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Effect of Varying Rate of Leaf Defoliation on Maize Growth, Development and Yield Components and Yield

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Abstract: Pot trial was conducted at the Faculty of Agriculture, Kogi State University Anyigba, within the southern Guinea savanna agro ecological zone of Nigeria, with daily temperature range between 250C - 350C. The experiment, a Randomized Complete Block Design (RCBD) with eight treatments (defoliation at 25% above the ear, 25% under the ear, 50% above the ear, 50% under the ear, 75% above the ear, 75% under the ear, 100% defoliation and no defoliation as control) was replicated four times. Treatment was imposed at ear initiation. Growth and yield parameters collected were: number of leaves per plant, leaf area, plant height, stem girth, days to ear initiation, number of cobs/plant, days to crop maturity, cob weight, cob length, seed rows per cob, 100-seed weight as well as total cob yield/ha. All data collected were subjected to analysis of variance (ANOVA) and New Duncan Multiple Range Test (NDMRT) was used to estimate the differences among significant means at 5% level of probability. Prior to imposition of the treatment, analyzed results indicate no significant differences between number of leaves at 2, 4 and 6 WAS, as well as plant heights and stem girth at 2, 4, 6, 8 and 10 WAS. However there were significant differences between leaf areas at 4 and 6 WAS. In addition, there were significant effects of defoliation on cob length and dry cob weight with the highest cob weight obtained in 25% defoliation carried out above the ear. In addition, there were significant differences in the number of rows per cob and grain yield per ha with 0% defoliation giving the highest result while the least was in 100% defoliation. Generally, it was observed that defoliation at any rate and position influenced maize yield, notwithstanding that the treatment was imposed at cob initiation, an indication that harvest of solar radiation post cob initiation plays important role on eventual maize yield.

Keywords: Maize; Defoliation; Plant height; Stem girth; Leaf area; Yield components; Yield.

1. Introduction

Defoliation or leaf damage, such as that associated with hail, frost, wind, crop protection chemicals and insects can influence photosynthesis and subsequent grain production [1]. Whole plants photosynthesis is instantaneously reduced in response to canopy removal either by grazing or by deliberate removal or by mechanical damages or by clipping [2-5]. If large portions of the canopy of individual plants are removed by grazing, hail or wind, plants adjust to such conditions of chronic defoliation and the associated reductions in whole-plant photosynthetic rates by altering resource allocation pattern and reducing relative growth rates [2-5].

Corn yield is reported to be strongly depended on leaf area index (LAI) and leaf efficiency for absorption of solar radiation for photosynthesis process [1]. Thus, defoliation treatments have been observed to decrease assimilates availability during grain filling [6]. It should however be observe that in addition to leaves, other chlorophyll containing organs such as stems, parts of inflorescences and fruits can also significantly be effective in supplying photosynthates thus able to change pattern of preparation and distribution of materials [7].

Generally, throughout plant growth and development, photosynthetic materials are transferred from sources to sinks [8]. If the rate of transfer is lower than production, photosynthates would be stored as starch in different parts of plants, and as soon as grains are formed in the plant, the greater amount of photosynthetic materials moves to the grains.

Field trials conducted on wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) revealed that photosynthesis in the nearest source to the grain such as flag leaf, stem and spike supply the main part of grain weight [9]. Andrew and Peterson [10] reported that distance of the leaves to the ear and their photosynthetic efficiency are important in defoliation. They showed that leaves on top of the ear transferred 23 - 91% of photosynthates to the cob and the greatest amount of transferred materials was in the nearest leaf on top of the ear [10]. A study on sunflower (*Helianthus annus*) revealed that whereas defoliation had no effect on stem diameter, filled grain percentage, 1000-

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seed weight, harvest index and grain yield were affected by the defoliation treatments; observing that middle leaves of the stem have most important role than the other leaves because of greater surface and active participation in the photosynthesis. 100 percent defoliation resulted in minimum yield of seeds compared to control because of decrease in grain weight and filled grain percentage [11].

