Temporal and Rate of Vermicompost Application on Early Growth of Physic Nut (Jatropha Curcas L.) in Degraded Soil

Richmund A. Palma
Institute of Agriculture
Misamis Oriental State College of Agriculture and Technology
Claveria, Misamis Oriental, 9000 Philippines
richmundp@yahoo.com

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Abstract

This study was conducted to determine the effects of rate and timing of vermicompost application on: root collar diameter; height increment; number of leaves; and root – shoot ratio of Jatropha curcas L. planted in degraded soil. The generative characteristics of Jatropha in response to the treatments were evaluated under field conditions. The results showed that addition of vermicompost significantly increased root collar diameter, number of leaves and height increment while, timing of application has also increased the root collar diameter and number of leaves but not the height increment. Both treatments had no significant effect on the root – shoot ratio. Based on the study, Jatropha pits filled with vermicompost during outplanting will performed better than those applied 10 to 20 days after planting in degraded soil.

Keywords*:* vermicompost, biodiesel, Jatropha, growth

1. Introduction

The rising cost of petroleum-derived fuel prompted the government to look for alternative fuels. At present, biodiesel become an essential alternative due to its ecological and economic benefits. The importance of biodiesel in the world energy scenario will increase relative to the present supply situation and environmental problems. The interest in using *Jatropha curcas* L. (JCL) as a feedstock for the production of biodiesel is rapidly growing. The properties of the crop and its oil have persuaded investors, policy makers and clean development mechanism developers to consider JCL as a substitute of fossil fuel (Achten *et al.*, 2008). *Jatropha curcas* Linn. (Tropical physic nut) belonging to family Euphorbiaceae is a native species

of tropical America (Gohil and Pandya, 2008). Jatropha can be grown in all countries falling under tropical, subtropical zones and in certain countries fall in temperate climate (Agricultural Management Resource Center, 2009). It has gained attention in tropical and subtropical countries as a potential bio-fuel crop and other uses with many attributes and considerable potential (Kumar and Sharma, 2008; Kumar *et al.*, 2009).

Nutrient requirement is one of important aspects for successful management of JCL plantation particularly in degraded areas devoid of essential nutrients for plant growth. The use of organic amendments such as traditional thermophilic composts has been recognized generally as an effective means for improving soil aggregation, structure and fertility, increasing microbial diversity and populations improving the moisture-holding capacity of soils, increasing the soil cation exchange capacity (CEC) and increasing crop yields (Marinari *et al.*, 2000). Vermicompost contains most nutrients in plant-available forms such as nitrates, phosphates and exchangeable calcium and soluble potassium (Orozco *et al*., 1996). It is seven times richer than compost that has been rotted without introduction of worms, so only one seventh of the quantity is needed to enrich the soil (Agricare, 2009).

There is accumulating scientific evidence that vermicomposts can significantly influence the growth and productivity of plants (Edward, 1998). On degraded sites JCL plants are found to respond better to organic manure than mineral fertilizer (Francis *et al.*, 2005). Various greenhouse and field studies showed the effects of a variety of vermicomposts on a wide range of crops including cereals and legumes (Kaushik and Garg, 2003), vegetable (Tomati *et al*., 1990), ornamental and flowering plants and field crops (Arancon *et al*., 2004). Addition of vermicompost significantly increased plant survival, plant height, stem diameter, number of branches/plant, number of seeds/plant and oil content (6.76% & 19.21%) over FYM and control (Kumar *et al*., 2004). In most cases the biomass yield of JCL were found to be slightly higher with vermicompost than farmyard manure however, results of some studies showed improvement of stem length when farmyard manure were applied (Kumar and Sharma, 2005).

Timing of application of vermicompost into the pit is also one of the important activities in growing JCL. Few studies applied vermicompost 1 month before planting (MBP) and 2 weeks before planting (Kureel, 2006). Review of the literature revealed that not much work has been done on the

timing of application of vermicompost for increasing growth and yield of JCL.

To determine the interactive effects of timing and rate of vermicompost application on the early growth, tuba-tuba (*Jatropha curcas L.*) was grown in a 3 x 3 factorial Experiment in Randomized Complete Block (RCB) Design with three levels of vermicompost and three period of application. The objectives were to determine (1) the early stage growth of JCL planted in degraded soil as affected by the rate of vermicompost application, and (2) temporal application (incorporation) of vermicompost.

