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Responses of Cowpea to Growth Regulators on Nodulation and Yield

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Abstract- A field study was conducted at Makurdi, Nigeria, during 2011 and 2012 cropping seasons to determine the responses of seven cowpea varieties to four growth regulators with respect to nodulation and yield. Aluminum tetraflouride (AlF_4) and 2, 4-D were applied at 200mg/L; while coconut milk and potassium nitrate (KNO_3) were applied at 15%; all applications as foliar spray. Parameters evaluated per plant included: number of nodules, number of branches, nodule weight (g), number of pods, number of leaves, pod length (cm), pod weight (g) and seed weight (kg/ha). Results showed that coconut milk at 15% produced significantly higher nodule number, number of leaves, pods, pod length, and pod weight than KNO_3, 2, 4-D, AIF_4 and control treatments. The stimulative effect of KNO_3 yielded higher seed weight, which was significant. Varieties IT98KD-391 and Borno brown gave significantly higher nodule number and pod number. Variety IT89KD-288 recorded longer pods which differed significantly from pod length of variety IT03K-338-1, and higher pod weight which differed significantly from pod weights of other varieties except Borno brown. Borno brown showed greater potential for seed production than other varieties used in this study.

Index Terms- Responses, cowpea varieties, growth regulators, nodulation and yield

I. Introduction

'Cowpea' has the ability to fix atmospheric nitrogen through its root nodules and leave reasonable quantity of nitrogen in the soil (up to 30kgN/ha). Nodulation and legume yield are directly related to the magnitude and efficiency of symbiotic N_2 fixation occurring in root nodules (Schubert, 1982). The interaction between roots of leguminous plants and bacteria leads to the formation of unique plant organ, the root nodule, in which the differentiated bacteria fix atmospheric nitrogen. It is generally believed that plant growth regulators viz; coconut milk, potassium nitrate, 2, 4-D, aluminum tetraflouride are involved in triggering the initiation of root nodules and that hormonal balance is an important factor in the control of nodule development, maintenance and senescence (Hirsch, *et al*., 1977). Research works to improve the yield potential of cowpea apart from breeding programmes have not received desired attention. There is a dearth of information on the response of cowpea to some growth regulators with respect to nodulation and yield. The present study attempts to investigate the effects of growth regulators on the process of nodulation and yield in cowpea.

II. Materials and Methods

Seeds of seven cowpea varieties viz: IT97K-499-35, IT98K-573-1-1, IT89KD-391, IT98K-205-8, IT03K-338-1, IT89KD and Borno brown, were procured from IITA, Ibadan. Plant growth regulators namely: dichlorophenoxyacetic acid (2, 4-D), potassium nitrate (KNO_3) and aluminum tetraflouride (AlF_4) were purchased from University of Agriculture, Makurdi; while coconut milk was procured from coconut plantation at Owerri, Nigeria. Cypermethrine insecticide was also procured for pest control. 2, 4-D and AIF_4 were formulated at concentrations of 200mg/L, while coconut milk and KNO_3 were prepared at concentrations of 15%. The growth regulators were applied split as foliar sprays before flowering and during poding.

Two seeds were planted per hill on the ridge and spaced 25cm x 75cm. Thinning to one plant per hill was done two weeks after planting. The gross plot size was 8m x 9.9m ($79.2m^2$), with net plot size of $7.2m^2$.

At maximum flowering stage, plant samples were collected from each net plot for determination of nodule number and nodule weight per plant. The experiment was laid out as split-plot in Randomized Complete Block Design with three treatment replications.

Cowpea varieties occupied main plots; growth regulators were assigned to subplots. The plots were weeded manually twice; before and after flowering. Foliar sprays of each growth regulator were made, before flowering and during poding. Cowpea plants were sprayed with cypermeterine insecticide before flowering to control beetles, grasshoppers, aphids etc.

Determination of nodule number and weight:

At harvest maturity (14 WAS), the number and weight of nodules were determined from five randomly selected plants from each plot.

