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Yield Dynamics Response and Correlation of Foliarly N-Application at Different Clusters in Soybean

Isong, A.[1*], Eze, J. N.[1], Mohammed, I. G.[1], Gbadeyan S. T.[1], Shauu, A. A.[1], Umar, F. A.[1], Aremu, P. A., Kolade, M. O.[1], Uyokei U.[1], Onyia, K. C.[1], Isong, C.[2], Ekaete, J.[1]

[1]National Cereals Research Institute, Badeggi, PMB 08, Bida, Niger State, Nigeria

[2]Federal University of Technology, Minna, Nigeria

*Corresponding Author E-mail: isongplus@yahoo.com

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ABSTRACT

Yield is a quantitative trait, controlled by polygenes and highly affected by environment. Foliar application of nitrogen constitute the environment believed to greatly influence the contribution of different attributes to yield when applied at different clusters. The experiment was laid out in a randomized complete block design using soybean TGX1440-E variety in a plot size of 2m x 2m, replicated three times to investigate the yield response dynamics. Nine clusters; R_0, R_1R_2, $R_1R_2R_3$, R_2R_3, $R_2R_3R_4$, R_3R_4, $R_3R_4R_5$, R_4R_5, $R_4R_5R_6$ of different vegetative stages of development were adopted as treatments, urea was dissolved in water and applied. Correlation to establish the relationship of the yield components to the yield was also carried out. Significant differences were observed for all the traits at 5% probability level and treatment stage R_4R_5 presented the highest grain yield of 1965.6Kg/ha. Yield was positively correlated with hundred seed weight, number of seeds per pod and number of pods per plant. Cluster stage R_4R_5 may be adopted as most appropriate for N-application especially when foliarly applied.

Keywords: *Soybean, Cluster, N-application, Yield, correlation.*

INTRODUCTION

Soybean (*Glycine max* (L.), also known as 'wonder crop' originated in China. The legume is self-pollinated, consumed by humans, animals and also used to improve soil fertility. Soybean is one of the major sources of edible vegetable oils and protein for livestock feed. It is grown as a commercial crop in over 35 countries and the total world production is put at 261.6 million metric tons (FAO, 2012). According to OECD (2006), the major producers of soybeans are United States, China, Democratic People's Republic of Korea, Republic of Korea, Argentina and Brazil where it is grown primarily for the production of seed used as food, feed and for industrial purposes.

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In Africa, production of about 1.5 million tons was recorded, West Africa producing 437,115 metric tons and Nigeria is the leading producer in West Africa with 393,860 metric tons (FAO, 2012). In Nigeria, soybean is one of the few leguminous crops that have great potential for employment and generate income for rural dwellers especially when agro-industrial potentials are exploited. In terms of production and utilization, MoFA (2011) and Ibrahim (2018) reported that soybean ranks third after groundnut and cowpea amongst legumes in the country.

The use of soybean products for feed and food has continued to expand worldwide. Many developing countries in the tropics shows interest in the production due to increasing demands for animal feed, regulating soil fertility and demands for protein and vegetable oils (Desissa & Gemechu, 2018). Increase in alternative source for plant protein has caused the production to lack behind increasing demand for the products. Yield per hectare is observed to be plateaued and breeders are task to breed for superior quality traits without compromising the yield regime (Weiss, 2000). Attempts to raise yield of soybeans above the average through soil fertilization are obvious, but the results have been limited and sometimes discouraging (Odeleye, 2007). However, if obvious nutrient deficiencies exist, yields can be increased by appropriate fertilization and the response of the plant to such practice is similar to that of cereals.