2. Methodology

2.1 Plant Material and Treatment Conditions

JCL bareroot seedlings were obtained from the UPLBFI – PNOC - AFC Nursery, Barangay Putho, Los Banos, Laguna. The seedlings have similar provenance (General Santos City, Philippines) and planted at the same time in the nursery. Bare root seedlings were transported to the experimental site (IRNR nursery) a day before the scheduled planting. The seedlings were carefully packed to prevent root damage during transport. Roots were mud packed and leaves were partly removed to prevent dehydration.

The growing media was prepared before planting relative to the temporal treatments (i.e. 20 days before planting (DBP), 10 DBP and during planting). In lieu of the pit, 8" x 14" black polyethylene bag was used. Soils from degraded area were placed in the bottom of the 8" x 14" black polyethylene bag. Different rate (i.e. 500 g, 1000 g and 1,500 g) of vermicompost was applied in the bag at different time. The vermicompost used in the study was taken from the Bureau of Plant Industry (BPI), Anos, Los Banos, Laguna. The BPI vermicompost utilized farm waste materials in their vermicompost production. Vermicompost was analyzed (Table 1) using Kjeldahl method (Nitrogen), Vanadomolybdate method (Phosphorus) and Flame Photometer (Potassium) at the Soils and Agro-Ecosystems Division (SAED) – Analytical Service Laboratory (ASL). Degraded soil was added to the bag during planting. One hundred thirty five bags were prepared for each five experimental plants per treatment combinations. The bags with compost were placed outside the nursery for optimum sunlight and rainfall exposure. The compost was exposed to the climatic condition similar to the real field

condition for 20 days and 10 days before planting. All the bareroot seedlings were planted on the same day.

Table 1. Compost Characteristics (BPI Vermicompost – Farm Waste substrate)

N (%)	P_2O_5 (%)	K_2O (%)
1.61	1.42	0.24

Table 2. Degraded Soil Characteristics

pH	Organic Matter %	Total Nitrogen	Available Phosphorus ppm (Olsen)	Exchangeable Potassium me/100gsoil
6.4	1.72		50	1.82

Table 3. Climatic Characteristics

	Total Rainfall (mm)	Rainy Days	Rainfall (Mean)	Temperature (Max)	Temperature (Min)	Temperature (Mean)
July	377	25	15.08	35.4	22	27.8
August	178.1	19	9.37	34.8	22.7	28.4
September	502.9	21	23.95	35.4	22	27.8

2.2 Physiological Measurements

Initial measurements of seedlings were done before treatments, transplanting and exposing outside the nursery. Likewise, a sample of two seedlings per treatment combination per replication were harvested, weighed and dried at 70^0C for 48 hours to determine the initial root-shoot biomass ratio. Seedling height was measured monthly after planting for a period of two months with meter stick calibrated in centimeters. Similarly, the root collar diameter was measured using digital caliper. Leaves were counted every week for a period of two months.


Figure 2. Measurement of plant diameter (left photo) and height (right photo)

2.3 Seedling Growth and Nutrient Concentration

Before the start of the treatments, seedling height, diameter and number of leaves were measured and counted, and a sample of two (2) seedlings per treatment combinations per replicate was harvested, weighed and dried at 70 ^{0}C for 48 hours to determine the fresh and dry weight of root and shoot biomass. Preliminary sample coming from the harvested bare root seedlings was weighed then excised into sections (i.e. root and shoot) and dried at 70 ^{0}C for 48 hours. Dry root and shoot were brought to the SAED – ALS for plant tissue analysis (Table 4).

Table 4. Result of the composite tissue analysis of JCL

N (%)	P_2O_5 (%)	K_2O (%)
1.11	0.33	3.67

2.4 Experimental Design

The study was laid out following the 3 x 3 Factorial Experiment in randomized complete block design (RCBD) with three replications. There were nine (9) treatment combinations assigned in each block. The treatments were represented by different time and rate of vermicompost application. The treatments were the following:

Temporal Application	Rate of Application
T_1 - Control (during filling of pits)	V_1 - 500 grams
T_2 - 10 days before planting (DBP)	V_2 - 1000 grams
T_3 - 20 DBP	V_3 - 1500 grams

A total of 27 experimental plots were constructed. Each plot was composed of 5 experimental plants.

