Determination of Placement Distance of Fertilizer for Sugarcane as an Agronomic Requirement Relevant in the Design of a Fertilizer Applicator

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Abstract

Fertilizer placement distance at which sugarcane utilizes fertilizer optimally was determined in terms of its growth parameters (root distribution, stem height, stalk thickness, and leaf count). Three placement distances (4, 8 and 12 cm) were used as treatment and replicated four times. After subjecting the data obtained to Analysis of Variance (ANOVA) for Complete Randomized Design (CRD), the average means for a placement distance of 4 cm (for root distribution, stem height, stalk thickness and leaf count) are 3,910.75 cm^2, 30.83 cm, 0.763 cm, and 9.5, while for 8 cm placement distance are 2,011.63 cm^2, 27.70 cm, 0.699 cm, and 8.5. The values for 12 cm placement distance are 5,840.06 cm^2, 34.55 cm, 0.788 cm and 11.25, respectively. These show that the effects of fertilizer placement distance on root distribution, stalk thickness and stem height are significant at 0.05 level of significance during three months of growth. It was highest at 12 cm placement and lowest was at 8 cm placement distance. Hence, fertilizer placement distance at 12 cm was recommended for the design and construction of a fertilizer applicator for sugarcane.

***Keywords**: Growth parameters, root distribution, stem height, stalk thickness, leaf count.*

Introduction

Sugarcane *(Sacharumn officianarum)* has been identified as the cheapest source of energy, giving food with the lowest unit of land area per unit energy produced (Purseglove 1988). The plant was known in its original habitat of New Guinea and spread to the tropical and sub-tropical areas of the world (Baikow 1981). The plant was introduced in Egypt around 640 AD and it appeared in West Africa between 640 and 1,500 AD (Irvine 1976).

Duke (1983) reported that cane sugar, cane syrup, molasses, wax and rum are products of sugarcane, which are used as sweetener, explosive, synthetic rubber and in combustion engines. Sugar itself is used as a preservative for fruits and meats, while the by-products from sugar are used as industrial raw materials (paper manufacturing) and pharmaceutical or medicinal products (antidote, antiseptic, antivirus, laxative, etc.) (Burkill 1966). However, sugarcane has other characteristics, which makes it superior to almost all other forage crops and especially appropriate as feed reserve for livestock in the tropics (Alvarez and Preston 1976). In contrast with other tropical grasses, the nutritive value of sugarcane increases with maturity, while the time of maturity coincides with the dry season.

In the world economy, sugarcane is among the most important cultivated crops (FAO 1988). It is classified as a political crop and its world production in 2009 was 1,661.25 million tons (FAOSTAT 2009). Approximately a third of this quantity is exported by the producing countries after processing it into sugar. The economies of countries like Cuba and Brazil are built on sugar.

Fertilizer application machines have been designed and constructed, and many others imported without recognizing the distance at which the cane utilizes the fertilizer optimally in other to improve yield. According to Hunsigi

(2001): "To improve the fertilizer use efficiency, time and method of application assume great importance. Band or point placement to the stool is recommended…" Research has shown that nitrogen has generally increased yields and lessened sugar percentage, with a larger response when irrigation is applied. Phosphates have increased yields on certain types of soil.

More than four decades of research inputs have gone into investigating the nutrition of sugarcane and have facilitated the proper use of organic and inorganic fertilizers, including the time and methods of application. In order to improve yield and quality of cane as well as to maintain soil fertility, much emphasis has been placed on balanced fertilization in the recent past and compound formulations have been increasingly used since they are cheaper on a unit nutrient basis. Aerial spraying of fertilizers and the use of tracer techniques to discover the rate of applied fertilizer are some important milestones in cane culture. Agronomical requirements for the design of fertilizer application machines are most vital with reference to sugarcane. The fertilizer application has been a problem due to improper application as a result of inconsistent information as regards the optimal distance from the plant to the point of application. This has drastically affected: the yield of sugarcane, the industries requiring sugarcane as raw material, and the source of income to the developing countries at large.

The aim of this study was to determine the optimum placement distance of fertilizer from the stalk, which is an agronomic requirement relevant in the design of a fertilizer applicator.

Materials and Methods

For this study, soil samples of vertisols were collected from Savannah Sugar Company Limited (SSCL), Numan, in Adamawa state, Nigeria. Other materials used include chemical fertilizer N.P.K (15:15:15), knife, vernier caliper, metric ruler, measuring tape, sugarcane seedling, cardboard paper, containers, and stable water supply. The research was done within the teaching and research site of the green house of the Federal University of Technology, Yola, Nigeria.

Since the stem height, stalk thickness, root distribution (area) and leaf count play a vital role in determining the distance of fertilizer placement for optimal yield, the fertilizer placement distances used were 4 cm, 8 cm, and 12 cm, respectively, which were taken as treatment, while the plots were replicated four (4) times, which gave a total number of 12 plots.