Despite the known ability of legumes to fix atmospheric nitrogen in symbiotic association with rhizobia, it has been demonstrated that foliar spray is a practical means of replenishing N in the leaves of legumes during pod development, since the efficiency of uptake by roots, as well as symbiotic fixation are known to decline at that stage (Ashour & Thalooth, 1983). Garcia (1976) had earlier suggested that foliar application of N may be effective in extending the pod filling period by delaying senescence. Foliar application could be used to avoid the depletion of N in the leaves and also the resulting reduction in photosynthetic rate during this period, due to poor N uptake from the soil, translocation to the leaves and developing seeds (Kuepper, 2003; & Mallarino, 2005). Ashour and Thalooth, (1983) had observed that the application of N during anthesis to the foliage increases fruit set, weight of pod, oil yield and protein in soybean seeds. Vasilas et al. (1980) reported increased soybean yield with foliar fertilization when other limiting factors particularly soil moisture were minimized and when measures were taken to prevent leaf burn.

Correlation, a measure of intensity of linear association between two variables or a measure of joint variation degree. The more positively correlated attributes of soybean when foliarly N-application will as well be obvious in the yield attributes. Therefore, by urea foliar N-application, the research seeks to exploit appropriate cluster of application for the improvement of grain yield in soybean production.

MATERIALS AND METHOD

The investigation to understand the variability associated with grain yield and yield contributing traits of soybean when Nitrogen is foliarly applied was carried out during the rainy season of 2019. The field work took place at experimental fields of National Cereals Research Institute, Badeggi (Lat. 9° 45'N and Long. 6° 07'E), in the Southern Guinea Savannah of Nigeria. The experimental material used was TGX1440-E variety of soybean, the design was Randomized complete block (RCBD) and replicated three times. The seeds were planted in a plot of 2m x 2m, two seeds were planted per stand at intra and inter spacing of 10cm and 50cm respectively. The clusters which described the stages by which the foliar N-application was administered, Fehr et al. (1971) description of the stages was adopted as follows;

S/No.	Cluster Symbol	Description
1	R_0	Control where no fertilizer was applied
2	R_1R_2	One flower at any node and flower at node immediately below the uppermost node with a completely unrolled leaf
3	$R_1R_2R_3$	One flower at any node, flower at node immediately below the uppermost node and pod at 0.5cm long at one of the four uppermost nodes with a completely unrolled leaf
4	R_2R_3	Flowers at node immediately below the uppermost node and at pod 0.5cm long at one of the four uppermost nodes with a completely unrolled leaf
5	$R_2R_3R_4$	Flowers at node immediately below the uppermost node, pod 0.5cm and 2cm long at one of the four uppermost nodes with a completely unrolled leaf
6	R_3R_4	Pod at 0.5cm and 2cm long at one of the four uppermost nodes with a completely unrolled leaf
7	$R_3R_4R_5$	Pod, 0.5cm and 2cm long at one of the four uppermost nodes with a completely unrolled leaf and when beans begin to developed (can be felt when pod is squeezed) at one of the four uppermost nodes with a completely unrolled leaf
8	R_4R_5	Pod, 2cm long and when beans begin to develop at one of the four uppermost nodes with a completely unrolled leaf
9	$R_4R_5R_6$	Pod 2cm long, beans begin to develop and containing full size green beans at one of the four uppermost nodes with a completely unrolled leaf

'R' represents reproduction, Reproductive stages R_1 and R_2 were based on flowering, R_3 and R_4 were on pod development and R_5 and R_6 were on seed development. Basic agronomic practices were carried out as recommended, fertilization was according to the cluster treatments at the rate of 30kg/ha by dissolving in water and foliarly applied. Field observations and data collection were done and recording was on ten selected plants in each entry for abscission percentage (AP), number of nodes per plant (NNPP), number of reproductive nodes per plant (NRNPP), Pods per reproductive nodes (PPRN), number of pods per plant (NPPP), number of flowers per plant (NFPP), number of branches per plant (NBPP), number of harvestable pods per plant (NHPPP). One thousand grain weight (1000GW) and grain yield (GY) were also recorded after harvesting and threshing were carried out.

Statistical Analysis

The data obtained were subjected to statistical analysis for Analysis of Variance (ANOVA), Least Significant Difference (LSD) was applied to separate the means where significant differences were observed. Pearson's product-moment Correlations was carried out using Statistical Tools for Agricultural Research (STAR) version 2.0.1 (2014).

