± 0.120		

Table : 3 No. of branches and No. of fruits of the Ladies finger plant in in different dosages and different treatments

Treatments	No. of branches			No. of fruits		
	Three different dosages			Three different dosages		
	100 gm	200 gm	300 gm	100 gm	200 gm	300 gm
Lampito mauritii (T_1A)	6.025 ± 0.035	5.485 ± 0.049	3.285 ± 0.078	12.40 ± 0.070	8.485 ± 0.233	4.950 ± 0.070
Octochetona pattoni (T_1B)	4.865 ± 0.120	3.485 ± 0.049	2.955 ± 0.077	15.81 ± 0.198	10.96 ± 0.077	7.780 ± 0.311
Priodocheta pellucida (T_1C)	5.965 ± 0.049	4.210 ± 0.297	2.570 ± 0.240	20.98 ± 0.035	12.95 ± 0.070	6.225 ± 0.318
Notoscolex palniensis (T_1D)	6.120 ± 0.113	5.905 ± 0.049	3.7500 ± 0.141	18.77 ± 0.332	10.22 ± 0.141	8.760 ± 0.226
Lemnoscolex scutarius (T_1E)	4.700 ± 0.197	3.256 ± 0.276	2.185 ± 0.092	11.46 ± 0.106	7.800 ± 0.169	4.980 ± 0.028
Hoplochetella stuarti (T_1F)	2.115 ± 0.163	1.147 ± 0.00014	0.541 ± 0.0064	8.425 ± 0.134	5.300 ± 0.085	2.155 ± 0.219
Control (T_1)	2.115 ± 0.163			7.775 ± 0.289		

Table : 4. Occurrence of soil physico-chemical parameters before and after vermicompost application with mean values

Physico-chemical parameters	Nature of soil	
	Before cultivation control soil	After vermicompost applied soil
N	69.00 ± 2.65	76.00 ± 2.00
P	11.00 ± 5.00	25.33 ± 17.009
K	87.66 ± 13.65	129.0 ± 19.31
pH	6.99 ± 0.94	7.35 ± 0.22
EC	0.27 ± 0.16	0.69 ± 0.481
Fe	9.65 ± 2.52	41.0 ± 9.49
Mn	12.75 ± 3.33	17.91 ± 3.68
Zn	0.25 ± 0.012	0.553 ± 0.258
Cu	0.566 ± 0.241	2.93 ± 1.96

Figure : 1 yield of fruit (in gm) in Ladies finger plant in different treatments and different dosages

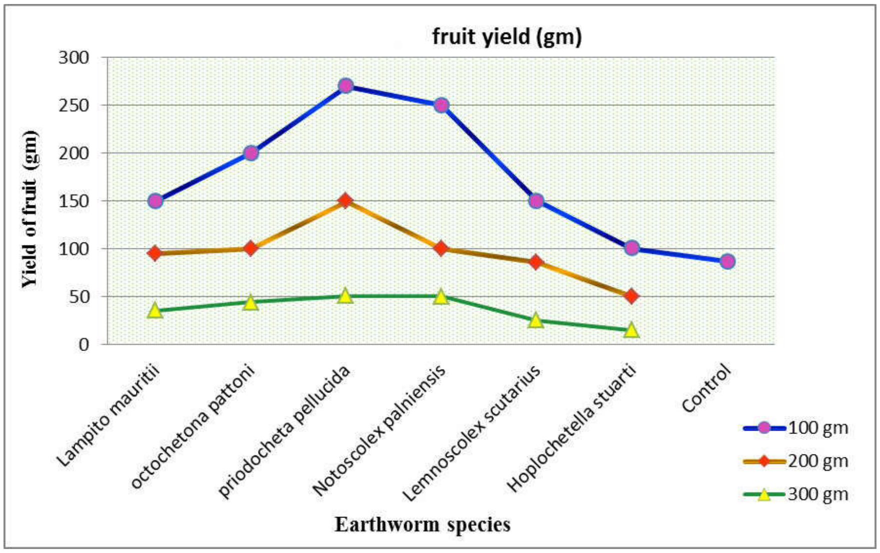
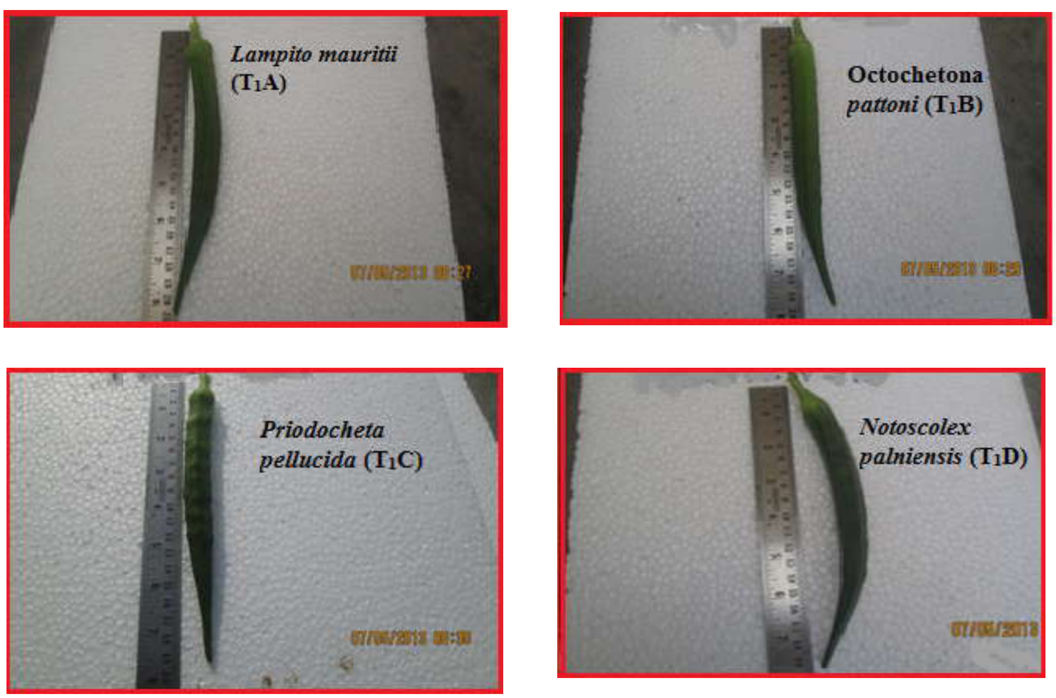


