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INFLUENCE OF NUTRIENT ELEMENT COMBINATIONS ON THE EARLY GROWTH RESPONSE OF *Parkia biglobosa* IN AN ALFISOL AT FORESTRY RESEARCH INSTITUTE OF NIGERIA

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ABSTRACT

The study was carried out in a screenhouse at the Soils and Tree Nutrition Section of Forestry Research Institute of Nigeria to determine nutrient requirement and record the effect mineral deficiencies and the effect of a super abundance of a particular nutrient under nursery conditions. Degraded soil was collected from within the arboretum of the Institute. The soil was air dried, passed through a 2 mm diameter sieve before being filled into poly-pots of 13cm X 23cm dimension with 2 kg soil capacity. The nutrients solutions were formulated using Minus-one technique (MOET). The experiment was laid out in a completely randomized design with sixteen (16) treatments replicated three (3) times. Plant height, stem diameter, number of leaves and dry matter yield were assessed at two weeks intervals starting from two weeks after transplanting. Data collected were subjected to Analysis of Variance and Means was separated using DMRT at 5% level of probability. The result obtained indicated that the phosphorus available in the initial soil is sufficient to support the plant growth without external supply. Nitrogen deficiency in the –N nutrient solution also significant reduced the plant stem diameter (0.76 – 1.09 mm) from 6 – 16 WAT compared to the results obtained from plants of every other nutrient element combinations during the same period. Meanwhile, from 10 - 16 WAT, the plant supplied with +K nutrient element combination recorded the highest values for stem diameter (3.07 – 4.49 mm) compared to all other nutrient element combinations. It is therefore recommended that nitrogen and potassium is essential for the early growth production of *Parkia biglobosa* in the study.

Keyword: Soil, Nutrient, Growth, Dry matter yield, *Parkia biglobosa*

INTRODUCTION

One of the most critical aspects of soil use and management is the maintenance of soil productivity, which is affected by soil nutrient status or soil fertility [1]. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by organic or inorganic fertilizers. [2]. In plant nutrition, there is a law known as Liebig's law of the minimum. It is named after its author, Justus von Liebig, who said that the growth of a plant is limited by the nutrient that is in shortest supply. Once its supply is improved, the next limiting nutrient controls plant growth. A plant can also produce to its full potential when all nutrients are at an optimal level, i.e. without any deficiencies or excesses. In order to produce high yields, plant nutrition requires a continuous effort to eliminate minimum factors and provide balanced nutrition in the optimal range. Recently a biological method known as minus-one element technique (MOET) was developed by PhilRice [3, 4, 5]. MOET is based on the principle that plant growth responds to the most limiting nutrients. Results of past studies [3] showed that MOET was able to identify deficiencies, which could not be checked by soil analysis. Parkia biglobosa is a dicotyledonous angiosperm that belongs to the family of fabaceae, it is categorized under spermatophytes, vascular plants [6]. It is a deciduous perennial that grows up to seven to twenty meters high. The tree of parkia biglobosa is a fire resistant heliophyte with thick dark gray – brown bark. The pods are commonly referred as locust beans, about 30-40 centimeters long on average with some reaching length of about 45 centimeters. The seed of this tree is very rich in nutrient like protein (35%), lipid (29%), and carbohydrate (16%), it also serve as good source of fat and calcium for rural dwellers [7]. The fruit pulp leaves and seeds are used to feed livestock and poultry. The flowers are attractive to bees which serve as a good source of nectar [8]. The seed also serve as source of income to many women when it is sold after processing to be used as part of food ingredient [9]. It is use for treating hypertension, as anti-malarial plant and also for wound healing [10]. Application of the knowledge of optimum nutrient requirement of tree species is expected to improve the economic productivity [11]. Hitherto there is paucity of information on soil nutrient requirement of these species compared to those of agricultural crops. In this context the study was conducted to determine nutrient requirement and record the effect mineral deficiencies and the effect of a super abundance of a particular nutrient under nursery conditions.