RESULTS AND DISCUSSION

Per se performance of fertilizer at different clusters for the traits is presented in Table 1, means separation is also indicated. Percentage contributions of different clusters are in Figure 1. Pearson's product-moment correlation for 10 characters of 9 soybean clusters are presented in Table 2.

Foliar application of essential mineral nutrients, either singly or in combinations as reported by Odeleye (2007) are beneficial to soybean growth, development and yield especially during the flowering and pod filling stages. All the traits studied showed significant differences at 5% probability level. Most of the traits were significantly different from the control at different clusters. According to the Analysis of Variance, significant and highly significant differences among the characters were measured, this indicates that all the clusters of N-application had substantial variability, this is similar to the reports by IITA (2010) and Maestri et al. (1998). The highest number of branches was obtained when urea was foliarly applied at R_4R_5, similar to reports of Uko et al. (2002). The highest number of pods per plant (19.87) and highest grain yield (1965.6kg/ha) were observed for cluster R_4R_5, this also is in tandem with the reports of Gutte et al. (2018) when fertilizer was foliarly applied to soybean. The grain yield results further indicated that the rate of nutrient accumulation was slow in early stages followed by an increase at the beginning of flowering. After flowering, and until senescence, nutrient uptake continued at a relatively constant rate as earlier reported by Garcia (1976). This observation could be as a results of effects on chlorophyll content, photosynthetic rate in plants treated with foliar fertilizer, cumulative effect in favoring growth contributing traits and superior values of morphological characters like number of branches per plant, number of pods per plant, number of nodes per plant, number of reproductive nodes per plant, Pods per reproductive nodes and number of harvestable

pods per plant as earlier postulated by Thiyageshwari and Rangnanathan (1999).

Yield was positively correlated with hundred seed weight, number of seed per pod and number of pod per plant similar to the reports by Malik et al. (2006) and Rajkumar and Vello, (2010). According to Ibrahim et al. (2018), increase in the number of these traits may ultimately results in the increase in grain yield of soybean.

Table1. Per se performance and Mean separation for grain yield and some traits of Soybean at different clusters of foliarly N-application

Clusters	NBPP	NPPP	NNPP	NRNPP	PPRN	AP	NHPPP	NFPP	100GW(g)	GY(kg/ha)
R_0	2.23^{b}	13.33^{bc}	16.20^{a}	9.40^{ab}	1.32^{b}	1.10^{a}	13.03^{b}	13.77^{bc}	8.97^{b}	1254.1^{f}
R_1R_2	2.40^{b}	14.60^{b}	15.67^{a}	9.30^{ab}	1.55^{ab}	1.22^{a}	11.80^{b}	15.82^{bc}	9.57^{b}	1505.2^{de}
$R_1R_2R_3$	2.43^{b}	12.00^{cd}	14.43^{a}	8.27^{b}	1.39^{b}	1.62^{a}	11.50^{b}	12.95^{bc}	9.97^{b}	1594.6^{cde}
R_2R_3	2.33^{b}	13.83^{bc}	15.80^{a}	9.40^{ab}	1.47^{ab}	1.63^{a}	11.03^{b}	16.13^{bc}	10.17^{b}	1621.3^{c}
$R_2R_3R_4$	1.97^{b}	10.47^{d}	10.07^{b}	5.70^{c}	1.34^{b}	1.07^{a}	11.53^{b}	11.57^{c}	9.57^{b}	1605.1^{cd}
R_3R_4	1.97^{b}	13.10^{bc}	13.80^{ab}	8.73^{ab}	1.39^{b}	1.05^{a}	11.53^{b}	13.15^{bc}	9.67^{b}	1609.0^{cd}
$R_3R_4R_5$	2.37^{b}	13.57	16.57^{a}	8.90^{ab}	1.41^{b}	1.20^{a}	11.70^{b}	13.43^{bc}	13.80^{a}	1761.8^{b}
R_4R_5	3.47^{a}	19.87^{a}	17.57^{a}	10.33^{a}	2.11^{a}	1.12^{a}	18.07^{a}	20.32^{a}	9.57^{b}	1965.6^{a}
$R_4R_5R_6$	2.17^{b}	13.57^{bc}	15.53^{a}	10.03^{ab}	1.38^{b}	1.30^{a}	11.03^{b}	14.87^{bc}	10.37^{b}	1495.6^{e}
Mean	**2.37**	**13.81**	**15.07**	**8.90**	**1.48**	**1.26**	**12.36**	**14.67**	**10.18**	**1601.4**
Max	**3.47**	**19.87**	**17.57**	**10.33**	**2.11**	**1.63**	**18.07**	**20.32**	**13.80**	**1965.6**
Min	**1.97**	**10.47**	**10.07**	**5.70**	**1.32**	**1.07**	**11.03**	**11.57**	**8.97**	**1254.11**
S.E.	**0.18**	**0.59**	**1.07**	**0.56**	**0.19**	**0.19**	**0.62**	**0.98**	**0.81**	**1254.1**
CV(%)	**9.24**	**5.27**	**8.71**	**7.71**	**15.82**	**18.49**	**6.17**	**8.15**	**9.85**	**2.33**
LSD5%	**0.64**	**2.11**	**3.81**	**1.99**	**0.68**	**0.68**	**2.22**	**3.47**	**2.91**	**108.35**