Results of many studies about the effects of defoliation on seed yield of sunflower showed that increase of defoliation intensity and defoliation near flowering stage resulted in decreased seed yield because of decrease in the photosynthetic surface [12-14]. In addition, complete defoliation had the most negative effect on the ear diameter, dry grain weight, 100-grain weight and grain yield. However, there were no significant differences between removing of the whole leaves on the top of ear and the whole leaves under ear, observed Remison [15].

It has been observed that reduction in whole-plant photosynthesis following defoliation is not necessarily proportional to leaf-area or biomass removal because of associated modification in canopy microclimate, the unequal photosynthetic contributions of leaves of various ages and, in some cases, compensatory photosynthesis [16, 17]. For example, when mature, previously shaded leaves remain on the plant following defoliation, canopy photosynthesis is reduced to a greater extent than the proportion of leaf area removed because of the low photosynthetic capacity of the remaining leaves. A large decrease in the photosynthesis / transpiration ratio of the canopy (i.e. water-use efficiency) is also associated with this pattern of plant defoliation [17, 18]. Conversely, if a high proportion of relatively young leaves remain on the plant following defoliation, the reduction in canopy photosynthesis is more directly related to amount of leaf area removed. Consequently, canopy measurements of photosynthesis are reported to be more strongly correlated with the potential for re-growth than are measurements of single-leaf photosynthesis [16, 19, 20].

In view of the importance of maize in Nigeria, efforts are continuously made to increase yield per unit area of land, thus justifying any effort at understanding yield related parameters. Therefore general objective of this research was to assess the effect of leaf defoliation on maize development, yield components and yield, while specific objectives were to:

- **i.** Evaluate effect of different levels of defoliation on the maize growth;
- **ii.** Evaluate effect of different levels of defoliation on maize grain yield and
- **iii.** Evaluate effect of different levels of defoliation on maize yield components.

2. Materials and Methods

Between March and August 2016 pot trial was conducted at the Faculty of Agriculture, Kogi State University Anyigba, which falls within the southern Guinea savanna agro ecological zone of Nigeria. The daily temperature range is about 25 ^{0}C – 35 ^{0}C. The experiment was a Randomized Complete Block Design (RCBD) with eight treatment components (defoliation at 25% above the ear, 25% under the ear, 50% above the ear, 50% under the ear, 75% above the ear, 75% under the ear, 100% and control), which were replicated four times. The treatment was imposed at ear initiation.

Fertile sandy-loam soils obtained from fallowed farm land were filled into perforated plastic pots to 2.5 cm from the top, after sorting out debris, pebbles and plant roots. Seeds of maize (Ife-Hybrid VI) obtained from the Institute of Agricultural Research (IAR), Zaria were planted into the pots at the rate of two seeds per hole to a depth of 5 cm, which were later thinned to one plant stand 2 weeks after sowing (2 WAS). The pots were kept weed free by hand picking the weeds at regular intervals. Water supply was from rain water as the crops were kept out in the field. The growth and yield parameters collected at two week intervals beginning 2 WAS include: number of leaves per plant (determined by direct counting of leaves on each plant); plant height; stem girth (determined by measuring the thickness of the plants stem with the aid of veneer calipers); days to ear initiation; number of cobs (counting the number of cobs/plant); days to maturity; cob weight; cob length; rows/cob; 100-seed weight as well as total cob yield/ha.

All data collected were subjected to analysis of variance (ANOVA) as described for RCBD [21] and New Duncan Multiple Range Test (NDMRT) was used to estimate the differences among significant means at 5% level of probability.

3. Results and Discussion

3.1. Effect of Varying Rate of Defoliation on Growth Parameters

No significant differences ($P \geq 0.05$) were observed between the number of leaves / plant at 2, 4 and 6 WAS (Table 1), plant heights and girths at 2, 4, 6, 8 and 10 WAS (Tables 2 and 3, respectively). These non significant observations are understandable, considering that the defoliation process was imposed only at ear initiation, so could not have impacted on these parameters at this stage. There were, however significant differences ($P \leq 0.05$) between leaf areas at 4 and 6 WAS (Table 1), which could not be due to the treatment, since it was only imposed afterwards, but could be the result of the manifestation of individual crop characters. There is though the possibility that the significant differences in leaf areas at 4 and 6 WAS may exert influence on crop yield. Noting that corn yield is reported to be strongly depended on leaf area index (LAI) and leaves efficiency for absorption of solar radiation for photosynthesis process [1]; though whole-plant photosynthesis is not necessarily proportional to leaf-area or biomass removal because of associated modification in canopy microclimate, the unequal photosynthetic contributions of leaves of various ages and, in some cases, compensatory photosynthesis [17].

