ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 10 (4): 123-127, 2011
ISSN 1812-5379 / DOI: 10.3923/ja.2011.123.127

Growth and Yield Response of *Thevetia periviana* J. to Applied Nitrogen and Phosphorus Fertilizers in the Southern Guinea Savannah of Nigeria

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Abstract: A field experiment was conducted during the 2010 rainy season to study the growth and yield response of *Thevetia peruviana* J. to rates of nitrogen and phosphorus fertilizers at the Research Farm of the Bio-fuel and Alternative Renewable Energy Ltd., Edidi, Kwara State in the Southern Guinea Savannah of Nigeria. The treatments were combined in split plot and laid out in Randomised Complete Block Design with three replicates. The experiment comprised of nine treatments combination of three levels of nitrogen fertilizer (control, 30 and 60 kg N ha^{-1}), three levels of phosphorus fertilizer (control, 30 and 60 kg P_2O_5 ha^{-1}) and one plant population (2,500 plant ha^{-1}) at 2 m by 2 m plant spacing. The results indicated that 30 kg P_2O_5 ha^{-1} rate of phosphorus fertilizer increased plant height, number of branches, stem girth, reduced number of days to flowering and fruit maturity and increased fruit yield which were statistically similar to application of 60 kg P_2O_5 ha^{-1} rate of phosphorus fertilizer. It can therefore be concluded that 30 kg P_2O_5 ha^{-1} rate of phosphorus fertilizer is appropriate in enhancing the fruit yield of thevetia. Further increase in phosphorus fertilizer to 60 kg P_2O_5 ha^{-1} will not be economical as it will amount to waste of fertilizer.

Key words: *Thevetia periviana*, fertilizers, performance, yield

INTRODUCTION

Thevetia is an evergreen tropical arborescent shrub in the family Apocynaceae of the order Gentianales. It is commonly known as Yellow oleander (nerium), Lucky nut, Be-still tree, gum bush, bush milk, exile tree in India, Cabalonga in Puerto Rico and Olomi ojo by the Yorubas in Nigeria. In spite of the high oil content (67%) of its kernel (Azam *et al*., 2005) and favourable protein content (37%) in de-oil cake (Ibiyemi *et al*., 2002), it has remained only an ornamental, fencing or wasteland plant.

The plant contains a milky sap, rich in a compound called thevetin that is used as a heart stimulant or cure for breast cancer (Bose *et al*., 1999) but in its natural form, the sap is extremely poisonous, as are all parts of the plant.

In the wild the plant flowers after about one and half years and blooms thrice a year (Balusamy and Manrappan, 2007). *Thevetia peruviana* J. plants produce between 400-800 fruits yearly depending on the rainfall and plant age (Ibiyemi *et al*., 2002). The number of kernels per fruit and the oil yield are significantly different among geographical locations. The plant has annual seed yield of 52.5 tonnes ha^{-1} and about 1,750 L of oil can be obtained from an hectare of waste land (Balusamy and Manrappan, 2007). Its kernel oil has a very good thermal stability (Ibiyemi *et al*., 1995) and thus has a potential for various uses. The content of essential oils and their composition are affected by different factors, including genetic makeup (Muzika *et al*., 1989) and cultivation conditions, such as climate, habitat, harvesting time, water stress and the use of fertilizer (Yang *et al*., 2005; Stutte, 2006).

Ibiyemi *et al*. (2002) produced quality and sizable bio-diesel from *Thevetia peruviana* seeds and reported that the shrub has a wider range of uses. Some of the identified uses includes the seeds, when pressed to obtain a semi-drying bio-oil (50-67%) is good for the production of bio-diesel and its oleic acid (55%) is close to the value computed for an ideal bio-diesel (70%). Secondly, the seed cake, when detoxified is a good protein supplement in livestock feedmeals (Oluwaniyi *et al*., 2007) and the toxin isolate (thevetin) from the seed can also be used for cardiac and breast cancer drugs (Bose *et al*., 1999). The objectives of the study were to determine the effects of different levels of nitrogen and phosphorus fertilizers on the performance of the plant; and to evaluate the effects of fertilizer on the fruiting age, growth and yield performance of thevetia.

MATERIALS AND METHODS

The research work was carried out during the 2010 rainy season at the Research Farm of the Bio-fuel and Alternative Renewable Energy Ltd., Edidi, Kwara State in the Southern Guinea Savanna of Nigeria.

The treatment combinations included three levels of phosphorus (P_0, P_{30} and P_{60}), three levels of nitrogen (N_0, N_{30} and N_{60}) and plant population of 2,500 plants ha^{-1}.