AP= abscission percentage; NNPP= number of nodes per plant; NRNPP= number of reproductive nodes per plant; PPRN= Pods per reproductive nodes; NPPP= number of pods per plant; NFPP= number of flowers per plant; NBPP= number of branches per plant; NHPPP= number of harvestable pods per plant; 1000GW= one thousand grain weight; GY= grain yield

Table2. Pearson's product-moment correlation of yield and its attributes when forliarly N-Applied

	NBPP	NPPP	NNPP	RNPP	PPRN	AP	HPPP	FPP	X1000GW	GYPP
NBPP	1.00	0.81**	0.59	0.47	0.75*	-0.04	0.80**	0.77*	0.00	0.67*
NPPP		1.00	0.67*	0.68*	0.78*	-0.16	0.83**	0.89**	-0.06	0.75*
NNPP			1.00	0.84**	0.38	0.17	0.71*	0.68*	0.24	0.68*
RNPP				1.00	0.41	0.20	0.69*	0.68*	0.12	0.69*
PPRN					1.00	-0.11	0.74*	0.68*	-0.14	0.62
AP						1.00	-23*	0.02	0.04	-0.12
HPPP							1.00	0.68*	-0.16	0.73*
FPP								1.00	-0.09	0.67*
X1000GW									1.00	0.22*
GYPP										1.00

Figure1. Percentage Contributions of foliarly N-Application at different clusters to yield and yield attributes

CONCLUSION

Efforts to increase yield per hectare of soybeans above the current average is promoted by scientists, soil fertilization is one of such obvious recommendations. Appropriate fertilization especially in the appropriate vegetative stage during the obvious nutrients need can increase yield.

Nine clusters representing the growth stages (R_0, R_1R_2, $R_1R_2R_3$, R_2R_3, $R_2R_3R_4$, R_3R_4, $R_3R_4R_5$, R_4R_5, $R_4R_5R_6$), adopted in this experiment shows that Cluster stage R_4R_5 when Pod was 2cm long and when beans begin to develop at one of the four uppermost nodes with a completely unrolled leaf recorded the highest number of branches and grain yield of 1965.6Kg/ha when urea was foliarly applied. Also, grain yield was positively correlated with hundred seed weight, number of seed per pod and number of pod per plant, indicating that increase in the number of these traits may ultimately results in increase of grain yield of soybean

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Conflict of Interest

There is no conflict of interest whatsoever from any institution, journal or individual**.**

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Author Contributions

All the authors listed participated in the design and execution of the experiment. Gbadeyan S. T., Mohammed, I. G. and Shaahu, A. together made the observations and collected data while Isong, C carried out the statistical analysis.

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