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Effect of Detasseling on Grain Yield Stability of Maize Grown Under Increased Plant Density

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Abstract

Competition for resources increases abiotic stress for maize planted at high planting density, while tassel removal has the potential to increase grain yield and minimize the negative effects of pressure occasioned by high plant population. A split-split plot experiment arranged in a randomized block design (r=3) was established at the Institute of Agricultural Research and Training, Moor Plantation Ibadan in the years 2017 and 2018, respectively. Treatment included four maize varieties (V) (DMRLSR-W, SUWAN-1, OBASUPER-1 and OBASUPER-2), two plant densities (D) 80,000 pl ha^{-1} and 53,333 pl ha^{-1} and detasselling. Data were collected on the number of rows and kernels per cob, 100-grain weights, grain moisture content (GMC %), and total grain yield (GY). From the results, tassel removal has no significant effect on the total grain yield (P<0.05). Grain moisture content was higher in grains obtained from detasselled plots (27.91%) than grains from non-detasselled plots (27.19%), Tasselling and Density interactions on GMC were also significant. A significant interaction was observed between the maize varieties and tasselling, such that the GY of the maize varieties in the detasselled plots except SUWAN-1 were significantly higher than maize grain yield from the non-detasselled maize plots except SUWAN-1. Detasseling did not impact positively on the GY in this study. However, genotypic differences were observed among the varieties of detasselling and non-detasselling treatments. Non-beneficial role of detasselling on GY was not seen in this experiment due to the availability of resources and that 80,000 plants ha^{-1} may not be high enough to induce competition among the plants for resource utilization.
Keywords: Grain moisture content, Grain yield, Plant population, Maize varieties, and Tasselling

Introduction

Maize is an important economical plant, valuable for livestock feed formulation, and industrial uses and an important staple in sub-Saharan Africa. Maize is a unique monoecious crop among the grass family with staminate inflorescence located on the apex of the plant while the pistillate inflorescence is situated on the apex of the axillary branches. Due to this unique floral architecture, there is usually a competition between the apical and axillary inflorescences for resources like water, nutrients and photosynthates Sangoi and Salvado (1998). Naturally, the apical structure (Tassel) usually has preferential use of resources over the axillary structure (Ear) (Apical dominance). There is this assumption that the removal of the apical inflorescence (tassel) would lead to the diversion of resources into the ear. In the last 30 years, many research reports on tassel removal before anthesis have been adequately documented. Hunter *et al*. (1969), and Mosterd and Marais (1982) reported an improvement in the grain yield of detasseled maize while Luis and Ricardo (1998) reported a non -non-significant increase in the yield of detasselled maize grown under two plant densities. Removal of tassel (Detaseling) from maize at anthesis has been reported to alleviate the negative effects of water deficit stress on maize yield (Subedi, 1996). A normal maize tassel is estimated to produce 2,50,00,000.00 pollen grains of which all small quantity is required for pollination (Smith *et al*., 2004). Since fewer numbers of tassels are needed to produce a sufficient amount of pollen grains required for pollination in a maize field. Excessive pollens are wasted while the huge amount of energy and resources expended on pollen production and dispersal could be diverted towards the sinks to enhance crop productivity (Smith *et al*., 2004; Jakhar *et al*., 2017b). Apart from the benefits elucidated above, detasselling improves light penetration in the canopy of maize plants and increases both the seed yield and the seed quality of maize (Bhandari *et al*., 2022). Planting at increased plant density increases intercepted photosynthetically active radiation (IPAR) and consequently increases competition among plants for resources such as light, water and nutrients (Clampitti and Vyn, 2011; Rossini *et* *al*., 2011). The intense competition for resources results in abiotic stress evidenced by reduced; leaf area, leaf chlorophyll content and grain yield (Osakabe *et al*., 2014). Since removal of tassel at anthesis has been considered a viable agronomic practice that could break apical dominance and minimize the negative effects of abiotic stress. It is with this concept that detasselling is been considered as a vital option to enhance the grain yield of maize grown under higher plant density as against the general plant density recommendation of 53,333 plants per hectare in Nigeria. Therefore, the purpose of this study is to determine whether the removal of tassel at anthesis would enhance maize grain yield tolerance to increase plant density.