Fig 2 : Measurement of fruit (Abelmoschus esculentus) length (in cm)



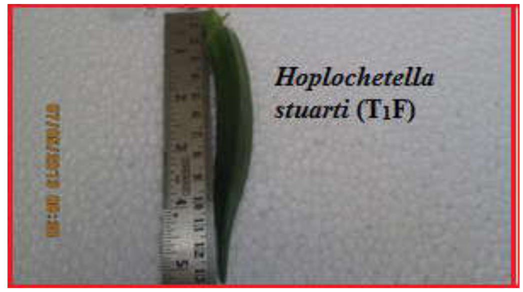
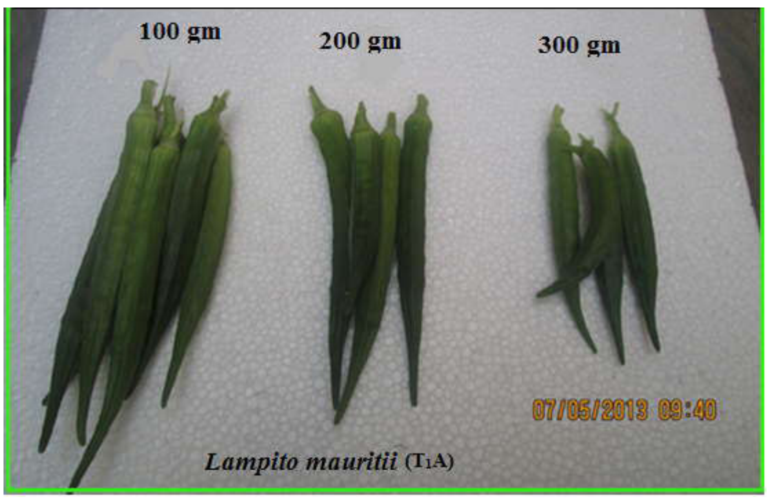
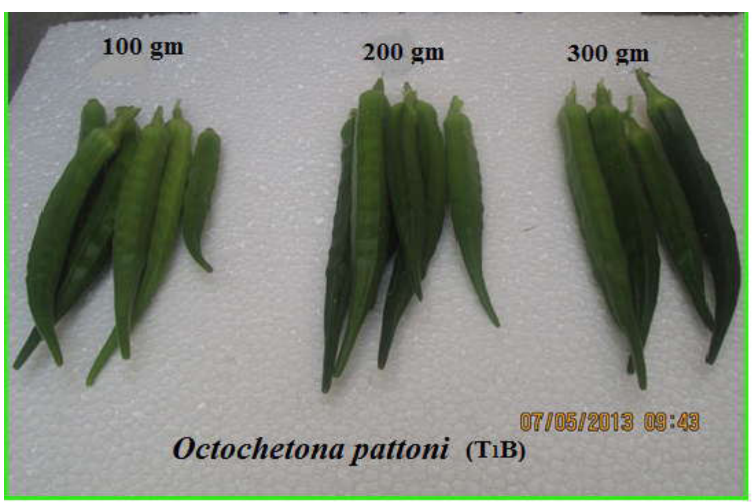


Fig 3 : A.esculantus plant fruit yield on different treatments Lampito mauritii (T_1A), Octochaetona pattoni (T_1B) and Priodocheta pellucida (T_1C) in 3 different dosages





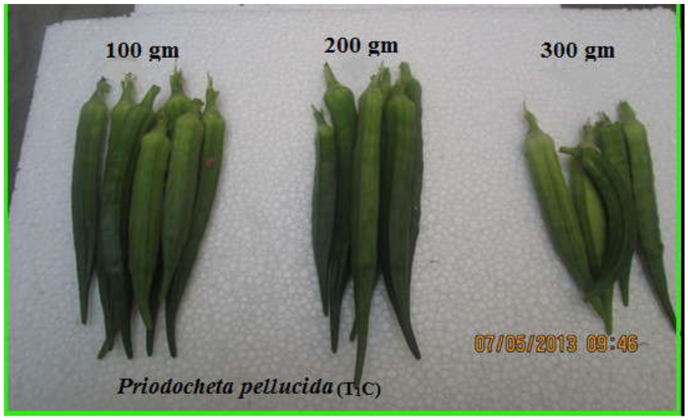


Fig 4 : Normal probability – Plot of Regression Standardized Residual