Determination of yield:

Data on yield traits collected from five randomly selected plants from each net plot were recorded at harvest maturity as follows:

- Number of leaves $plant^{-1}$
- Number of branches $plant^{-1}$
- Number of pods $plant^{-1}$
- Pod length (cm)
- Pod weight (g)
- Seed weight (kg/ha)

The data were analyzed statistically by Analysis of variance technique and comparison among treatment means was made by Fisher's Least Significant Difference procedure (F-LSD) at 5% probability.

III. Results and Discussion

Number of nodules and nodule weight:

The results of F-LSD showed significant (LSD=0.05) difference in number of nodules and nodule weight plant^{-1} among the treatments. The result revealed that maximum nodule number plant^{-1} was recorded in variety IT98KG-391 and Borno brown while the least nodule number was variety IT97K-499-35 (Table 1.). Varieties IT98KG-391 and Borno brown differed significantly from other varieties in nodule number plant^{-1}. Coconut milk at 15% produced significantly higher nodule number plant^{-1} compared to other treatments. There were significant differences among treatments regarding their effects on nodule weight plant^{-1}. Variety IT98KG-391 produced nodule weight which was significantly different from nodule weight of other varieties; IT97K-499-35 had least nodule weight.

The stimulative effect of coconut milk at 15% yielded significantly higher nodule weight compared to other growth regulators (Table 1.). This was followed by KNO_3 treatment at 15%. The observed increases in nodule number and nodule weight in coconut milk treatment indicate the distinct role of cytokinin in nodule morphogenesis (Hirsch and Fang, 1994). Previous work of Zarrin *et al.* (1998), Zarrin and Bano (1998) and Bano (1986) demonstrated the positive role of cytokinin in nodulation. Garg *et al.* (1995), Dayal and Bharti (1991) also observed cytokinin-induced increase in nodule weight and nodule number. Singh (1993) noticed that growth regulators like 2, 4-D, Naphthaline Acetic Acid (NAA) and Indole Acetic Acid (IAA) used as foliar spray brought considerable varieties in nodulation.

Yield of Cowpea:

Number of branches plant^{-1}:

Results on effects of variety and growth regulators on yield components of cowpea are presented in Table 2. Results indicated that cowpea varieties showed significant difference in all the yield components analyzed. Maximum number of branches plant^{-1} was observed with variety IT98K-573-1-1 which was significantly different from number of branches from other varieties. Varieties IT98KG-391, IT98KG-205-8, IT89KG-288, and Borno brown were statistically the same in number of branches plant^{-1}, but differed significantly from varieties IT97K-499-35 and IT03K-338-1. Coconut milk treatment produced maximum number of branches but the difference in number of branches among growth regulators was not significant.

The greater number of branches produced by variety IT98K-573-1-1 could be attributed to its genetic make-up. Hudson (1984) reported that growth, development and yield of crops are products of interplay between its genetic make-up and the environment.

Number of leaves plants^{-1}:

Results in Table 2 showed that variety IT98K-573-1-1 recorded significantly higher number of leaves compared to other varieties. The least number of leaves was observed with variety IT98K-205-8.

Coconut milk at 15% produced number of leaves which was higher and significantly different from number of leaves produced by other growth regulators. Number of leaves produced by other growth regulators except 15% of coconut milk was statistically the same. Variety and growth regulator interaction on number of leaves was significant. IT98K-573-1-1 x coconut milk, KNO_3 interactions produced maximum number of leaves which were significantly different from other variety growth regulator interactions (Table 3). Caers and Vending (1986) reported that application of coconut milk to *Solanum gilo* promoted photosynthetic activity mainly by means of increase in leaf chlorophyll content and leaf number. Davis (1984) showed that the quantity of dry matter produced per unit time is a function of the number and size of leaves per plant at optimum light intensity, light duration and soil moisture conditions. The fewer number of leaves produced with other growth regulators was probably due to decline in their stimulative effect and hence decline in the quantity of dry matter produced.