Materials and Methods

The study was conducted during the growing seasons of 2017 and 2018 under rain-fed conditions at the Institute of Agricultural Research and Training (IAR&T) in Ibadan, Oyo state, in the derived savannah ecological zone of Nigeria. The experimental area is located at 7° 23' North; 3and ° 51' East. The experiment was laid out in a randomised complete block design with a split-split plot arrangement, replicated thrice. The treatments consisted of two plant population densities (D1= 80,000 plants/ha and D2= 53,333 plants/ha) as the main plots, tasselling [Detasselled (DT) / non-detasselled (T)] constituted the sub-plot while the four maize genotypes (DMR LSR-W, Suwan-1, Oba Super-1 and Oba Super-2) formed the sub-sub plot. The desired plant densities were achieved with intra and inter-row spacing of 25 cm x 75 cm (53,333 plants/ha) and 25 cm x 50 cm (80,000 plants/ha), with a net plot size of 3 m x 3 m. Two seeds were planted per hole after land preparation, the emerging seedlings were later thinned down to one plant per hill. Pre-emergence herbicide was sprayed a day after planting and later complemented with manual weeding. A basal application of compound fertilizer (NPK 20:10:10) was applied within 14 days (2 weeks) after planting at the rate of 60 kg N ha^{-1} and Urea at six weeks after planting at 40 kg N ha^{-1} for optimum plant growth.

Detasseling: One hundred per cent (100%) of tassels from the detaselled plots were removed by gently pulling upward without destroying the upper leaves.

Data were collected on the following parameters:

- Number of rows and the number of kernels per cob: Five cobs were selected randomly from each plot. Their number of rows and number of kernels per row was counted and the average was calculated.
- Grain yield (t/ha) = (FWT (kg)/Plot size (m^2) x [(100 – moisture content) x 10,000 x SP]/86 x 1000 (SP = Shelling percentage (weight of grain expressed as a percentage of ear weight) FWT = Field weight) (Oloyede-Kamiyo and Olaniyan, 2020).
- Fresh Harvest Weight= Weights of harvested ears (obtained using measuring scale)

Data analysis: The analysis was carried out using Statistical Tool for Agricultural Research (STAR, 2014), and means were separated using Fisher's Least Significant Difference (LSD) at P<0.05.

Results and Discussion

Results

Table 1 presents the mean square of yield components from the analysis of variance of four detasselled maize varieties grown under two planting distances and in Ibadan. Across the rep (R), all the yield parameters were not significant (*P*<0.05). Plant density (D) was significant in fresh harvest weight and grain yield (P<0.05), while D* TC was significant for grain moisture content (GMC). Tasseling (TC) was also significant for GMC (*P*<0.05). The maize variety (V) was significant for the weight of 100 grains (P<0.05). Tasselling (TC) and variety interaction (TC*V) were significant for fresh harvest weight and the total grain yield (*P*<0.05). Table 2 presents the means of yield parameters of four maize varieties as determined by detasseling and planting density and the interactions. The number of rows per cob, number of kernels per cob, weights of 100 grains and moisture content of grains were not significantly influenced by plant density except biomass yield and total grain yield which differed significantly at *P*<0.05. Biomass and grain yield were highest at 80,000 plants per hectare (4.50 and 3.29 t ha^{-1}) than at 53,333 (3.97 and 2.93 t ha^{-1}), respectively. The tasselling (TC) effect was only significant on grain moisture content with grains from detasselled maize plants showing significantly higher grain moisture content (27.91%) than grains from non-detasseled plants (27.19%). The varieties only showed significant differences in the weights of 100 grains, maize variety OBASUPER-1 had the highest 100-grain weight of 30.38 g and higher than DMRLW-SR (27.08 g), OBASUPER-2 (27.38 g) and SUWAN-1 (27.42 g) which were not significantly different from one another. Plant density and variety interaction (D*V) across all the yield parameters evaluated were not different. Plant density and tasselling interaction were significant on percentage grain moisture content at *P*<0.05. The percentage moisture content of non-detasselled maize under 80,000 pl ha^{-1} (27.93%), 53,333 pl ha^{-1} (27.88%) and 53,333 (28.20%) under detasselled was significantly higher than the percentage moisture content of maize detasselled maize under 80,000 pl ha^{-1} (26.18%).