To determine the effect of timing and rate of vermicompost application, regular monitoring of the following parameters was made. These were: root biomass yield and above ground stem diameter, height, above ground biomass yield and number of leaves.

2.5 Statistical Analysis

Data were analyzed by the analysis of variance (ANOVA) of a two – factor experiment in RCB design with an experiment involving three rates of vermicompost and three periods of vermicompost application and three replications. Each experimental unit was composed of 5 experimental plants. The means of the diameter, height and number of leaves were entered into the data table. The list of the 9 factorial treatment combinations was constructed to facilitate computation. The means were compared using the Least Square Difference (LSD).

3. Results and Discussion

3.1 Effect on Root Collar Diameter (RCD)

Analysis of variance in Table 5 showed the significant effect of rate and timing of vermicompost application of JCL. The average root collar diameter increment is 3.43 mm in 2 months and the increase ranged from 1.5 mm to 5.15 mm (Figure 3). Based on the comparison of treatment means using LSD, treatment 500g/ pit (9.76 mm) and 1500g/ pit (10.66 mm) were not significantly different from treatment 1000g/ pit (10.50 mm - control). Application during planting (11.72 mm - control) showed significant increase in RCD compared to 10 DBP (9.75 mm) and 20 DBP (9.44 mm). However, the interaction between the rate and timing of application was not significant.

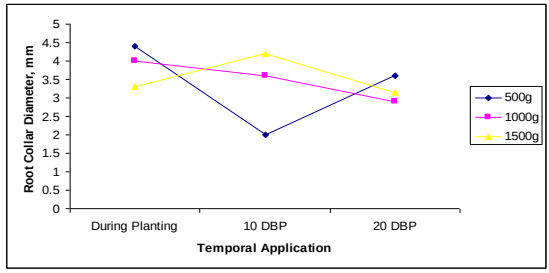

Figure 3. Root Collar Diameter increment of JCL

Table 5. Analysis of variance showing the effect of rate and timing of vermicompost application on Root Collar Diameter of JCL after 2 months of planting

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	$F_{computed}$	$F_{tabulated}$	
					.05	.01
Replication	2	8.27	4.14	8.69^{**}	3.63	6.23
Treatment	8	20.98	2.66	5.59^{**}	2.59	3.89
Vermicompost (A)	2	11.04	5.52	11.60^{**}	3.63	6.23
Timing (B)	2	8.46	4.23	8.89^{**}	3.63	6.23
A x B	4	1.48	.37	$.77^{ns}$	3.01	4.77
Error	16	7.61	.48			
Total	26	36.86				

CV = 20%; ** = significantly different at .01 level; ^{ns} = not significant

Several studies have evaluated the effect of vermicompost-amended potting media on plant growth greenhouse production. Generally, potting medium with 10 to 20% vermicompost by volume provides adequate fertilization for transplant growth (Subler *et al*., 1998; Atiyeh *et* al., 2000a; Ozores-Hampton and Vavrina, 2000). Studies confirmed that vermicompost application resulted in increase in root collar diameter (Kumar *et al.*, 2009; Dickens *et al.*, 2008). Compost applications significantly increased mean groundline diameter and total height (Dickens *et al.*, 2008). While trees in the incorporated compost treatment had a greater mean groundline diameter as compared to trees in the surface applied compost treatment, they were not significantly greater.

This increase in root collar diameter with vermicompost might be due to organic amendment which improved the structure of the soil by increasing the water holding capacity, good aeration and drainage that encourage better root growth and nutrient absorption (Zink and Allen, 1998; Azarmi *et al.*, 2008; Pattnaik and Reddy, 2010). The better role of vermicompost could be also due to better mobilization and availability of plant nutrients (nitrogen, sulphur, potash, phosphorus, calcium, magnesium, etc.) and growth enhancing substances to the plants (Bhatia and Shukla, 1982; Orozco *et al.*, 1996; McClintock, 2004; Azarmi *et al.*, 2008) in soil amended with vermicompost.