Table-1. Effect of varying rate of defoliation on number of leaves and leaf area of maize

Defoliation	Number of Leaves			Leaf Area	
	2WAS	4WAS	6WAS	4 WAS	6 WAS
0%	5.25	7.75	7.75	124.17	542.04
25% DAE	5.00	7.00	8.25	155.81	589.78
25% DUE	5.25	7.25	7.50	154.61	498.08
50% DAE	5.25	7.25	7.50	116.81	529.23
50% DUE	5.00	7.25	7.75	162.56	587.05
75% DAE	5.25	6.75	7.00	102.70	471.05
75% DUE	5.75	7.00	7.78	125.23	506.05
100%	5.00	6.75	6.75	122.25	470.93
F-LSD	NS	NS	NS	26.47*	17.26*
CV%	10.84	12.15	10.80	15.71	6.68

DAE = Defoliation above ear, DUE = Defoliation under ear

Table-2. Effect of varying rate of defoliation on plant height of maize

Defoliation	Plant Height (cm)				
	2WAS	4WAS	6WAS	8WAS	10WAS
0%	9.73	19.23	49.53	122.98	136.08
25% DAE	9.33	17.00	54.43	126.05	148.53
25% DUE	9.38	19.33	50.75	133.25	138.23
50% DAE	9.20	19.25	52.83	120.03	137.83
50% DUE	9.63	18.13	56.83	128.60	147.78
75% DAE	9.70	16.80	48.95	135.43	143.23
75% DUE	9.65	18.55	50.73	116.35	137.90
100%	9.63	17.00	52.03	124.98	128.55
F-LSD	NS	NS	NS	NS	NS
CV	14.39	18.42	8.67	18.63	16.33

DAE = Defoliation above ear, DUE = Defoliation under ear

Table-3. Effect of varying rate of defoliation on stem girth of maize

Defoliation	Stem girth (cm)				
	2WAS	4WAS	6WAS	8WAS	10WAS
0%	0.83	1.05	1.70	1.75	1.80
25% DAE	0.78	1.10	1.70	1.78	1.78
25% DUE	0.78	1.10	1.68	1.68	1.70
50% DAE	0.75	1.13	1.63	1.80	1.80
50% DUE	0.80	1.10	1.73	1.83	1.83
75% DAE	0.80	1.05	1.63	1.63	1.73
75% DUE	0.85	1.13	1.65	1.80	1.80
100%	0.83	1.00	1.55	1.55	1.68
F-LSD	NS	NS	NS	NS	NS
CV%	12.50	13.09	14.08	12.78	13.23

DAE= Defoliation above ear, DUE = Defoliation under ear

The non-significant effects observed on most parameters prior to the imposition of the treatment, may imply that any significant difference observed on such parameters after imposition of the treatment could only result from the impact of the defoliation.

3.2. Effect of Varying Rate of Defoliation on Yield Components and Yield

There were significant ($P \leq 0.05$) effects of defoliation on cob length and dry cob weight, with the highest cob weight obtained in 25% defoliation above the ear (Table 4). In addition there was significant ($P \leq 0.05$) difference in the number of rows per cob, with 0% defoliation giving the best result while the least was in 100% defoliation. The treatment did not however influence significant change in seed weight. Significant effect of defoliation was observed on grain yield per ha, with the highest grain yield obtained in 0% defoliation, while 100% defoliation gave the least, this was similar to the findings made by Abbaspour, *et al.* [11], as investigated for sunflower.

