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MODELING THE GROWTH RATES OF AFRICAN YAM BEAN (*Sphenostyles stenocarpa*) FOLLOWING APPLICATION OF FERTILIZERS

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ABSTRACT
The effect of fertilizer on the performance of three cultivars of African Yam Bean (AYB), Benue Brown (BB) and Emure White (EW) were evaluated in a pot and field trials. The fertilizers were applied as complete NPK (20-10-10) to the soil at the rate of 0 kg/ha, 30 kg/ha, 60 kg/ha, 90 kg/ha and 120kg/ha at planting. Plant vegetative characteristics, dry matter (DM), accumulation and yield characteristics increase progressively as NPK level increased up to 60 kg NPK per hectare before declining in pot and field experiments. The calculated growth rates: Net assimilation rate (NAR); Absolute growth rate (AGR); Crop growth rate (CGR); Relative growth rate (RGR); Specific leaf area (SLA); Leaf weight ratio (LWR); Leaf area duration (LAD) and Leaf area index (LAI) responded positively to NPK fertilization. From this study, it is evident that AYB responded positively to soil applied and 60 kg NPK/ ha seems adequate for optimum growth, flowering, pod formation of the crop under local conditions.

INTRODUCTION
The early growth of AYB (Sphenostyles stenocarpa) in Nigeria is slow. Applying fertilizers to enhance the early vegetative development of the crop might therefore improve growth, development and yields. Soil application of chemical fertilizers has also been found to produce varied responses in pigeon pea (Cajanus cajan) depending on the time and type of fertilizer (Chowdhury and Bhata, 1971; Abram, Morales and Julia, (1978), Andrews and Manajuti, (1980); Ogunwale and Olaniyi (1981). Tayo and Togun (1984). Several authors (Lathwell and Evans, (1951), Hashimoto and Yamamoto (1970); Mann and Jaworski, (1970) and Hashimoto (1971) have indicated the critical importance of adequate fertilizer to high yield during vegetative development, flowering and seed set in Soyabean (Glycine max). On the other hand, there are no reports yet on the effect of soil applied fertilizer on the performance of AYB. The responses of AYB cultivars to soil applied NPK were examined in pot and field experiments.

MATERIALS AND METHODS
The two cultivars of AYB; Benue Brown (BB) and Emure White (EW) were obtained from the crop physiology unit, Department of crop protection and Environmental Biology, University of Ibadan, Nigeria, and include those whose reproductive development has been described by Togun and Egunjobi (1997).

Pot Experiment
Seeds of BB and EW cultivars of AYB were sown in pots containing moist soil on June 28th 1994 and the seedlings were thinned to one per pot and each plant supported by a stake. The soil was a sandy loam belonging to Ibadan soil series. The experimental design was Randomized Complete Block (RCBD) with four replicates. Each cultivar had five fertilizer levels as treatment designated $T_1 – T_5$. a single dose of treatment of treatment of NPK fertilizer (20- 10- 10) was applied in the pots in bounds. The weight of soil/pot was 6.85

kg. The rate of NPK fertilizer applied per pot to give the equivalent rate per hectare of N, P and K were 0, 30, 60, 90 and 120 kg NPK per hectare. The amount of fertilizer applied per pot to give the equivalent rate per hectare of N, P and K were 0, 0.51g, 1.02g, 1.53g and 2.04g. the numbers of flower that opened or aborted per plant and total number of pods produced were determined on plants per treatment, two plants representing 1 replicate were assessed, that is, 30 potted plants were tagged for flower production, 40 each for (BB) and EW. At plant maturity, the growth characteristics; number of leaves per plant; stem length, number of primary and secondary branches, number of nodes as well as the following yield parameters were determined; number of pods produce per pod, dry weight of 100 seed, total seed dry weight, husk dry weight, pods dry weight and the leaf dry weight after oven dry to constant weight (at 80^oC for 48 hours). Soil sample were collected at the start of experiment and soil chemical and mechanical analysis carried out as per the standard laboratory (IITA, 1979). The result is presented in Table I.