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The treatments were combined in split plot and laid out in a Randomized Complete Block Design (RCBD) and replicated three times.

The land was ploughed once and harrowed twice to give a well pulverized soil. Thereafter the field layout was carried out to mark out the appropriate number of treatment plots. The size of each plot in the experiment was 10.0×4.0 m = 40 m^2 (i.e., 10 plants/plot at 2.0 by 2.0 m spacing) and there was nine plots in each replicate. The size of each replicate was therefore 40.0 m^2× 9 = 360 m^2.

The seeds were collected from the wild and pre-germinated in a covered and protected nursery in plastic bags for 6 weeks before they were transplanted on a flat field at a spacing of 2×2 m^2.

Nitrogen fertilizer in form of Urea (46% N) was applied at the rate of 0, 30 and 60 kg N ha^{-1} while phosphorus fertilizer in the form of single superphosphate (18% P) was applied at the rate of 0, 30 and 60 kg$P_2O_5$$ha^{-1}$ (i.e., 0 667 g and 1.33 kg $plot^{-1}$).

Phosphorus fertilizer was applied once at transplanting while nitrogen fertilizer was applied in two split doses, the first half of nitrogen was applied at 2 Weeks after Transplanting (WAT) while the second half was applied at 6 weeks after transplanting.

Glyphosate a systemic and non-selective herbicide was used at the rate of 2.5 kg ha^{-1} to control both annual and perennial weeds at interval of six weeks. The herbicide was carefully applied so that it does not contact with any green part of the tree, including the trunk.

Statistical analysis: The data collected was subjected to statistical analysis of variance (ANOVA) using Statistical Analysis Software (SAS) and the significant treatment means were compared using Duncan Multiple Range Test (Duncan, 1955) at 0.05 level of probability.

RESULTS

Table 1 shows the effect of treatments on the plant height of *Thevetia periviana.* Application of nitrogen fertilizers had no significant effect on plant height at 8WAT but at 16 and 24WAT, application of 30 kg N ha^{-1} gave a taller height although similar with other rates. At all sampling periods, application of Phosphorus fertilizer at 30 kg P_2O_5 ha^{-1} gave taller plants which were statistically similar with other rates except at 8WAT where application of 0 kg P_2O_5 ha^{-1} gave a significantly shorter height.

Varying levels of nitrogen fertilizers from the control to 60 kg N ha^{-1} had no significant effect on number of primary branches at all sampling periods. Increasing phosphorus fertilizer rate from 0 kg P_2O_5 ha^{-1} to 30 kg P_2O_5 ha^{-1} significantly increased number of primary at all sampling periods while further increase to 60 kg P_2O_5 ha^{-1} reduced the number of primary branches which was statistically similar to phosphorus rate of 0 kg P_2O_5 ha^{-1} (Table 2).

Table 1: Effect of rates of nitrogen and phosphorus fertilizers on plant height (cm) of *Thevetia periviana*

	Sampling periods (WAT)		
Treatment	8	16	24
Nitrogen (N) rate (kg ha^{-1})			
0	42.47^a	74.73^a	93.98^a
30	41.38^a	72.36^{ab}	90.38^{ab}
60	40.93^a	70.00^a	87.40^b
SE (±)	0.95	1.23	1.86
Phosphorus (P) rate (kg ha^{-1})			
0	40.13^b	71.40^a	89.49^a
30	43.52^a	73.64^a	92.20^a
60	41.12^a	72.04^a	90.07^a
SE (±)	0.95	1.23	1.86
Interaction			
N×P	N.S	N.S	N.S

Means within a column followed by the same letter do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). *Significant at 5% level of probability. **Significant at 1% level of probability. N.S: Not significant

Table 2: Effect of rates of nitrogen and phosphorus fertilizers on Number of primary branches of *Thevetia periviana*

	Sampling periods (WAT)		
Treatment	8	16	24
Nitrogen (N) rate (kg ha^{-1})			
0	10.47^a	25.47^a	33.04^a
30	10.04^a	25.80^a	32.82^a
60	9.24^a	23.87^a	31.20^a
SE (±)	0.42	0.83	1.04
Phosphorus (P) rate (kg ha^{-1})			
0	8.87^b	22.76^b	29.67^b
30	10.69^a	27.71^a	35.60^a
60	9.93^{ab}	24.67^b	31.80^b
SE (±)	0.42	0.83	1.04
Interaction			
N×P	N.S	N.S	N.S

Means within a column followed by the same letter do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). *Significant at 5% level of probability. **Significant at 1% level of probability. N.S: Not significant

Table 3 shows the stem girth as influenced by rates of nitrogen and phosphorus fertilizers. Increasing nitrogen fertilizer rates from 0-60 kg N ha^{-1} did not significantly affect the stem girth at all sampling periods. Varying levels of phosphorus had a statistically similar effect on stem girth at 16 and 24 WAT but at 8 WAT phosphorus rate of 0 kg P_2O_5 ha^{-1} significantly reduced the stem girth. A significant interaction was observed between nitrogen and phosphorus fertilizers at 8 WAT.