The observations made in this trial in respect of maize yield, relates well with previous studies on the effects of defoliation on seed yield of sunflower that showed that increase of defoliation intensity and defoliation near flowering stage resulted in decreased seed yield because of decrease in the photosynthetic surface [12-14]; that, complete defoliation had the most negative effect on the ear diameter, dry grain weight, 100-grain weight and grain. Abbaspour, *et al.* [11], also observed in a study on sunflower (*Helianthus annus*) that whereas defoliation had no

effect on stem diameter, filled grain percentage, 1000-seed weight, harvest index and grain yield were affected by the defoliation treatments, emphasizing that middle leaves of the stem have most important role than the other leaves because of greater surface and active participation in the photosynthesis. 100 percent defoliation resulted in minimum yield of seeds compared to control because of decrease in grain weight and filled grain percentage; findings, which are in consonance with the findings in this trial.

4. Conclusion

Pot trial was conducted at the Faculty of Agriculture, Kogi State University Anyigba, within the southern Guinea savanna agro ecological zone of Nigeria, with daily temperature range between 25^0C - 35^0C. The experiment, a Randomized Complete Block Design (RCBD) with eight treatments (defoliation at 25% above the ear, 25% under the ear, 50% above the ear, 50% under the ear, 75% above the ear, 75% under the ear, 100% defoliation and no defoliation as control) was replicated four times. Treatment was imposed at cob initiation. Defoliation had no effect on plant height, leaf number, stem diameter and seed weight, however defoliation at any rate and position influenced maize yield, notwithstanding that the treatment was imposed at ear initiation, an indication that harvest of solar radiation post cob initiation plays important role on eventual maize yield. Observing that throughout plant growth and development, photosynthetic materials are transferred from source (the leaf) to sink (storage points, such as maize ears), and any factor (such as defoliation) that may influence source's photosynthetic ability should impact on yield. 100 percent defoliation resulted in the least yield of seeds compared to control.

Table-4. Effect of vary rate of defoliation on some yield parameters of maize

Defoliation	Yield parameters				
	Cob length (cm)	Cob weight (g)	No of row/cob	Grain yield (g)	100-seed weight (g)
0%	11.05	2.52	11.75	2.05	21.70
25% DAE	12.15	2.61	11.50	1.64	17.83
25% DUE	8.43	1.37	9.00	1.12	17.51
50% DAE	10.03	1.65	11.75	1.32	15.20
50% DUE	11.85	2.28	8.50	1.72	16.96
75% DAE	7.80	2.03	8.75	1.18	12.05
75% DUE	11.55	1.44	5.25	0..76	4.33
100%	0.00	0.00	0.00	0.00	0.00
F-LSD	3.45*	11.53*	5.93*	21.11*	NS
CV%	25.84	25.48	4.86	62.99	74.26

DAE = Defoliation above ear,
DUE = Defoliation under ear
* Significance at (P≤0.05)

References

[1] Mouhamed, S. G. A. and Ouda, S. A. H., 2006. "Predicting the role of some weather parameters on maize productivity under different defoliation treatments." *Journal of Applied Sciences Research*, vol. 2, pp. 920-952.

[2] Jarman, P. J. and Sinclair, A. R. E., 1979. "Feeding strategy and the pattern of resource- partitioning in ungulates." p. 130-163. In: Oluotanmi, O.R (2017). "Effect of varying rate of leaf defoliation on maize growth, development and yield components and yield." B. Agric. Project submitted to the Department of Crop Production, Kogi State University, Anyigba, Kogi State, Nigeria. p. 67.

[3] Norton, B. E. and Johnson, P. S., 1983. "Pattern of defoliation by cattle grazing crested wheatgrass pastures." p 462-464. In: Smith, J.A. and Hayes, V.W. (eds.) Proc. XIV Int. Grassld. Cong. West view Press, Boulder, Colorado. In: Oluotanmi, O.R (2017). "Effect of varying rate of leaf defoliation on maize growth, development and yield components and yield." B. Agric. Project submitted to the Department of Crop Production, Kogi State University, Anyigba, Kogi State, Nigeria. p. 67.

[4] Anderson, J. E. and Shumar, M. L., 1986. "Impacts of black-tailed jackrabbits at peak population densities on sagebrush-steppe vegetation." *J. Range Management*, vol. 39, pp. 152-155.