Table 1: PRE-PLANTING SOIL ANALYSIS

Soil properties	Values
PH (H_2O)	6.5
Organic carbon (%)	2.1
Total N (%)	0.08
Available P (ppm)	7.09
Exchangeable Ca (meq/100g)	3.92
Exchangeable Ca (meq/100g)	0.42
CEC (meq/100g)	6.02
Extractable Mn (ppm)	120.00
Extractable Fe (ppm)	30.00
Extractable Cu (ppm)	0.35
Extractable Zn (ppm)	7.77
Extractable Bo (ppm)	11.20
% Sand	91.30
% Silt	6.20

Field experiment

The experiment was done at the University of Ibadan experimental Farm. Seeds of CVs, BB and EW were sown in flat, that is, unridged 11.4 x 27 m plot at a spacing of 0.6m between rows and 0.4m within rows on 7th July, 1994. For the soil fertilizer treatment, 0; 30; 60; 90 and 120 kg NPK were applied to the soil 4 WAS in a single fertilizer dosage using NPK (20- 10- 10). The corresponding quantity of NPK (20- 10- 10) fertilizer applied in field were 0g row^{-1} (T_1), 51.3g row^{-1} (T_2), 02.6g row^{-1} (T_3), 153.9g row^{-1} (T_4), 205.2g row^{-1} (T_5). The experimental design used was RCBD with four replicates. The same sampling and measurements as described for the pot experiment were made using 10 plants taken randomly from each replicate. Seed yield was estimated from 20 plants per replicate.

Statistical Analysis

The data from both the pot and field experiments were subjected to analysis of variance from which the least significance difference (LSD) at 5% level was calculated.

RESULTS

In pot grown plants; the leaf areas, number of branches and total dry weight plant^{-1} increased with increasing level of NPK up to 60kg ha^{-1} and thereafter declined with further increase in applied fertilizer (Figure 1). All other growth characteristics; Net Assimilation Rate (NAR), Absolute Growth Rate (AGR), Relative Growth Rate (RGR), Specific Leaf Area (SLA), Leaf Weight Ratio (LWR), Leaf Area Duration (LAD) and Leaf Area Index increase followed the same pattern. There was a linear relationship between the level of fertilizer application and Absolute Growth Rate (AGR) up till19th week after sowing, the period of active pod formation, pod falling and dry matter accumulation and partitioning. AGR was obtained with 60 kg/ha NPK (Figure 2). The RGR increased rapidly from 15 – 19 week after sowing and then declined (Figure 2). There was significant difference between the RGR of 60 kg/ha NPK and other levels of treatment. Like the AGR, the application of 60 kg NPK resulted in the highest dry matter (DM) production. The highest Net Assimilation Rate (NAR) was obtained 19th week after sowing (figure 2) there was significant difference between NAR value for 60 kg NPK ha^{-1} and other levels of fertilizer application. Lowest NAR value was obtained in the control plot. That is, 0 kg NPK ha^{-1}

Table 2: Flower and Pod Formation Characteristics of AYB (BB and EW) following Application of Fertilizers in Pot Experiment

	Fertilizer Level					
	T_1	T_2	T_3	T_4	T_5	LSD(P=0.05)
No of (BB) opened flower	330	345	370	365	360	9.81
(EW)	312	320	345	330	321	6.52
No of (BB) flowers That formed pod	169	173	`192	201	196	5.56
(EW)	152	158	174	180	175	4.93
No of (BB) Matured Pods	102	108	125	120	116	4.37
(EW)	93	97	104	72	65	5.67
Open (BB) Flower Forming Matured Pods%	30.90	31.30	34.43	34.25	32.22	0.02
(EW)	29.81	28.12	30.14	21.81	20.25	4.59

Values = mean of 40 plants

T_1= 0 kg NPK ha^{-1}, T_2= 30 kg NPK ha^{-1}, T_3= 60 kg NPK ha^{-1}, T_4= 90 kg NPK ha^{-1}, T_5=120 kg NPK ha^{-1}