METHODOLOGY

The study was carried out in a screenhouse at the Soils and Tree Nutrition Section of Forestry Research Institute of Nigeria, (FRIN) located on the longitude 07 ^{o} 23'18"N to 07 ^{o} 23'43"N and latitude 03 ^{o} 51'20"E to 03 ^{o} 23'43"43E [12]. Degraded soil was collected from within the arboretum of the Institute. The soil was air dried, passed through a 2 mm diameter sieve before being filled into poly-pots of 13cm X 23cm dimension with 2 kg soil capacity. Pre-germinated seedlings in top soil were then transplanted at 4 leaves stage into the pre-filled poly pots and were watered with nutrients solution. The nutrients solutions were formulated using Minus-one technique (MOET) [4]. The nutrients used were Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Zinc and Boron. Stock solutions of each nutrient were prepared and nutrients solution used was then prepared using 1ml of stock/l of distilled water. The experiment was laid out in a completely randomized design with sixteen (16) treatments replicated three (3) times. The treatment definition/ summary of nutrients solution composition were presented in Table1.

Table1. Treatments/summary of nutrient solution composition

S/NO	Treatment	KNO_3	$Ca(NO_3)_2$	$Cacl_2$	K_2SO_4	$MgSO_4$	$Mg(NO_3)_2$	NaH_2PO_4	ZnO	BO_4^-
1	Complete	✓	✓	-	-	✓	-	✓	✓	✓
2	-N	-	-	✓	✓	✓	-	✓	✓	✓
3	-P	✓	✓	-	-	✓	-	-	✓	✓
4	-K	-	✓	-	-	-	✓	✓	✓	✓
5	-Ca	✓	-	-	-	-	✓	✓	✓	✓
6	-Mg	✓	✓	-	-	-	-	✓	✓	✓
7	-Zn	✓	✓	-	-	✓	-	✓	-	✓
8	-B	✓	✓	-	-	✓	-	✓	✓	-
9	+N	✓	✓	-	-	-	✓	✓	✓	✓
10	+P	✓	✓	-	-	✓	-	✓✓	✓	✓
11	+K	✓	✓	-	✓	✓	-	✓	✓	✓
12	+Ca	✓	✓	✓	-	✓	-	✓	✓	✓
13	+Mg	✓	-	✓	-	✓	✓	✓	✓	✓
14	+Zn	✓	✓	-	-	✓	-	✓	✓✓	✓
15	+B	✓	✓	-	-	✓	-	✓	✓	✓✓
16	Control	-	-	-	-	-	-	-	-	-

The growth variables: plant height, stem diameter, number of leaves and dry matter yield were assessed at two weeks intervals starting from two weeks after transplanting. Data collected were subjected to Analysis of Variance and Means was separated using DMRT at 5% level of probability.

RESULTS AND DISCUSSION

The soil used for the research was loamy sand [13], However, the soil was deficient in total nitrogen [14] and had low available P content [15],[16] which could retard crop development (Table 2).

Table 2: Initial soil analysis

S/N	PARAMETERS	VALUES
1	Na (Cmol/kg)	1.35
2	K (Cmol/kg)	0.0010
3	Ca (Cmol/kg)	0.75
4	Cu (mg/kg)	8.63
5	Zn (mg/kg)	14.12
6	Mn (mg/kg)	67.37
7	Fe (mg/kg)	27.5
8	Avail. P (mg/kg)	4.1
9	O.C (%)	2.07
10	T.N (%)	0.18
11	pH (1:2)	6.23
12	% Sand	80.50
13	% Silt	8.8
14	% Clay	10.7

The results on the effect of plant nutrient elements combination on the early growth response of *Parkia biglobosa* showed that different combinations of the nutrients significantly affected the plant growth response at successive growth stages. At 2 - 10 weeks after transplanting (WAT), the plant height obtained from the plant in the control soil (without nutrient application) recorded the highest plant height (19.07 – 24.02 cm) compared with others while the least height (6.67 – 7.07 cm) during the same period was observed from -N nutrient solution (Table 3). This showed that at such an early stage, the concentration of each nutrients in the plant system were adequate except for nitrogen which is required in large quantity for rapid vegetative growth [16].The inhibited growth observed with the –N nutrient solution could also be attributed to a negative interaction of nutrient elements in the absence of nitrogen which had also reduced the demand for other nutrient elements by the plant [17]. From 12 – 16 WAT, plant height obtained from the plant supplied with –P recorded the highest plant height (25.00 – 26.50 cm) that is significantly higher than those supplied with –N and +Zn nutrient solutions (7.57, 8.47 and 14.67 cm) at 12 – 16 WAT respectively (Table 3). This suggests that the phosphorus concentration in the initial soil is sufficient for the growth of *Parkia biglobosa* while further increase (luxury) did not translate to higher plant height