Number of pods plant^{-1}:

Higher number of pods plant^{-1} was observed in variety IT98KG-391 which differed significantly from number of pods produced by other varieties. Variety IT98K-205-8 had the least number of pods plant^{-1}. Higher number of pods plant^{-1} were observed when cowpea plants were treated with coconut at 15%, and this differed significantly with the control, 2, 4-D and AIF_4. Reinbott and Blevins (1998) observed increase in number of seeds and number of pods of soybean due to foliar application of coconut milk. Applying adequate potassium nitrate (15-20%) to soybean increased the pod yield by 26% and oil yield by 34% (Keen and Zidenberg-Cher, 2000). Foliar spray of KNO_3 at 0.5% at 50% flowering showed maximum values of pods plant^{-1}, pod length, seeds pod^{-1} and 1000 seed weight which were significantly superior to water spray and unsprayed control (Sharma *et al.*, 2000). Peterson *et al* (1990) concluded that BAP (synthetic cytokinin) significantly reduced pod abscission and subsequently increased total number of pods and seeds.

Pod length:

Results in Table 2 showed that variety IT89KG-288 recorded pod length (18.52 cm) which was significantly higher and different from pod lengths of other varieties. Results indicated that other varieties did not differ significantly in pod length. The pod length produced by 15% of coconut milk was higher and significantly different compared to pod length of 2, 4-D and the control. The maximum pod length recorded in coconut milk treated plants could be attributed to cytokinin regulation of photosynthetic capacity. Single treatments of 100mg/L IAA, 100mg/L GA_3, 15% coconut milk; as welll as combined treatments of 100mg/L IAA + 10% coconut milk, and 100mg/L GA_3 + 15% coconut milk resulted in significantly increased pod length in *Abelmoschus esculentus* (Mukaila, 2005). Sharma *et al* (2000) reported that foliar application of KNO_3 to grasspea at 0.50% during 50% flowering stage showed maximum pod length which was significantly superior to water spray and unsprayed control.

Pod weight:

Higher pod weight was observed with variety IT89KG-288(1.54g) and was significantly different from pod weights produced by other varieties except Borno brown and IT98K-573-1-1 (Table 2). The stimulative effect of coconut milk at 15% produced significantly higher pod weight (1.42g) compared to other growth regulators.

The cytokinin, 6-benzyl-amino-purine when sprayed on open flowers of *Solanum melongena*, increased the number of fruits set as well as the total weight of the fruits (Olympios, 1976). Keen *et al* (2000) observed increase of coconut milk at pod weight of soybean due to application of coconut milk at 10%.

Seed Weight Plant^{-1}:

Results summarized in Table 2 indicated that higher seed weight (2561.00kg/ha) with variety Borno brown, differed significantly from seed weights of other varieties except IT98K-205-8. Variety IT98K-573-1-1 had the least seed weight (1397kg/ha).

KNO_3 at 15% gave weight (2156kg/ha) which was significantly higher compared to other growth regulators, except AIF_4 at 200mg/L. Variety x growth regulator interaction on seed weight was significant. Borno brown x growth regulator interactions produced maximum seed weight which differed significantly from other variety x growth regulator interactions (Table 4).

Maximum seed weight for KNO_3 treatment may be attributed to the KNO_3-induced translocation of assimilates from vegetative to reproductive parts. Applying adequate potassium (100kg/ha KNO_3) in split application to soybean increased seed weight by 26% and oil yield by 34% (Keen *et al.*, 2000). Mukaila *et al* (2005) reported that single treatments of 10% and 15% of coconut milk resulted in significantly increased plant height, chlorophyll content and seed weight of Hibiscus sabdariffa, Abelmoschus esulentus and Solanum gilo L. field trials showed that by applying potassium nitrate, the grain yield as well as the protein content in the grains could be increased (Cakmak, 2003).
Through this study it could be concluded that both the nodulation and the yield of cowpea seem to be differently affected by growth regulators application. Among types of growth regulators applied coconut milk at 15% was significantly more effective in nodulation and yield production than 2, 4-D, KNO_3, AIF_4 and the control. Potassium nitrate performed better than other growth regulators with respect to seed weight.

