INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)

ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 9, No. 1, p. 55-62, 2016

RESEARCH PAPER

OPEN ACCESS

Growth parameters of oil palm (*Elaeis guineensis* Jacq.) tree seedlings in response to fertilizer types

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Article published on July 23, 2016

Key words: Oil palm (*Elaeis guineensis* Jacq.), Fertilizers, Growth parameters, *Tenera* seedlings, Small holder farmers.

Abstract

African oil palm (*Elaeis guineensis* Jacq.) is a perennial crop whose by-products are used for food, non-food and medicine worldwide. Cameroon has over 42% of its total land surface suitable for oil palm cultivation however, production remains low due to poor management options. This research investigates the effect of fertilizer types on growth parameters of oil palm seedlings. The experiment was carried out in the South West region of Cameroon using five different treatments: T1 (bunch waste), T2 (poultry droppings), T3 (urea), T4 (bunch waste + poultry droppings + urea) and finally T5 (control) with three replications on hybrid seedlings of *Tenera*. Growth parameters recorded were; survival, plant heights, leaf lengths, leaf width and stem girth after twelve weeks of planting. Result showed that T2 and T3 had no significant difference between each other for heights, second leaf length (SLL) and second leaf width (SLW) with T3 being the highest in all the above parameters. T2 was significantly higher than T3 for the stem girth (SG). From these results, inorganic fertilizer (urea) best support the proper growth and development of oil palm seedlings, but can equally be substituted by organic fertilizer (poultry droppings) which showed a significantly bigger stem girth than urea after twelve weeks.

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Introduction

African oil palm (*Elaeis guineensis* Jacq.) is a perennial crop whose by-products are used for food, non-food and medicine worldwide. Oil palm is cultivated on approximately 15 million ha across the world (Koh and Wilcove, 2008a; Fitzherbert *et al.,* 2008; Koh and Ghazoul, 2008, FAO, 2009). Cameroon has over 42% of its total land surface suitable for oil palm cultivation, (Stickler *et al.,* 2007) with the largest surface occupied by smallholder farmers. The government of Cameroon is empowering smallholder farmers to boost agricultural production because it provides direct and indirect employment to the local population. However, with the large surface areas and government subvention their production is usually low due to poor management options (Nkongho *et al.,* 2014). Smallholder farmers usually face the greatest difficulties in their efforts while producing oil palm in Cameroon. In the past, the growing of oil palms was done as a mixed cropping system, i.e. farmers grow native oil palm varieties mixed with other crops like cocoa (*Theobroma cacao*) plantains and banana (*Musa parasidiaca and Musa accuminata*), without adding fertilizers. All they depended on was the natural richness of the soil and the supplementary elements from green fertilizers due to the mixed cropping system (Etoga, 1971). With this system today farmers face low yield due to ageing oil palm fields with low fertilizer and scarcity of land for further expansion.

There is migration of the planting systems from a mixed cropping to monoculture system (Ricardo, 2013). For large scale plantation establishment, higher yield can be obtained if improved seeds are used in combination with good management techniques (Ng, 2001; Roberts, 2009). Improved genetic material such as *Tenera* is a hybrid from *dura* and *pisifera*, and the most cultivated variety because it produces fruits with higher oil content (Rieger, 2012). The wild variety *dura* develops fruits with thick endocarp while the interspecific heterozygous hybrids *tenera*, have thin shells surrounded by a distinct fiber ring (Bermaert and Vanderweyer, 1941) Shell thickness has a major effect on oil content, with *tenera* having 30 % more mesocarp and 30 % greater oil content (Corley and Tinker, 2003).

In Cameroon the oil palm improved seed (*Tenera*) is available in two research institutions (PAMOL Research Department and IRAD La Dibamba) that are responsible for the production of certified seeds in the country. Many factors (biotic and abiotic elements and their interaction) contribute to the management techniques in oil palm production. Biotic factors are generally more flexible and are subject to modification through silvicultural manipulation like varying the planting compositions, structure, density etc. While abiotic elements of productivity are relatively fixed such as climate, topography, and soils are not easily modified on a large scale by conventional management practices. Where such modifications are undertaken they usually prove quite costly, but their major impact and long lasting effects may justify the efforts.