Table 3: Flower and Pod Formation Characteristics of AYB (BB and EW) Following Application of Fertilizers in Field Experiment

Fertilizer Level kg/ha

	T_1	T_2	T_3	T_4	T_5	LSD(P=0.05)
No of opened flower (BB) (EW)	659 640	669 662	728 709	684 679	679 672	21.88 18.32
No of flowers That formed pod (BB) (EW)	324 320	378 331	398 354	367 340	325 336	27.57 10.44
No of Matured Pods (BB) (EW)	192 189	217 195	253 209	248 201	221 198	20.57 5.65
Open flower Forming Matured Pods% (BB) (EW)	29.13 29.53	32.43 29.45	34.75 29.47	36.25 29.60	32.54 29.46	

Values = mean of fourty plants
T_1= 0 kg NPK ha^{-1}, T_2= 30 kg NPK ha^{-1}, T_3= 60 kg NPK ha^{-1}, T_4= 90 kg NPK ha^{-1}, T_5=120 kg NPK ha^{-1}

Flower formation in the pot experiments was low for all levels of fertilizer application compared with what was obtained in the field experiments (Tables 2 and 3). Flower formation was low in the pot experiment as a result of the restriction placed on the plants in terms of soil volume availability. However, flower formation was enhanced by fertilizer application in both cultivars under field condition (Table 3). The highest number of open flowers was recorded under 60 kg NPK ha^{-1} in both pot and field experiments (Tables 2 & 3). The percentage of matured pods formation from open flowers was higher at 90 kg NPK ha^{-1} in both pot and field experiments, both results were recorded for BB cultivar of AYB. This seems to suggest a more positive response to fertilizer application in BB and EW.

DISCUSSION

The application of fertilizer enhanced the growth characteristics of AYB in the pot and on the field. AYB responded positively to fertilizer application in the field experiment than pot experiment. Pods formation for both cultivars; BB and EW were lower in the pots than in the field (Tables 2 & 3). But the application of 60 kg NPK ha^{-1} in both experiments seems adequate for optimum productive pod formation.

Pod formation of the field grown AYB showed positive response to NPK application. Increasing the level of application above 60 kg NPK ha^{-1} led to reduction in the number of pods formed, this suggest that AYB does not require high level of N-application for optimum pod formation.

The total dry weights of the different plant parts increased progressively with age of the plants. Empty were higher in fertilized plants than the control plants. There were significant differences between the total dry weight $plant^{-1}$ at each stage of growth (Figure 1). Pods dry weight $plant^{-1}$ was highest in the plants with 60 kg NPK ha^{-1} and lowest in the plants with 120 kg NPK ha^{-1}. There was no significant difference between the pod dry weight $plant^{-1}$ of the 0 kg NPK ha^{-1} and120 kg NPK ha^{-1} (Figure 1).

The application of varying levels of NPK fertilizer exert considerable influence on calculated growth rates of AYB under field conditions. The Absolute Growth Rate (AGR) almost double with increasing level of fertilizer application. The highest AGR was obtained with the application of 60 kg NPK $plant^{-1}$. Maximum AGR was obtained 19^{th} week after sowing, the period of active pod formation and partitioning to meet the demand for productive capacity. The Relative Growth Rate (RGR) like the AGR was highest with the application of 60 kg NPK ha^{-1}. RGR increased rapidly from 15^{th} -19^{th} week after sowing and then declined (Figure 2). There was significant difference between the RGR of the 60 kg NPK ha^{-1} plants and other levels of fertilizer application. The Net Assimilation Rate (NAR) was highest at the period of active reproductive development, that is, 19^{th} week after sowing in AYB. The application of 60 kg NPK ha^{-1} had the highest NAR and hence the most efficient leaf surface for photosynthetic activity. There was significant difference between the NAR value for 60 kg NPK ha^{-1} and other levels of NPK application (Figure 2). The Leaf Area Index (LAI) was similar for all levels of fertilizer application in the field grown AYB and was significantly different at all stages of the plant growth. LAI was fairly constant between 15^{th} - 19^{th} weeks after sowing, the period of active reproductive growth (Figure 2). The Specific Leaf Area (SLA) was highest with the application of 60 kg NPK ha^{-1} and significantly different from the SLA for other levels fertilizer application (Figure 2).