Table 1. Effects of Variety and Growth Regulators on Nodulation of Cowpea in 2011 and 2012 (combined data).

Treatments	Number of nodules per plant	Nodule weight per plant (g plant^{-1})
Variety		
IT97K-499-35	26	1.20
IT98K-573-1-1	28	1.26
IT98KG-391	35	1.56
IT98K-205-8	30	1.34
IT03K-338-1	32	1.42
IT89KG-288	31	1.40
Borno brown	35	1.48
LSD (0.05)	**4.38**	**0.11**
Growth Regulators		
Control	27	1.21
2, 4-D @ 200mg/L	28	1.34
Coconut milk @ 15%	36	1.57
KNO_3 @ 15%	30	1.46
AIF_4 @ 200mg/L	28	1.36
LSD (0.05)	**2.02**	**0.12**

Table 2. Effects of Variety and Growth Regulators on yield components of Cowpea in 2011 and 2012 (combined data).

Treatments	No of branches per plant	No of leaves per plant	No of pods per plant	Pod length (cm)	Pod weight (g)	Seed weight (kg/ha)
Variety						
IT97K-499-35	3	89	29	16.94	0.93	1827.00
IT98K-573-1-1	5	137	28	16.17	1.24	1399.00
IT98KG-391	4	81	32	16.80	1.07	1868.00
IT98K-205-8	4	65	21	15.81	1.09	2437.00
IT03K-338-1	3	69	24	14.67	1.03	1137.00
IT89KG-288	4	84	24	18.52	1.54	1862.00
Borno brown	4	86	33	15.80	1.31	2561.00
LSD (0.05)	0.55	12.00	3.15	1.35	0.35	127.12
Growth Regulators						
Control	3.72	80	25	14.68	0.94	1700
2, 4-D @ 200mg/L	3.78	82	26	15.00	1.00	1689
Coconut milk @ 15%	3.92	97	29	17.01	1.42	1753
KNO_3 @ 15%	3.86	86	28	16.48	1.16	2156
AIF_4 @ 200mg/L	3.83	84	26	16.00	1.02	2098
LSD (0.05)	**NS**	**6.66**	**1.11**	**0.64**	**0.16**	**79.02**

Table 3. Variety x Growth regulator interaction on number of leaves per plant in 2011 and 2012 (combined data).

Variety	Coconut milk @ 15%	Potassium nitrate @ 15%	2, 4-D @ 200mg/L	AIF_4 @ 200mg/L
IT97K-499-35	93	88	80	86
IT98K-573-1-1	152	131	121	127
IT98KG-391	95	78	69	74
IT98K-205-8	71	64	58	62
IT03K-338-1	81	64	62	66
IT89KG-288	101	79	70	76
Borno brown	85	86	78	83
LSD (0.05)	**11.23**	**9.32**	**8.04**	**8.02**

Table 4. Variety x growth regulator interaction on seed weight (kg/ha) in 2011 and 2012 (combined data).

Variety	Coconut milk @ 15%	Potassium nitrate @ 15%	2, 4-D @ 200mg/L	AIF_4 @ 200mg/L
IT97K-499-35	916	2441	998	1342
IT98K-573-1-1	1241	1346	1120	1227
IT98KG-391	1487	2813	1397	1634
IT98K-205-8	2299	2448	2122	2421
IT03K-338-1	968	1200	1100	1255
IT89KG-288	1780	1774	1645	1766
Borno brown	3211	3078	2915	3135
LSD (0.05)	**124.43**	**122.14**	**121.42**	**122.33**

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