Davidson (1993) reported that among seven factors responsible for higher yields, fertilizer was the most important accounting for 29% of the yield increment and constituting the highest operational cost in well run plantations in Malaysia. The use of inorganic nitrogen fertilizers (synthetic fertilizers) an artificially made and very fast releasing fertilizers have lots of negative effects such as cancer on the health of humans. They contain fewer elements but of very high quality (Silva, 2000) with example such as urea and ammonium sulphate. These inorganic fertilizers also causes pollution of the environment and destruction of water bodies when they are carried away by run off to streams and seas. Even so, supplementing the soil nutrients with inorganic fertilizers has been hampered by the high cost of purchase and acute scarcity (Aduayi, 1980; Agbede and Kalu, 1990; Amir *et al.,* 2001; Nkongho *et al.,* 2014). The application of chemical fertilizers is now being considered because of the harmful effect on the environment, soil productivity and human (Yadav and Prassad, 1992). Organic fertilizers such as pruned fronds, empty fruit bunches (EFB), decanter cake and palm oil mill affluent have been shown to be an excellent sources of organic fertilizer for oil palm in Malaysia (Kee and Goh, 2006; Lim *et al.*, 1999) and in bitter cola (*Garcina kola*) seedlings in Nigeria (Moyin-Jesu and Adeofun, 2008). The main objective of this research is to investigate the effect of fertilizer types on the growth of oil palm seedlings to suggest an alternative to inorganic fertilizer use, especially for the smallholder farmers in Cameroon.

Materials and methods

Climatic condition of the experimental site

The research was carried out in Limbe at the CDC Bota farm, situated in the South West region of Cameroon. Limbe is found in the humid dense forest of monomodale pluviometery zone of Cameroon. This zone is found between 2°6" and 6°12 of latitude Nord, and 8°48" and 10°30 of latitude East and covers the Littoral and the South West regions. It occupies a surface area of 4.5 million of hectares. Limbe is situated along the coastal plain with temperature varies between 22 and 29°C and air humidity is between 85 and 90 %, (IRAD, 2008). Abundant rainfall, with an average of 2500 to 4000 mm, with the exception of the locality of Debundscha which is considered as one of the regions in the world with the heaviest rainfall, of 11000 mm water per year.

Treatment preparation and establishment of seedlings

Loam topsoils and sand were mixed in a ratio of 3:1, sieved through a mesh of 1cm² and given five treatments.

- Rotten empty fruit bunch waste (T1). Here the loam top soil and sharp sand mixture was mixed with rotten bunch wastes,

- Decomposed poultry droppings (T2): For this treatment, the sieved loam topsoil and sand mixture was mixed with decomposed poultry droppings. These poultry droppings were collected from Mr Ngwa's poultry farm in New Town Limbe, and then allowed for three weeks to decompose well.

- Urea treatment (T3): The sieved loam topsoil and sand mixture was treated with urea. This is the chemical fertilizer which was applied as one of the treatments, after six weeks of planting. The fertilizer is applied in the liquid form as follows, Urea 15 g in 10 liters of water. This was conducted fortnightly in every two weeks and the application began at the two-leaf stage, which is when the seedlings are 1.5 or 2 months old. This method of application is the foliar application method and carried out only in the morning. Immediately after urea application, the leaves were washed with water to prevent leaf scorching.

- Decomposed poultry droppings rotten bunch waste and urea (T4): Finally, the mixture of loam topsoil and sharp sand was mixed with a combination of decomposed poultry droppings, rotten bunch waste and urea

- Control treatment (T5): No treatment was given to it.

Fifteen polyethylene bags of 14 cm × 20 cm were filled per treatment with three replications. These filled polyethylene bags were perforated so as to allow free circulation of air and water. Watering was done for two days before planting. Prophylactic treatments were carried out by mixing MANCOXYL PLUS 720 WP (fungicide), 40 g and GAMALINE EC (insecticide), in 15 liters of water and stirred properly. 3 g of MOCAP (nematicide) were sprinkled on the polythene bags and watered to dissolve in the soil. These preparations were repeated after every three weeks of application.

Hybrids seedling known as *Tenera* were bought from IRAD La DIMBAMBA. Oil palm seedlings were already 21 days old when they were planted, and they were at the hammer stage. The chitted seeds with healthy germ in the hammer stage were planted in a hole, made with fingers, at the middle of the bag. The hole was 3 to 4 cm deep. The radicle (roots) was placed downward and the plumule (shoot) was placed upward in the planting hole.

The planting was completed by a careful covering of the chitted seeds with a thin layer of soil, so as to facilitate easy growth of the fragile seedlings. After planting, all the polythene bags were watered and prevented from direct sunlight by the use of shades from young oil palm trees of about five years old. Manual weeding was done in and outside the bags to prevent weeds from interfering with proper growth of the seedlings.

Data collection and analysis

The different parameters measured were percentage survival, plant height, leaf length, leaf width, and stem girth after twelve weeks of planting. A gradated measuring rule was used to collect the different quantitative parameters from all seedlings in every treatment. At the end of the experiment, data were analyzed using single factor analysis of variance (ANOVA) and the means were separated by DUNCAN Multiple Range test of SPSS (version 20) at 5 % significant level.