The treatment T_1 (during filling of pits) showed bigger RCD compared to T_2 (10 DBP) and T_3 (20 DBP) maybe due to the effect of precipitation. The rates of mineralization are largely dependent on soil moisture (Ranells and Wagger, 1992 as cited by McClintock, 2004). Flooding can lead to denitrification and subsequent N deficiency and growth reduction in corn plants (Ashraf and Rehman, 1999). N availability is highly variable and

largely dependent on the compost feedstock and maturity, soil chemical characteristics, and environmental changes in moisture and temperature (Iglesis – Jimenez, 2001).

3.2 Effect of Rate and Timing of Vermicompost Application on Height Increment of JCL

The observation on height increment of JCL on rate and timing of vermicompost application is summarized in Table 6. JCL seedling height increment increased in response to the rate of vermicompost application (Table 7; FC > FT.05). The average increase in height increment for treatments 500g/ pit and 1500g/ pit which are 10 cm and 11.2 cm respectively was not significantly different from treatment 1000g (8.1 cm – control). The increase ranged from 5.33 cm to 14.9 cm. The study of Kumar *et al.* (2009) verified that the addition of vermicompost resulted in the significant increase of JCL height increment at 4 MAP (25.13 & 17.53%) over control at 11 and 14 MAP respectively. Further, Karmegam *et al.*, (1999) evaluated the shoot length of Phaseolus aureus grown in a 3:1 mixture of potting soil and vermicomposted cow manure. Phaseolus aureus shoot length increased by 28%. Coleman et al. (1986) found that Ponderosa pine seedlings responded to compost treatment, with significant treatment effects on height. The effect of the timing of application and its interaction to the height increment was not significant (FC < FT.05). Although this is not part of the study, the significant effect of vermicompost amendment might be due to partitioning of photosynthate for maintenance because of the stressed experienced during planting and poor weather (Franklin and Mercker, 2009).

Table 6. Effect of rate and timing of application of vermicompost on height increment of JCL after two months of planting

Vermicompost Level, g/ pit	T_1	T_2	T_3	Total
V_1 (500)	28.47	18.65	25.43	72.55
V_2 (1000)	32.16	29.1	28.56	89.82
V_3 (1500)	36.57	29.51	34.41	100.49
Total	97.2	77.26	88.40	

Table 7. Analysis of Variance showing the effect of rate and timing of application of vermicompost on JCL after 2 months of planting

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	$F_{computed}$	$F_{tabulated}$ 0.05	$F_{tabulated}$ 0.01
Replication	2	3.76	1.88	0.35^{ns}	3.63	6.23
Treatment	8	72.25	9.03	1.70^{ns}	2.59	3.89
Vermicompost (A)	2	44.17	22.08	4.17^{*}	3.63	6.23
Timing (B)	2	22.19	11.10	2.09^{ns}	3.63	6.23
A x B	4	5.89	1.47	0.28^{ns}	3.01	4.77
Error	16	84.81	5.30			
Total	26	160.82				

CV = 23.6%; * = significantly different at .05 level; ^{ns} = not significant

3.3 Effect of Rate and Timing of Vermicompost Application on Number of Leaves of JCL

The addition of vermicompost at various rates and timing of application significantly affected the number of leaves ($F_C > F_{T.01}$) as shown in Table 9. The number of leaves produced ranges from 4 leaves to 20 leaves with an average of 11 leaves per plant (Table 8). Pits supplemented with 1500g vermicompost had produced the most number of leaves 2 more than the control on the average. Meanwhile, the application of compost during the time of filling (T_3) had given the most number of leaves with 13 (Table 8).

There are many different features of a plant that can be measured through observation to determine the extent of plant growth/ health. Results obtained from this study revealed that number of leaves was significantly affected by the rate of vermicompost and timing of application. Peregrim and Hinesley (No date) reported a significant, but less predictable, was the response to growth as measured in total foliage, foliage density, and needle weight. The study of Peyvast *et al.* (2007) on the effects of different amount of vermicompost (0, 10, 20 and 30%) on growth, yield and chemical characteristics of spinach (*Spinacia oleracea* L.) showed that an addition of vermicompost to soil can increase plant heights and number of leaves significantly. Spinach leaves and root were highest when fertilized with vermicompost and lowest when the vermicompost was not supplied.