The application of NPK to AYB influences the Leaf Area Duration (LAD). The application of 60 kg NPK ha^{-1} had the highest LAD (Figure 2).

The response of field grown AYB to NPK in terms of dry matter production varied. Although, NPK application improves dry matter production, dry weight decreased towards maturity. Yield in many crops may be found to depend on growth rate which is the product of LAI, NAR and Harvest Index (HI), which is the proportion of Dry Matter (DM) partitioned from the total biological yield into commercial unit of yield. The result of this experiment indicates that the application of 60 kg NPK ha^{-1} enhanced LAI and NAR than any other level of application. This suggests that, for optimum economic yield in AYB, the application of 60 kg NPK ha^{-1} might be adequate.
There were similarities in the NAR, RGR and CGR at all levels of application (Figure 2). This is in line with the findings of Tayo (1982), when he obtained similarities in the NAR,

RGR and CGR of pigeon pea under different population densities and concluded that calculated growth rates play nominal role in the expression of treatment effects on crops. This also seems to be true of AYB. LAR was similar for all levels of NPK application and declined progressively towards maturity (Figure 2d). This is an indication that varying the nutrients status of the soil did not affect the relationship between leaf area development and the shift in the DM partitioning to other plant parts.

LAI has been related to AGR and has been found to be high when AGR is high (Harper, 1983). The result of this experiment support this assertion as highest values for both AGR and LAI were obtained 19^{th} week after sowing. LAD was similar at all levels of NPK fertilizer application (Figure 2f). This suggest that varying the level of NPK application might not alter the pattern of leaf formation and duration (leaf persistence) in AYB, but treatments which prolong leaf persistence in an active phase has been found capable of increasing yield. The significant difference between the LAD values of plants with 60 kg NPK per hectare and other levels of treatment between 15^{th} – 19^{th} weeks after sowing supports this assertion. LWR pattern was similar for all treatments. The result indicates an inverse relationship between leaf weight and age of AYB. This is expected since LWR decreased as plant advanced in growth (Figure 2c). This is also indicative that the LWR pattern may not be altered by applied nutrients. What is feasible however, is the promotion of crop leafiness by variation of treatment levels. The SLA for AYB under field conditions in response to applied treatments was varied. This suggest that nutrient supply to soil exert great influence on the leaf area through the promotion of growth of large leaves and hence the photosynthesis ability of the crop.

The high SLA value for the 60 kg NPK per hectare early in the experiment might thus be an indication of an efficient use of applied nutrient for the promotion of early foliage development, improved photosynthetic ability and subsequent yield improvement of AYB responded positively to NPK application under field conditions (Figure 2e). Improved nutrition reduced flower shedding and promotes productive pod formation. What is not clear however, is if the timing of NPK at the reproductive phase would have yielded more positive results as suggested by Lathwell and Evans (1951); Hashimoto and Yanomato (1970); Mann and Jaworski (1970) and Hashimoto (1971), who indicated the critical importance of nitrogen to high yield during vegetative development, flowering and seed set.

It could be concluded that under prevailing local conditions, the promotion of early vegetative growth and optimum reproductive development of AYB, NPK fertilizer application of 60 kg ha^{-1} is adequate.