Results and discussion

The experimental field trial recorded a survival rate of 100% after twelve weeks of planting, and it was realized that there was an increased in different growth parameters (plant height, leaf length, leaf width, stem diameter) measured in each experimental block per week.

Effect of treatments on height

At the twelve-week after planting there was significant different between treatment on plant height (Table 1) with T2 (3.66) and T3 (3.89) being significantly higher than T4 (3.61), T1 (3.41) and T5 (2.88). T3 had the best result but was not significantly different from T2 while T5 recorded the least value (Table 2). The highest mean height value for T3 proves that urea must have provided enough nutritive elements (N, 45 %) for the growth of the oil palm seedlings because urea is a fast releasing fertilizer (Benson and Barnett, 1939; Francis and Haynes, 1991; Gezgin and Bayrakl, 1995). T5 had the least value because on this unite, there was no fertilizer application. Highest values were also recorded in plant height when treated with inorganic fertilizer in work reported by Anamaria *et al.* (2012) on oil palm seedlings in Casanare. Contrary to this result, best results for plant height on plot treated with empty fruit bunches ash was recorded by Uwunmaronngie-Illoria *et al.* (2012) and Roe and Comforth (2000).

Table 1. Effect of treatments on growth parameters after twelve weeks of planting.

Growth parameter	df	Sum of squares	Mean Square	F-Ratio	P-value
Height (Hgt)	4	1.7335	0.4334	11.15	**0.0006**
First leaf length (FLL)	4	12.5907	3.1477	1.71	0.2230
Second leaf length (SLL)	4	165.933	41.4833	6.77	**0.0066**
Third leaf length (TLL)	4	17.4988	4.3747	0.39	0.8141
Forth leaf length FTH LL)	4	139.087	34.7717	2.42	0.1171
First leaf width (FLW)	4	1.9773	0.4943	3.25	0.0593
Second leaf width (SLW)	4	7.1427	1.7857	6.32	**0.0084**
Third leaf width (TLW)	4	2.7964	0.6991	1.34	0.3217
Forth leaf width (FTH LW)	4	7.5627	1.8907	2.45	0.1139
Stem diameter (SG)	4	0.1239	0.0309	43.02	**0.0000**

Effect of treatments on leaves

During data collection, it was noticed that the first leave made it appearance at the third week after planting. At eight week, three leaves had developed in the entire treatment excerpt for treatment T5 whose third leave did not develop (data not shown). From table 1, the different fertilizer treatments had significant effects (p=0.0066) on the second leaf length (SLL). Separating the means using DUNCAN Multiple Range Test it was noticed that T1, T2, T3 and

T4 were not significantly different but significantly higher than T5 with T3 having the highest value. There was no significant effect of treatments on the first, third and fourth length at the twelve week of measurements (Table 2). Poultry dropping has been shown to increase the growth parameters especially leaf area than inorganic fertilizers (Moyin-Jesus and Adeofun, 2008) which was contrary with this study but not significantly different from the poultry dropping. Concerning the leave width measured, it can be seen that there was significant different only on the second leave width (SLW) with *p= 0.008* while no significant different existed for first, third and fourth leave width. The separation of means had similar trend as for the second leave length with T1, T2, T3, and T4 in the same homogeneous group and hence there were no significant differences between them. This was simply because T1, T2, T3, and T4 probably provided an equal amount of nutritive element for the growth of the leaf width. T5 (1.2) being the least because no fertilizer was applied in this unite.

Table 2. Duncan multiple range tests for the comparison of mean of treatments after twelve weeks of planting.

Treatment	Hgt	FLL	SLL	TLL	FTH LL	FLW	SLW	TLW	FTH LW	SG
T1	3.413^{b}	4.6	11.77^{b}	16.4	6.3	1.4	2.77^{b}	3.45	1.47	0.67^{b}
T2	3.66^{c}	6.0	14.0^{b}	17.1	8.8	1.97	3.07^{b}	3.5	1.9	0.81^{d}
T3	3.89^{c}	5.8	16.3^{b}	17.2	1.8	2.1	3.2^{b}	3.77	0.3	0.74^{c}
T4	3.61^{bc}	5.7	10.8^{b}	14.8	5.1	2.07	2.57^{b}	3.1	1.27	0.7^{bc}
T5	2.88^{a}	3.6	6.4^{a}	14.7	0.33	1.23	1.27^{a}	2.5	0.067	0.53^{a}
Mean	3.49	5.15	11.9	16.02	4.47	1.75	2.6	3.27	1.01	0.69
Standard Deviation	0.39	1.49	4.03	3.06	4.49	0.49	0.84	0.76	1.04	0.09
P	**0.0006**	0.223	**0.0066**	0.8141	0.1171	0.0593	**0.0084**	0.3217	0.1139	**0.0000**

On the same columns, the mean with the same letters are not significantly different in the Duncan multiple range test at a probability of 0.05.