Table 3: Effect of nutrient combinations on *Parkia biglobosa* plant height (cm)

Treatment	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT	14WAT	16WAT
B-	16.67^{ab}	19.50^{ab}	20.37^{a}	23.00^{a}	23.67^{ab}	25.23^{a}	25.67^{a}	25.33^{ab}
B+	17.00^{ab}	18.17^{ab}	18.67^{ab}	19.63^{ab}	20.50^{ab}	20.67^{a}	21.73^{a}	21.70^{ab}
Ca-	14.10^{ab}	16.00^{ab}	16.20^{ab}	18.33^{ab}	19.57^{ab}	21.40^{a}	22.93^{a}	23.73^{ab}
Ca+	18.50^{ab}	20.00^{ab}	21.17^{a}	23.00^{a}	24.30^{a}	24.70^{a}	24.50^{a}	24.10^{ab}
CP	15.33^{ab}	18.63^{ab}	19.77^{a}	20.83^{ab}	21.23^{ab}	22.27^{a}	23.73^{a}	24.00^{ab}
CT	19.07^{a}	21.00^{a}	22.30^{a}	23.50^{a}	24.20^{a}	24.27^{a}	24.83^{a}	25.17^{ab}
K-	13.27^{bc}	14.43^{b}	15.17^{ab}	16.50^{ab}	17.90^{ab}	18.00^{a}	18.13^{ab}	19.60^{ab}
K+	16.83^{ab}	18.33^{ab}	20.03^{a}	21.67^{ab}	22.03^{ab}	22.87^{a}	23.30^{a}	23.50^{ab}
Mg-	15.17^{ab}	17.40^{ab}	18.47^{ab}	19.53^{ab}	20.93^{ab}	21.50^{a}	22.07^{a}	22.33^{ab}
Mg+	15.50^{ab}	17.93^{ab}	18.67^{ab}	18.77^{ab}	20.57^{ab}	22.13^{a}	23.77^{a}	25.30^{ab}
N-	06.67^{c}	6.77^{c}	6.83^{c}	6.93^{c}	7.07^{b}	7.57^{b}	8.47^{b}	8.67^{bc}
N+	16.30^{ab}	19.83^{ab}	20.43^{a}	21.87^{ab}	23.07^{ab}	23.33^{a}	24.30^{a}	24.60^{ab}
p-	17.40^{ab}	19.23^{ab}	19.90^{a}	22.07^{ab}	22.90^{ab}	25.00^{a}	26.50^{a}	26.50a
P+	15.00^{ab}	16.60^{ab}	17.17^{ab}	19.00^{ab}	20.73^{ab}	22.17^{a}	22.40^{a}	23.00^{ab}
Zn-	13.33^{abc}	15.40^{ab}	16.17^{ab}	18.83^{ab}	20.60^{ab}	20.90^{a}	20.83^{a}	21.47^{ab}
Zn+	11.00^{c}	14.27^{b}	10.57^{bc}	12.83^{bc}	13.50^{bc}	14.77^{ab}	14.77^{ab}	14.67^{bc}

Means followed by the same letter in each column are not significantly different from each other (P>0.05)

Furthermore, Nitrogen deficiency in the –N nutrient solution also significantly reduced the plant stem diameter (0.76 – 1.09 mm) from 6 – 16 WAT compared to the results obtained from plants of every other nutrient element combinations during the same period (Table 4). Meanwhile, from 10 - 16 WAT, the plant supplied with +K nutrient element combination recorded the highest values for stem diameter (3.07 – 4.49 mm) compared to all other nutrient element combinations (Table 4). This is in line with the submission of [18] that Adequate K level is essential for the efficient use of N in crop plants, which in turn could be responsible for the increase in the plant stem diameter.