ACKNOWLEDGEMENT

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Figure 1

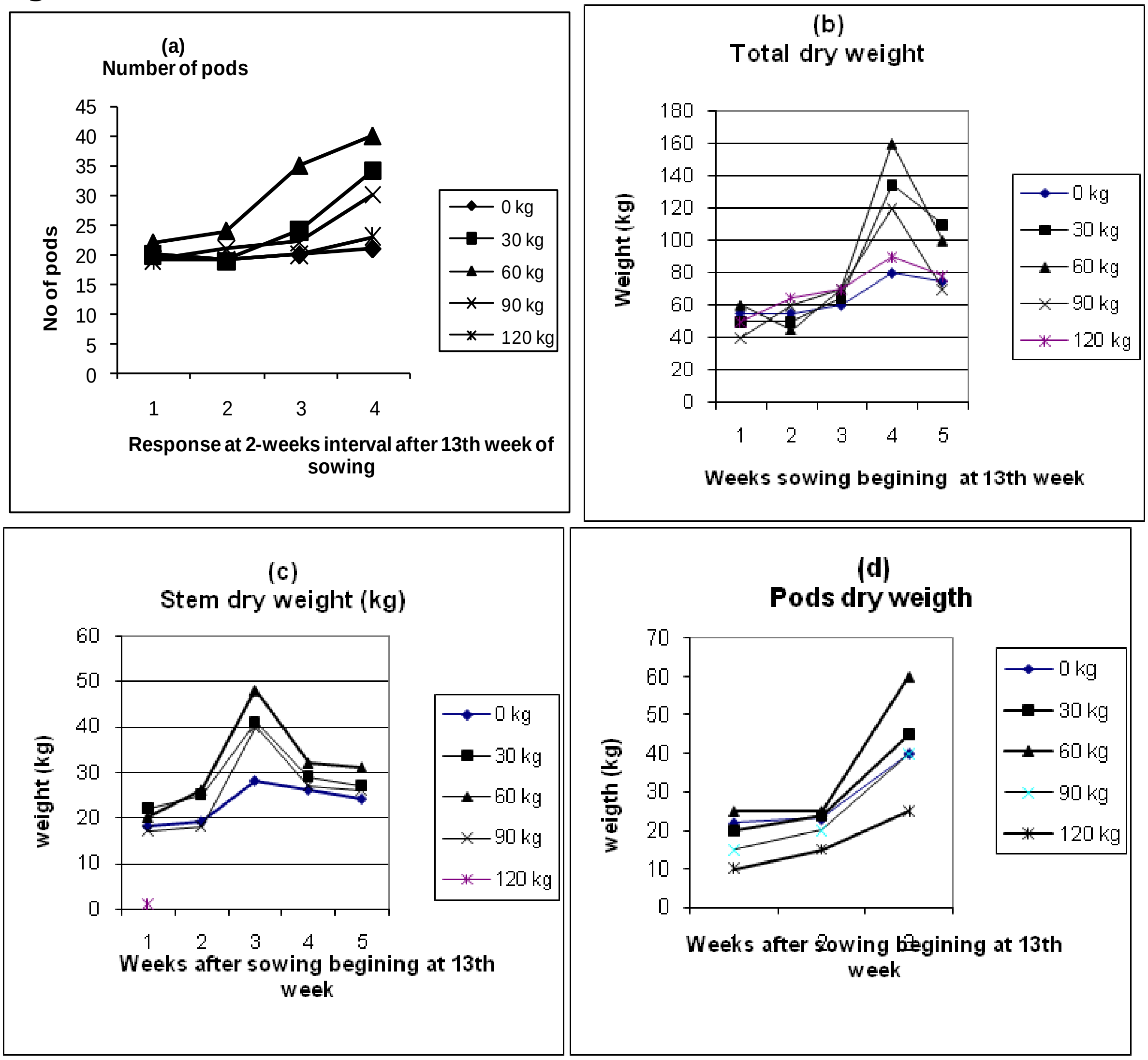
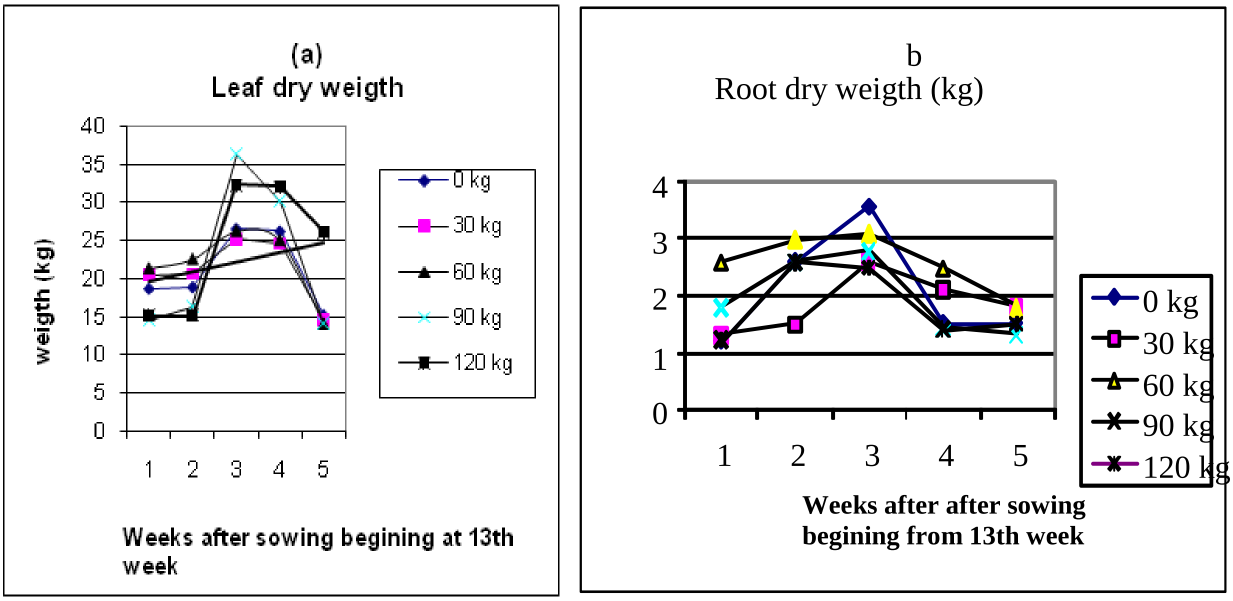