There was a significant interaction between rates of nitrogen and phosphorus fertilizers on stem girth at 8WAT (Table 4). At 8WAT, it was observed that the interaction between fertilizer rates of 30 kg N ha^{-1} and 30 kg P_2O_5 ha^{-1} recorded the widest stem girth while interaction of fertilizer rates 0 kg N ha^{-1} and 0 kg P_2O_5 ha^{-1} recorded the smallest stem girth.

Table 3: Effect of rates of nitrogen and phosphorus fertilizers on Stem girth (cm) of *Thevetia periviana*

	Sampling periods (WAT)		
Treatment	8	16	24
Nitrogen (N) rate (kg ha^{-1})			
0	0.97[a]	1.78[a]	2.11[a]
30	0.99[a]	1.81[a]	2.09[a]
60	0.93[a]	1.71[a]	1.97[a]
SE (±)	0.02	0.04	0.04
Phosphorus (P) rate (kg ha^{-1})			
0	0.90[b]	1.78[a]	2.09[a]
30	1.02[a]	1.79[a]	2.08[a]
60	0.98[a]	1.73[a]	2.01[a]
SE (±)	0.02	0.04	0.04
Interaction			
N×P	N.S	N.S	

Means within a column followed by the same letter do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). *Significant at 5% level of probability. N.S: Not significant

Table 4: Interaction of rates of nitrogen and phosphorus fertilizers on stem girth of *Thevetia peruviana* at 8 WAT

	Phosphorus fertilizer rates		
Nitrogen fertilizer rates	0	30	60
0	0.83[e]	1.02[abc]	1.04[ab]
30	0.97[abcd]	1.05[a]	0.94[bcd]
60	0.90d[e]	0.98[abcd]	0.92[cde]
SE (±)		0.02	

Means followed by the same letter (s) do not differ statistically at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). N.S: Not significant

Table 5: Effect of rates of nitrogen and phosphorus fertilizers on days to flowering of *Thevetia periviana*

Treatment	Days to flowering
Nitrogen (N) rate (kg ha^{-1})	
0	238.44[b]
30	237.00[b]
60	247.33[a]
SE (±)	2.77
Phosphorus (P) ratev (kg ha^{-1})	
0	243.56[b]
30	238.33[a]
60	239.89[a]
SE (±)	2.77
Interaction	
N×P	N.S

Means within a column followed by the same letter do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). *Significant at 5% level of probability. N.S: Not significant

Application of nitrogen fertilizer at the rate of 60 kg N ha^{-1} significantly increased number of days to flowering which differ statistically from nitrogen rate of and 30 kg N ha^{-1} (Table 5). Applied phosphorus fertilizer at 60 kg P_2O_5 ha^{-1} significantly decreased number of days to flowering although did not differ statistically with phosphorus rate of 30 kg P_2O_5 ha^{-1} while the control significantly increased number of days to flowering .

The highest number of days to fruit maturity from flowering was observed on the application of nitrogen fertilizer rate of 60 kg N ha^{-1} although not statistically different from fertilizer rate of 0 kg N ha^{-1} but differ statistically from fertilizer rate of 30 kg N ha^{-1} and similar to the control nitrogen rate. Applying 30 kg P_2O_5 ha^{-1} resulted in reduction in number of days to fruit maturity which was not statistically different from other phosphorus rates (Table 6).

Table 6: Effect of rates of nitrogen and phosphorus fertilizers on number of days to fruit maturity (from flowering) of *Thevetia periviana*

Treatment	Days to fruit maturity
Nitrogen (N) rate (kg ha^{-1})	
0	82.33[ab]
30	76.67[b]
60	84.33[a]
SE (+)	2.22
Phosphorus (P) rate (kg ha^{-1})	
0	83.44[a]
30	79.33[a]
60	80.56[a]
SE (±)	2.22
Interaction	
N×P	N.S

Means within a column followed by the same letter do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). *Significant at 5% level of probability. N.S: Not significant

Table 7: Effect of rates of nitrogen and phosphorus fertilizers on number of harvested mature fruits per plot (ha^{-1}) of *Thevetia periviana*