Tasselling and variety interaction (TC*V) effects were significant on biomass yield and grain yield, detasselled maize varieties DMRLSR-W (4.46), OBASUPER-1 (4.32), OBASUPER-2 (4.59), SUWAN-1 (3.87) and non-detasselled SUWAN-1 (4.87) t ha^{-1} were significantly higher than non- detasselled maize varieties DMRLSR-W (3.85), OBASUPER-1 (4.09), OBASUPER-2 (3.84) t ha^{-1}. Tasselling and variety interaction effect on grain yield shows that there were no significant differences in the grain yield of detasselled maize varieties DMRLSR-W (3.37), OBASUPER-1 (3.15), OBASUPER-2 (3.33) and maize grain yield of non-detasselled maize varieties DMRLSR-W (2.91), OBASUPER-1 (2.99) SUWAN-1 (3.62), while grain yield of non-detasselled OBASUPER-2 (2.69) and detasselled SUWAN-1 (2.84) had least grain yield.

Comparison of the effect of detasseling on grain yield of maize at each level of varieties shows that grain yield in detasselled-OBASUPER-2 was significantly higher than non-detasselled OBASUPER-2 maize variety (Table 3), while grain yield in non-detasselled SUWAN-1 was significantly higher than the detasselled SUWAN-1 maize variety, while there were no significant differences in grain yield of the other two maize varieties under detasselling and non-detasselling. Comparison of the maize varieties at each level of tasselling shows that the grain yield of the detasselled four maize varieties was not significantly different, while SUWAN-1 had the highest grain yield among the non-detasselled four maize group, OBASUPER-2 and DMR-LSR had the least grain yield (Table 4). Based on a comparison of detasseling effects on biomass yield of maize at each level of Varieties maize variety OBASUPER-2 had biomass yield from detasselled maize plants than the non-detasselled plants whereas the reverse is the case for SUWAN-1 (Table 5).
There was no significant difference in the biomass yield of the detasselled four maize varieties based on a comparison of varieties at each level of tasselling. Whereas, SUWAN-1 had the highest fresh harvest weight compared to the other three maize varieties under non-detasselled conditions (Table 6).

Discussion

Tassel removal at anthesis has been described as an agronomic practice that can enhance grain yield and minimize the negative effects of abiotic stress mostly due to increased plant density in maize cultivation (Sangoi *et al*., 2006) Heidari, 2013). To affirm this assumption tassels of four maize varieties grown under two plant densities, DI (80,000 plants/ha) and D2 (53, 3333 plants /ha) were removed at anthesis. From the results, the grain yield obtained in 80,000 plants per hectare was significantly higher than the grain yield obtained in 53,333 plants per hectare. The effect of detasselling was shown on the percentage moisture content of grains obtained from detasselled plots which were higher than the percentage moisture contents of grains from non-detasselled plots. The higher grain moisture content observed in grains of detasseled maize plants could probably be due to the diversion of moisture and other resources that could have been used in the production of pollen grains in the tasselled maize plants (Jakhar *et al*., 2017b). Although detasseling had no significant effect on the fresh harvest weight and total grain yield in this study, yet, differences were observed in variety-tasselling interaction, such that under detasselled maize population, maize varieties DMRLSR-W, OBASUPER-1 and OBASUPER-2 had better gain yield than SUWAN-1, whereas SUWAN-1 showed superiority in grain yield than other maize varieties under non-detasselled maize population. The non-significant effect of the tasselling effect of fresh harvest weight and total grain yield in this trial contradicts the initial premise of an earlier report by Mosterd and Marais (1982) and Bhandari et al. (2022). Failure of detasselling to significantly enhance fresh harvest weight and the total grain yield in this study may be attributed to so many factors. Luis and Salvador (1998) had earlier implicated such factors as plant density, type of cultivar used and climatic and edaphic conditions of the experimental sites. That pronounced effect of detasselling on the yield of maize would likely be much felt under lower and unfavourable growing conditions such as high temperature, moisture deficits and high plant density. Apical dominance of the tassel over the ear has been reported to be usually accentuated under conditions of high temperature and low moisture condition. This trial in the two years of study was established under cool and adequate moisture conditions. So also, the higher plant density of 80,000 plants per hectare might not be high enough to present competition and sufficient pressure that might have induced abiotic stress to the maize plant population thereby causing stress. Earlier reports had enumerated the role of detasseling on maize as a means of minimizing abiotic stress due to plant pressure (Subedi, 1996). While, the variations observed in the responses of the varieties to tassel removal could be attributed to differences in the genotypic potentials of the maize varieties to utilize resources and allocate them to the respective sinks (Andrade, 2002; Sammauria *et al*., 2019). Maize detasseling has been previously shown to affect the proportion of total incoming PAR that penetrates the canopy at anthesis (Sammauria et al., 2019). There is every likelihood that the net gain of detasseling could be obtained if these maize varieties were to be grown under high plant pressure or a more limiting environment.