Effect of treatments on stem girth

Finally, there was a significant difference at the level of the stem girth (Table 1). T2 (0.81^{d}) was significantly higher than T3 (0.74^{c}), T4 (0.7^{bc}), T1 (0.67^{b}) and T5 (0.53^{a}). T3 was significantly higher than T4, T1 and T5 while T4 was significantly higher than T1 and T5. T1 was significantly higher than T5 (Table 2). This highest mean of stem diameter by T2 proves that T2 is better than T3 for other nutritive elements like P and K which are needed by the oil palm seedlings for the development of their stem diameter. Poultry droppings have 2% P and 1% K, while Urea has 0% P and 0% K (Benson and Barnett, 1939; Francis and Haynes, 1991; Gezgin and Bayrakll, 1995). T4 did not give a good result as a combination of different fertilizers because there was accumulation of elements in the soil, making it difficult for the plants to take up these nutritive elements. T1 was also poor because T1 had lesser amount of nutritive elements for the growth of stem diameter of oil palm seedlings. T5, which was the control experiment gave the poorest results because no fertilizer treatments were applied on this unit. Arisha *et al.* (2003) had better results on stem diameter when mineral nitrogen fertilizer was applied under sandy soil condition which was contrary to our results. Stem girth are characters influencing nut production because they support leaves, flowers, fruits vascular systems that transport nutrients, water and assimilate (Corley and Tinker, 2003) and with highest stem girth for T2 we expect better nut production in the future.

It is also noticed that not all organic fertilizers had the same richness in certain nutrients for the growth of oil palm seedlings. It was noticed that poultry droppings are very rich in nutrients like nitrogen than bunch waste which is also a source of organic fertilizer. Therefore poultry droppings have the potential to be used by small-holder farmers in growing oil palm seedlings in Cameroon. However, more detail studies are needed for this important aspect in oil palm production for the benefit of the company and farmers who are investing in large scale palm oil production. In addition with the advancement of new technology, the environment will soon benefit from plant breeding programs. The use of improved crop for adapting to stressful environmental conditions or enhanced host plant resistance to pathogen and pests will reduce the negative impacts in our environment.

Correlation on growth parameters measured

High positive correlations were recorded among most of the traits measured at the twelve week after planting. Height was correlated to FLL, SLL, FLW, SLW, TLW, and SG. FLL was correlated to SLL, FLW, SLW, TLW, and SG. SLL was correlated to SLW, TLW, and SG. TLL was correlated to TLW. FTH LL was correlated to FTH LW. FLW was correlated to SLW. SLW was correlated to TLW and SG (Table 3). Positive correlation indicates that any change in one trait will lead to a positive change in the other traits. This genetic effect known as pleiotropy has been reported in *castanea sativa* growth traits in Greece (Tchatchoua, 2008).

Table 3. Trait-trait correlation table for growth parameters after twelve weeks.

	HGT	F LL	S LL	T LL	FTH LL	F LW	S LW	T LW	FTH LW	SG
HGT	1									
F LL	0.675**	1								
S LL	0.753**	0.688**	1							
T LL	0.504	0.295	0.283	1						
FTH LL	0.412	0.218	0.257	0.355	1					
F LW	0.803**	0.862**	0.619*	0.337	0.120	1				
S LW	0.835**	0.676**	0.926**	0.364	0.481	0.674**	1			
T LW	0.707**	0.648**	0.679**	0.672**	0.299	0.620*	0.696**	1		
FTH LW	0.408	0.243	0.12	0.342	0.992**	0.153	0.462	0.307	1	
SG	0.737**	0.630*	0.790**	0.261	0.472	0.571*	0.785**	0.493	0.425	1

**. Correlation is significant at the 0.01 level.

*. Correlation is significant at the 0.05 level.

Conclusion

From this result, it proves that inorganic fertilizer (urea) can be considered to be the best fertilizer for the proper growth and development of oil palm seedlings. However, it can equally be replaced by the organic fertilizer (poultry dropping) which was significantly higher than urea in stem girth and was not significant difference from urea on height, second leave length and second leave width in order to preserve our environment. High positive correlation was also found among traits evaluated in the experiment.. Organic fertilizers can therefore, act as an alternative fertilizer to the smallholder farmers in growing oil palm seedlings in Cameroon.

Acknowledgment

Our gratitude to the Cameroon Development Corporation (CDC) Bota Limbe for accepting Ngoe N. Oscar for an internship position and Mr. Boya for his assistance in setting up the experiment. Our sincere thanks go to Mr Ngwa and other poultry owners in Bota for providing materials used in the experiment.

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