Treatment	No of harvested fruits
Nitrogen (N) rate (kg ha^{-1})	
0	5,000[a]
30	3,444[ab]
60	2,944[b]
SE (±)	660.65
Phosphorus (P) rate (kg ha^{-1})	
0	1,972[b]
30	3,722[ab]
60	5,694[a]
SE (±)	660.65
Interaction	
N×P	N.S

Means within a column followed by the same letter do not differ significantly at 0.05 level of probability according to Duncan Multiple Range Test (DMRT). *Significant at 5% level of probability. N.S: Not significant

The highest number of fruits was observed in the control (0 kg N ha^{-1}) which was statistically different from nitrogen rates of 60 kg N ha^{-1} but similar in number of harvested fruits with nitrogen rates of 30 kg N ha^{-1}. Application of 60 kg P_2O_5 ha^{-1} gave the highest number of harvested fruits although statistically similar with application rate of 30 kg P_2O_5 ha^{-1} but differ from the control which gave the least number of harvested fruits (Table 7).

DISCUSSION

The result of this study showed that increasing nitrogen fertilizer rate from 0 to 60 kg N ha^{-1} did not positively affect the vegetative growth (plant height, number of primary branches and stem girth) of *Thevetia periviana* plants. It was also observed that number of days to flowering and number of days to fruit maturity from flowering increased with increasing nitrogen fertilizer rates although not significant. This indicates that thevetia plant applied with nitrogen fertilizer flowered late and had delayed or prolonged fruit maturity than the sparingly or unfertilized ones.

The yield of thevetia plant from this experiment was also observed to be suppressed with increasing nitrogen fertilizer. This indicates that excess nitrogen fertilizer had detrimental effect on the yield of thevetia plant. This is in conformity with an experiment by Menzel *et al.* (1994) who opined that excessive nitrogen fertilization will over-invigorate vegetative growth on fruit bearing trees which will reduce light into the canopy and result in reduced flower bud formation and reduced fruit yield. Achten *et al.* (2008) also confirmed that optimal fertilization can increase the seed and oil yield but high fertilization can induce high biomass but low seed production.

In a similar vein, the result indicated that phosphorus fertilizer rate of 30 kg P_2O_5 ha^{-1} resulted a significant tallest plant 8WAT, more number of primary branches and the widest girth. This result indicates that phosphorus is essential for the general health and vigour of thevetia plants and the effect of phosphorus on growth has been reported in several investigations where Das *et al.* (1991) found an increase in black cumin (*Nigella sativa*) height, number of branches and fresh weight and dry weight of shoots and roots with increasing phosphorus concentration from 20 to 40 kg ha^{-1}. This was also supported by Munshi *et al.* (1990), who reported an increase in plant height and number of branches of *Carum carvi* grown from root tubers when phosphorus was applied at the rate of 40 kg ha^{-1}.

Number of days to flowering (7.5-8 months) and number of days to fruit maturity from flowering significantly reduced with application of phosphorus fertilizer. This explained that well fertilized thevetia plants mature earlier (2.5-3 months) than unfertilized one. This could be attributed to the fact that phosphorus fertilizer supplied enough nutrients for vigorous growth, flowering, fruiting and early fruit maturity. This result was supported by Gayle *et al.* (2001), who said that phosphorous fertilizer is an essential nutrient for root formation, flowering, fruiting and ripening. In the same vein Rathore *et al.* (1992) observed that adequate amount of phosphorus in soils favours rapid plant growth, early fruiting/maturity and improve the quality of the produce.

Yield was also found to increase with increasing application of phosphorus fertilizer form 30 kg P_2O_5 ha^{-1} to 60 kg P_2O_5 ha^{-1} which was statistically similar. This showed that phosphorus fertilizer improved flower formation and seed production. This was supported by Armstrong (1988) observed that phosphorus fertilizer increased the strength of cereal straw, stimulates root development and promotes flower formation and fruit production.

CONCLUSION

Based on the overall results of this experiment, it was revealed hat application of controlled nitrogen fertilizer (0 kg N ha^{-1}) produced higher values for plant height, number of primary branches and stem girth while application of 30 kg P_2O_5 ha^{-1} rate of phosphorus fertilizer increased the vegetative growth and yield. Application phosphorus fertilizer rate beyond 30 kg P_2O_5 ha^{-1} will not be economical.

These results therefore concludes that 30 kg P_2O_5 ha^{-1} will be appropriate in enhancing the fruit yield of thevetia peruviana in the southern guinea savannah of Nigeria. This will focus majorly on the second year yield

ACKNOWLEDGMENTS

I wish to acknowledge the contributions of Mr. David Fashiku (Farm manager, Bio-fuel and Alternate Renewable Energy, Ltd) who assisted in carrying out the field work and the in collection of data.

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