Statistical Analysis

The data were subjected to Analysis of Variance (ANOVA) for complete randomized design (CRD) according to Gomez and Gomez (1989). Separation of mean using Least Significant Difference (LSD) was also used at $p = 0.05$, according to Fisher and Gray (1937).

Results and Discussion

Stem Height

Table 1 shows the ANOVA for the three placement distances of fertilizer and its response on stem height of sugarcane. Since *f*-calculated is greater than *f*-tabulated, it implies that there is a significant difference in treatment effects. Therefore, the treatment invariably has an effect on the stem height. This is consistent with the results of Dickey *et al.* (1985a, 1985b) which showed that time, method and distance of placement affect the growth of sugarcane. The optimum treatment "...ensures easy availability of nutrients through mass flow and diffusion" (Hunsigi 2001).

Table 1. ANOVA for average stem height (in cm).

Source of Variation	*df*	SS	MS	*f*-Cal.	*f*-Tab.
Rep. (*r*-1)	3	7.93	25.98	3.36	4.16*
Treat. (*t*-1)	2	2.15	46.08	4.19*	
Error (*r*-1)(*t*-1)	6	65.93	10.99		
Total	11	236.01			

Note: * Significant at 0.05 level.

Stalk Thickness

The average stalk thickness has shown a significant difference between the mean values, which implies that the placement distance affects the stalk thickness of sugarcane growth. Table 2 indicates that the stalk thickness shows a high level of significance for the three placement distances of fertilizer. According to Jika (1997, 2000), the diameter and the height of sugarcane determine the cane t/ha. If the diameter and the height are high, the sugar output will be high, which is due to the time and method of fertilizer application for vertisols with low level of nitrogen.

Table 2. ANOVA for average stalk thickness.

Source of Variation	*df*	SS	MS	*f*-Cal.	*f*-Tab.
Rep. (*r*-1)	3	0.007	0.002	2.50	4.16
Treat. (*t*-1)	2	0.017	0.009	11.25*	
Error (*r*-1)(*t*-1)	6	0.005	0.008		
Total	11	0.029			

Note: * Significant at 0.05 level.

Leaf Count

Statistically, the leaf count distances did not show any significance for the fertilizer placement. Calcino and Makepeace (1988) reported that soil and leaf analysis can be a guide to fertilizer requirements but field trials are essential to know the point of placement and type of fertilizer required to ascertain the most appropriate fertilizer levels and combination needed. Once the leaf analysis is correlated with the soil analysis and fertilizer response trials, this is a very convenient way to monitor changes during the life of the crop. Table 3 indicates that the leaf count does not show any significance for the three placement distances of fertilizer because *f*-calculated is less than *f*-tabulated.

Table 3. ANOVA for average leaf count (Foliar) at $\alpha = 0.05$.

Source of Variation	*df*	SS	MS	*f*- Cal.	*f*-Tab.
Rep. (*r*-1)	3	0.25	0.083	0.040	4.16
Treat. (*t*-1)	2	15.50	7.500	3.610^{ns}	
Error (*r*-1)(*t*-1)	6	12.50	2.08		
Total	11	28.25			

Note: ^{ns} Non-significant.

Root Distribution

The mean values of root distribution have shown a high significance, which implies that the root distribution depends upon the fertilizer placement distance from the plant stalk. Table 4 indicates that the root pattern distribution shows a high level of significance for the three placement distances of fertilizer.

Table 4. ANOVA for root distribution (area, in cm^2).

Source of Variation	*df*	SS	MS	*f*-Cal.	*f*-Tab.
Rep. (*r*-1)	3	4152481.11	1384160.37	1.76	4.16
Treat. (*t*-1)	2	29314398.13	14657199.00	18.65*	
Error (*r*-1)(*t*-1)	6	4723229.37	787204.89		
Total	11	38190108.16			

Note: * Level of significance.

Conclusion

The following conclusion can be drawn from the study:

- The measured parameters showed significant difference at 5% level of probability ($p = 0.05$).
- The growth of sugarcane for each placement distance had a stable growth, but at 4 cm and 12 cm there was a fast growth in all the measured parameters, with 12 cm having the highest one as shown in Table 5.

Table 5. Mean values for placement distances with three levels of significance.

Treatment (cm)	Average height (cm)	Average stalk thickness (cm)	Average leaf count (cm)	Average root distr. (cm)
4	30.83[b]	0.763[b]	9.5[ab]	3910.75[b]
8	27.70[a]	0.699[a]	8.5[ab]	2011.63[a]
12	34.55[c]	0.788[c]	11.25[b]	5840.06[c]
LSD	2.87	0.025	1.25	1535.18

Note: *a*, *b*, and *c* show the least significant difference (LSD).

- Using ANOVA, stem height, stalk thickness and root distribution showed significance for all fertilizer placements at 0.05 probability, while leaf count showed no significance.
- The fertilizer placement has a great influence on the growth of sugarcane.
- The ideal placement to be adopted for the variety (coast) is 12 cm from the plant stalk.

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