The leaves play a crucial role in growth and development of woody plants because they are the principal photosynthetic organs (Pallardy, 2008). Changes in photosynthetic activity by cultural practices eventually will influence growth of vegetative and reproductive tissues. It has long been recognized that plants growing under substantial soil moisture or nutrient

stress have smaller leaves and lower growth rates than plants of the same genotype growing under more favorable conditions. In addition, rapid production of leaf area appears to be an important attribute of fast-growing plants. Previous work on *Populus* has shown that mean leaf size per clone and clonal performance are correlated (Ceulemans, 1990). The number of leaves produced by JCL could be an indicator of plant vigor.

Table 8. Effects of rate and timing of vermicompost application on number of leaves of JCL after 2 months of planting

Vermicompost	T_1	T_2	T_3	Total
V_1	29.30	23	24.90	77.2
V_2	40.80	28.30	29.85	98.95
V_3	46.50	36.10	35.03	117.63
Total	116.6	87.40	89.78	

Table 9. Analysis of Variance showing the effect of rate and timing of vermicompost application on the number of leaves of JCL after 2 months of planting

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	$F_{computed}$	$F_{tabulated}$ 0.05	0.01
Replication	2	114.89	54.44	10.43^{**}	3.63	6.23
Treatment	8	155.66	19.46	3.73^{*}	2.59	3.89
Vermicompost (A)	2	90.99	45.50	8.72^{**}	3.63	6.23
Timing (B)	2	42.93	21.46	4.11^{*}	3.63	6.23
A x B	4	21.74	5.44	1.04^{ns}	3.01	4.77
Error	16	83.53				
Total	26	354.08				

CV = 21%; ** = significantly different at .01 level; * = significantly different at .05 level; ^{ns} = not significant

3.4 Effect of rate and timing of vermicompost application on root - shoot ratio of JCL

The result pertaining to the effect of level of vermicompost and temporal application on root - shoot ratio on JCL is summarized in Table 10. The ANOVA (Table 11) showed that there was no significant difference between the treatments tested ($F_C < F_{T.05}$). Kozlowski *et al.* (1991) as cited by Tulod (2008) stated that balance between root and shoot are important for tree growth and survival. South (2000) reported that a balanced root mass and shoot mass is especially important when seedlings are planted in areas or in seasons where moisture stress is likely to be severe.

Table 10. Effects of rate and timing of vermicompost application on number of leaves of JCL after 2 months of planting

Vermicompost	T_1	T_2	T_3	Total
V_1	1.78	1.51	1.78	5.07
V_2	1.48	1.45	1.66	4.59
V_3	1.26	1.54	1.36	4.16
Total	4.52	4.50	4.80	
Mean				

Table 11. Analysis of variance showing the effect of rate and timing of vermicompost application on the number of leaves of JCL after 2 months of planting

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	$F_{computed}$	$F_{tabulated}$	
					.05	.01
Replication	2	0.01	.01	$.45^{ns}$	3.63	6.23
Treatment	8	0.09	.09	1^{ns}	2.59	3.89
Vermicompost (A)	2	0.05	.025	2.27^{ns}	3.63	6.23
Timing (B)	2	0.01	.005	$.45^{ns}$	3.63	6.23
A x B	4	0.03	.008	$.73^{ns}$	3.01	4.77
Error	16	0.17	.011			
Total	26	0.27				

CV = 20.56%; ^{ns} = not significant

4. Conclusions and Recommendation

The result of this experiment suggested that growth of *Jatropha curcas L.* (root collar diameter, height and number of leaves) significantly increased with the addition of vermicompost. Similarly, temporal application had also affected root collar diameter and number of leaves. Results showed the potential and practical benefits of employing vermicompost for a sustainable establishment of JCL plantation in degraded soil. Moreover, application of 1500g vermicompost during the time of planting showed better growth for all parameters tested compared with other rates of application. Verification study related to these must be done to really determine the effects of the two factors possibly up to six months or longer period.

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