Table 4: Effect of nutrient combinations on *Parkia biglobosa* plant Stem diameter (mm)

Treatment	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT	14WAT	16WAT
B-	2.25^{ab}	2.33^{ab}	2.41^{a}	2.44^{a}	2.85^{a}	3.31^{ab}	3.51^{ab}	4.01^{a}
B+	2.12^{ab}	2.19^{ab}	2.34^{a}	2.503^{a}	2.73^{a}	3.07^{ab}	2.94^{ab}	3.62^{a}
Ca-	1.82^{bc}	1.94^{abc}	2.21^{ab}	2.10^{a-d}	2.25^{ab}	2.70^{ab}	2.84^{ab}	3.41^{a}
Ca+	2.167^{ab}	2.23^{ab}	2.36^{a}	2.46^{a}	2.83^{a}	3.3^{ab}	3.65^{a}	4.03^{a}
CP	2.1^{ab}	2.23^{ab}	2.31^{a}	2.34^{a}	2.70^{ab}	3.10^{ab}	3.12^{ab}	3.76^{a}
CT	1.95^{abc}	2.07^{abc}	2.18^{ab}	2.24^{a-d}	2.66^{ab}	2.92^{ab}	3.13^{ab}	3.71^{a}
K-	1.91^{abc}	2.03^{abc}	2.17^{ab}	2.06^{a-d}	2.19^{ab}	2.65^{ab}	2.85^{ab}	3.27^{a}
K+	2.12^{ab}	2.36^{a}	2.41^{a}	2.51^{a}	3.07a	3.53^{a}	3.61^{ab}	4.49^{a}
Mg-	2.09^{ab}	2.34^{ab}	2.62^{a}	2.28^{ab}	2.41^{ab}	2.78^{ab}	3.21^{ab}	3.68^{a}
Mg+	2.07^{abc}	2.31^{ab}	2.48^{a}	2.52^{a}	2.90^{a}	2.83^{ab}	3.10^{ab}	3.64^{a}
N-	1.73^{bc}	1.28^{c}	0.76^{c}	0.79^{d}	0.94^{c}	0.98^{c}	0.93^{c}	1.09^{b}
N+	1.91^{abc}	2.12^{ab}	2.26^{a}	2.15^{a-d}	2.46^{ab}	2.97^{ab}	3.03^{ab}	3.68^{a}
p-	2.02^{abc}	2.11^{ab}	2.34^{a}	2.283^{abc}	2.46^{ab}	2.77^{ab}	3.22^{ab}	3.47^{a}
P+	1.95^{abc}	2.23^{ab}	2.29^{a}	2.24^{a-d}	2.51^{ab}	2.80^{ab}	3.19^{ab}	3.53^{a}
Zn-	2.55^{a}	2.61^{a}	2.69^{a}	2.42^{a}	2.6^{ab}	3.11^{ab}	3.38^{ab}	4.39^{a}
Zn+	1.42^{c}	1.50^{bc}	1.29^{ab}	1.287^{bcd}	1.36^{bc}	1.87^{bc}	2.11^{bc}	2.77^{a}

Means followed by the same letter in each column are not significantly different from each other ($P>0.05$)

Similarly, adequate level of N and P was shown to increase the plant's number of leaves (29) but the plant with –B nutrient combination had an average of 33 leaves at the end of the study (Table 5). This suggests that boron is most likely to have an antagonistic effect on the leave production of *Parkia biglobosa.* The plant supplied with –N nutrient solution also recorded the least number of leaves throughout the study (Table 5). This further confirms the essentiality of nitrogen in plant production.