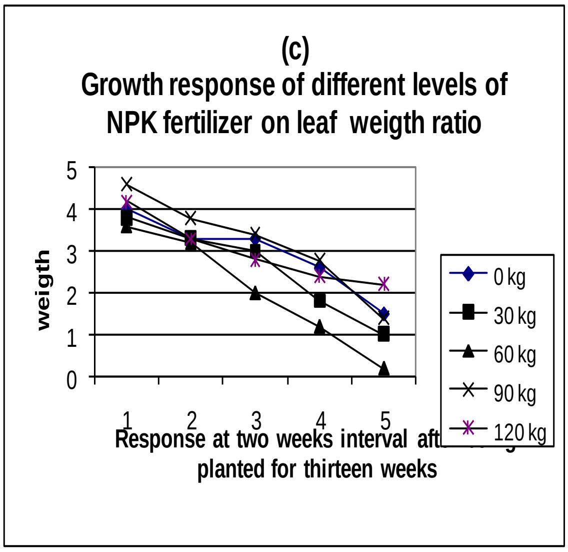
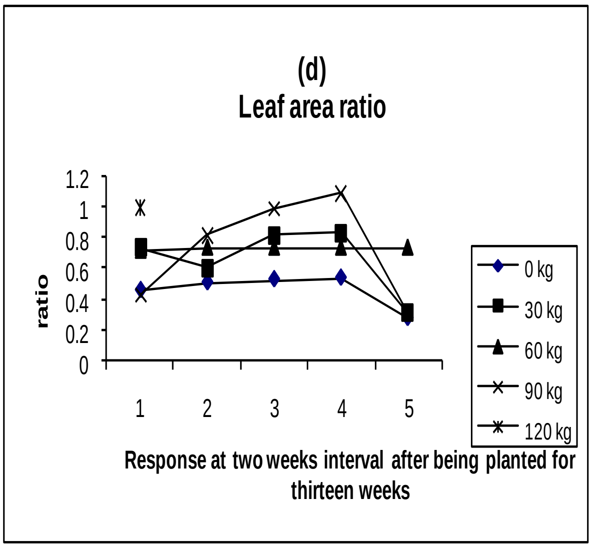
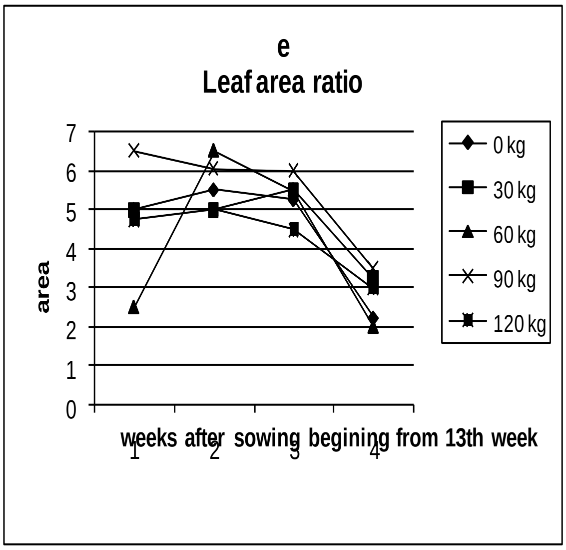