[5] Krueger, K., 1986. "Feeding relationships among bison, pronghorn, and prairie dogs: An experimental analysis." *Ecology*, 67:760-770. In: Oluotanmi, O.R (2017). "Effect of varying rate of leaf defoliation on maize growth, development and yield components and yield." B. Agric. Project submitted to the Department of Crop Production, Kogi StateUniversity, Anyigba, Kogi State, Nigeria. p. 67.

[6] Echarte, L., Andrade, F. H., Sadras, V. O., and Abbat, P., 2006. "Kernel weight and its response to source manipulations during grain filling in Argentinean maize hybrids released in different decades." In: Oluotanmi, O.R (2017). "Effect of varying rate of leaf defoliation on maize growth, development and yield components and yield." B. Agric. Project submitted to the Department of Crop Production, Kogi State University, Anyigba, Kogi State, Nigeria. p. 67.

[7] Wardlaw, I. F., 1990. "The control of carbon partitioning in plants." *New Phytologist*, vol. 116, pp. 341-381.

[8] Hashemi, D. A., Kocheki, E., and Banayan, A. M., 1995. *Increasing of crops yield*. Mashhad Jehade Daneshgahi Press, p. 287.
[9] Sarmadnia, G. and Kocheki, E., 1993. *Physiology of field crops*. Mashhad Jehade Daneshgahi Press, p. 357.
[10] Andrew, R. H. and Peterson, L. A., 1984. *Commercial sweet corn production*. Wisconsin Extension Service. Wisconsin University, p. 25.
[11] Abbaspour, F., Shakiba, M. R., Alyari, H., and Valizade, M., 2001. "Effects of defoliation on yield and yield components of sunflower." *Agric. Sci.*, vol. 12, pp. 71-77.
[12] De beer, J. P., 1983. "Hail damage simulation by leaf area removal at different growth stages on sunflower." *Crop Prod.*, vol. 12, pp. 110-112.
[13] Kene, H. K. and Charjan, Y. D., 1998. "Effect of defoliation on yield of sunflower (Helianthus annuus L.). PKV." *Res. J.*, 22:139-140. In: Oluotanmi, O.R (2017). "Effect of varying rate of leaf defoliation on maize growth, development and yield components and yield." B. Agric. Project submitted to the Department of Crop Production, Kogi State University, Anyigba, Kogi State, Nigeria. p. 67.
[14] Abdi, S., Fayaz, M., A., and Ghadimzade, M., 2007. " Effect of different levels of defoliation at reproductive stage on grain yield and oil percent of two hybrid sunflower." *Agric and Nat Res. Sci and Tech.*, vol. 11, pp. 245-255.
[15] Remison, S. U., 1978. "Effect of defoliation during the early vegetative phase and at silking on growth of maize (Zea mays L.)." *Annals of Bot.*, vol. 42, pp. 1439-1445.
[16] Ludlow, M. M. and Charles-Edwards, D. A., 1980. "Analysis of the re-growth of a tropical grass/legume sward subjected to different frequencies and intensities of defoliation." *Aust. J. Agric. Res.*, vol. 31, p. 673 692.
[17] Gold, W. G. and Caldwell, M. M., 1989. "The effects of the spatial pattern of defoliation on re-growth of a tussock grass. II. Canopy gas exchange." *Oecologia* vol. 81, pp. 437-442.
[18] Caldwell, M. M., Dean, T. J., Nowak, R. S., Dzurec, R. S., and Richards, J. H., 1983. "Bunchgrass architecture, light interception, and water-use efficiency: Assessment by fiber optic point quadrats and gas exchange." *Oecologia*, vol. 59, pp. 178-184.
[19] King, J., Sim, E. M., and Grant, S. A., 1984. "Photosynthetic rate and carbon balance of grazed ryegrass pastures." *Grass Forage Sci.*, vol. 39, pp. 81-92.
[20] King, J., Sim, E. M., Barthram, G. T., Grant, S. A., and Torvell, L., 1988. "Photosynthetic potential of ryegrass pastures when released from continuous stocking management." *Grass Forage Sci.*, vol. 43, pp. 41-48.
[21] Gomez, K. A. and Gomez, A., 1984. *A statistical procedures for agricultural research*. New York: John Wiley and Son. p. 680.