Table 5: Effect of nutrient combinations on *Parkia biglobosa* plant number of leaves

Treatment	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT	14WAT	16WAT
B-	12^{a}	17^{a}	19^{ab}	24^{a}	29^{a}	31^{a}	32^{a}	33^{a}
B+	12^{a}	16^{ab}	17^{ab}	20^{a}	22^{a}	26^{ab}	29^{a}	23^{ab}
Ca-	11^{a}	14^{ab}	16^{ab}	23^{a}	27^{a}	28^{ab}	31^{a}	27^{a}
Ca+	13^{a}	15^{a-d}	18^{ab}	22^{a}	25^{a}	28^{ab}	24^{a}	25^{ab}
CP	13^{a}	18^{a}	18^{ab}	22^{a}	25^{a}	25^{ab}	25^{a}	27^{a}
CT	11^{a}	14^{a-d}	16^{ab}	19^{a}	23^{a}	25^{ab}	24^{a}	26^{ab}
K-	12^{a}	13^{a-d}	15^{ab}	21^{a}	25^{a}	28^{ab}	28^{a}	23^{ab}
K+	11^{a}	15^{a-d}	21^{a}	25^{a}	27^{a}	29^{ab}	28^{a}	25^{ab}
Mg-	13^{a}	13^{a-d}	16^{ab}	20^{a}	26^{a}	26^{ab}	24^{a}	20^{ab}
Mg+	10^{a}	13^{a-d}	15^{ab}	21^{a}	24^{a}	30^{ab}	27^{a}	26^{ab}
N-	9^{a}	4^{d}	6^{c}	6^{b}	6^{b}	7^{ab}	9^{b}	11^{b}
N+	10^{a}	12^{a-d}	15^{ab}	20^{a}	21^{a}	28^{ab}	28^{a}	29^{a}
P-	11^{a}	14^{a-d}	15^{ab}	16^{ab}	21^{a}	24^{ab}	24^{a}	25^{ab}
P+	14^{a}	16^{a-c}	18^{ab}	22^{a}	24^{a}	29^{ab}	29^{a}	29^{a}
Zn-	11^{a}	15^{a-d}	18^{ab}	23^{a}	26^{a}	29^{ab}	27^{a}	27^{a}
Zn+	9^{a}	8^{b-d}	10^{bc}	15^{ab}	17^{ab}	18^{b}	20^{bc}	18^{ab}

Means followed by the same letter in each column are not significantly different from each other (P>0.05)

Table 6 shows the effect of nutrient elements combination on the shoot and root dry matter yield (DMY) of *Parkia biglobosa*. There was no significant difference in the shoot DMY data obtained but the plant supplied with +K and +N recorded the highest DMY (2.05 and 2.15 g) compare to those of –N and +Zn (0.77 and 0.92 g) that have the least values while similar trend was also repeated in the plant root DMY where plant supplied with +K recorded a significantly higher root DMY (1.90 g) compare to that of +Zn (0.74 g) (Table 6).

Table 6: Effect of nutrient combinations on *Parkia biglobosa* plant dry matter yield (g)

Trt	SHOOT	ROOT
B-	1.59	1.59^{ab}
B+	1.71	1.48^{ab}
Ca-	1.19	1.75^{ab}
Ca+	1.66	1.56^{ab}
Cp	1.32	1.14^{abc}
CT	1.59	1.64^{ab}
k-	1.67	1.15^{abc}
k+	2.05	1.90^{a}
Mg-	1.37	1.63^{ab}
Mg+	1.59	1.73^{ab}
N-	0.77	0.39^{c}
N+	2.15	1.73^{ab}
p-	1.69	1.79^{ab}
P+	1.46	1.23^{abc}
Zn-	1.30	1.27^{abc}
Zn+	0.92	0.74^{bc}

Means followed by the same letter in each column are not significantly different from each other (P>0.05)

CONCLUSION AND RECOMMENDATIONS

Parkia biglobosa early growth response was inhibited with the absence of nitrogen in the nutrient solution concentration while the absence of phosphorus in the solution applied was not a limiting factor affecting the plant early growth with resultant higher plant height. Increase in Nitrogen and Potassium concentrations in the applied nutrient solutions improved the plant shoot dry matter yield while plant root dry matter yield was improved significantly with application of excess potassium. It is therefore recommended that nitrogen and potassium is essential for the early growth production of *Parkia biglobosa* in the study.

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