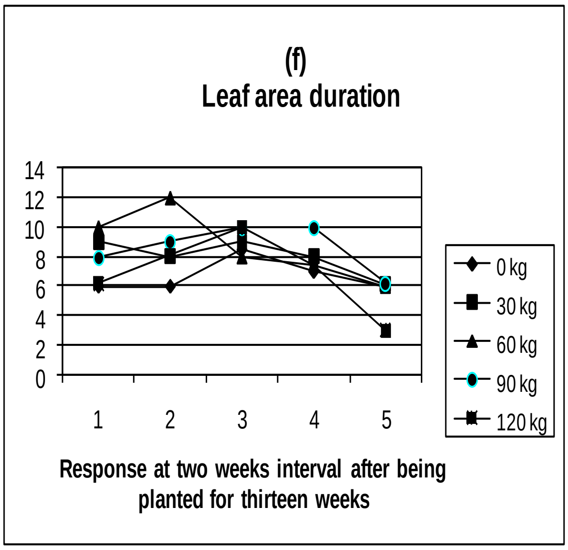
Figure 2

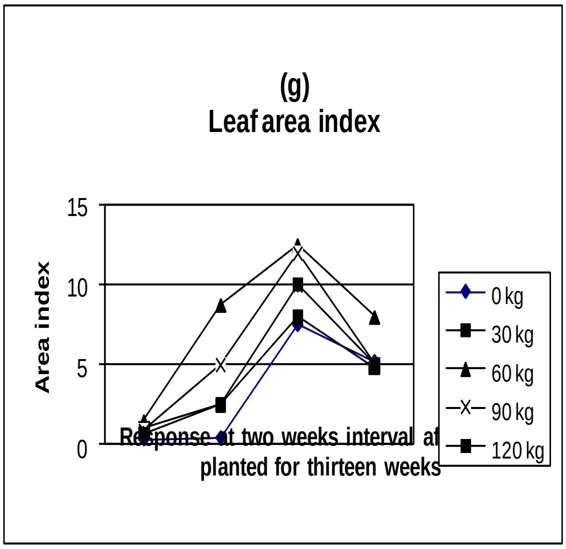


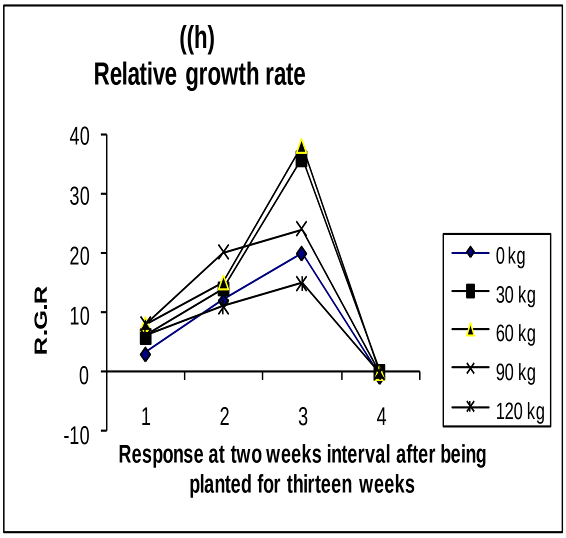

(c)
Growth response of different levels of NPK fertilizer on leaf weigth ratio
weigth
5
4
3
2
1
0
1
2
3
4
5
Response at two weeks interval aft
planted for thirteen weeks
0 kg
30 kg
60 kg
90 kg
120 kg

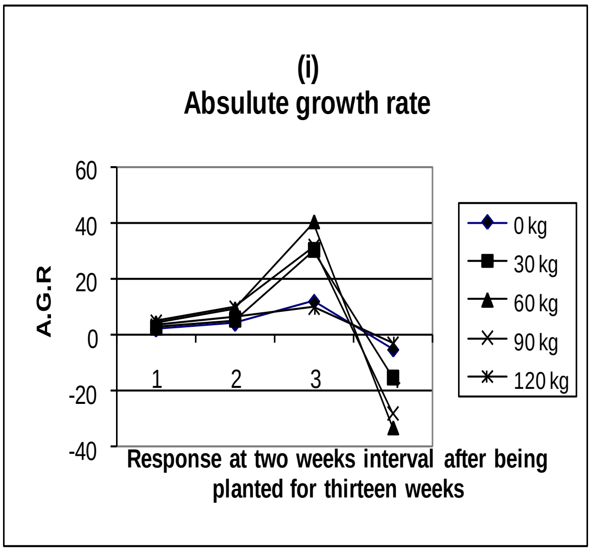

(d)
Leaf area ratio
ratio
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
Response at two weeks interval after being planted for thirteen weeks
0 kg
30 kg
60 kg
90 kg
120 kg

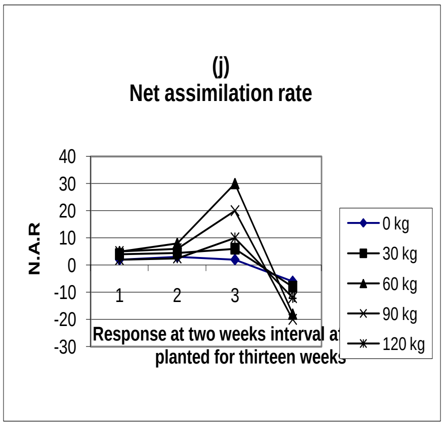

e
Leaf area ratio
area
7
6
5
4
3
2
1
0
1
2
3
4
weeks after sowing begining from 13th week
0 kg
30 kg
60 kg
90 kg
120 kg


(f)
Leaf area duration
14
12
10
8
6
4
2
0
1
2
3
4
5
Response at two weeks interval after being planted for thirteen weeks
0 kg
30 kg
60 kg
90 kg
120 kg


(g)
Leaf area index
Area index
15
10
5
0
Response at two weeks interval af
planted for thirteen weeks
0 kg
30 kg
60 kg
90 kg
120 kg


((h)
Relative growth rate
R.G.R
40
30
20
10
0
-10
1
2
3
4
Response at two weeks interval after being planted for thirteen weeks
0 kg
30 kg
60 kg
90 kg
120 kg





Scale at x-axis: 1=14th WAS, 2=15th WAS 3=16th WAS, 4=17th WAS (WAS=Week After Sowing)

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