Conclusion

Detasselling appeared not to enhance the biomass yield and the grain yield of maize grown under the two plant densities in this study, however, the percentage moisture contents of grains obtained from detasselled maize plants were higher than grain moisture of grains from plants with intact tassels. So also, variations were observed in the biomass yield and total grain yield of the interactions of these maize varieties with tasselling. Insufficient plant pressure and lack of moisture stress might have hindered the overall benefits of detasselling on grain yield in this study.

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Table 1: Mean square of yield components from Analysis of variance of four maize varieties grown under two planting distances after detasselling in Ibadan

Source of variation	D.F	100-GWT(g)	GMC(%)	FWT(Kg ha^{-1})	GY (t ha^{-1})
REP	2	2.67	18.69	0.98	1.20
Plant Density (D)	1	0.00	11.55	3.47*	1.56*
Error(a)	2	9.95	1.31	0.07	0.08
Tassel (TC)	1	0.02	6.13*	0.29	0.17
D*TC	1	6.75	12.87*	0.26	0.21
Error(b)	4	14.92	0.65	0.28	0.21
Varieties (V)	3	28.78*	5.36	0.11	0.11
D*V	3	1.26	0.61	0.31	0.10
TC*V	3	10.78	3.63	1.91*	1.20*
D*TC*V	3	7.35	5.05	0.69	0.43
Error(c)	24	5.73	6.55	0.41	0.29
Total	47				

***** *Significant at P< 0.05 level. D.F= Degree of freedom, R/C= Numbers of rows per cob, K/R= Numbers of kernels per row, 100-GWT=Weight of 100 grains, GMC= Grain moisture content FWT= Fresh weight and GY= Grain yield***

Table 2: Means of yield parameters of four maize varieties as determined by detasseling, plant densities and the interactions

Source of variation	100-GWT(g)	GMC(%)	FWT(Kg ha^{-1})	GY (t ha^{-1})
Plant Density (D)				
80,000 pl ha^{-1}(D1) ^{n}	28.06a	27.06a	4.50a	3.29a
53,333 pl ha^{-1}(D2) ^{m}	28.06a	28.04a	3.97b	2.93b
Tasseling (T)				
Tasseled (T)	28.08a	27.19b	4.16a	3.05a
Detasseled (DT)	28.04a	27.91a	4.31a	3.17a
Variety (V)				
DMRLSR-W	27.08b	27.39a	4.16a	3.14a
OBASUPER-1	30.38a	27.31a	4.20a	3.07a
OBASUPER-2	27.38b	28.52a	4.21a	3.01a
SUWAN-1	27.42b	26.98a	4.37a	3.23a
D*V				
D1*DMRLSR-W	27.25a	26.59a	4.23a	3.23a
D1*OBASUPER-1	30.08a	27.02a	4.41a	3.19a
D1*OBASUPER-2	27.75a	27.99a	4.56a	3.25a
D1*SUWAN-1	27.17a	26.63a	4.81a	3.51a
D2*DMRLSR-W	26.92a	28.18a	4.08a	3.05a
D2*OBASUPER-1	30.67a	27.60a	3.99a	2.95a
D2*SUWAN-1 -	27.67a	27.33a	3.93a	2.96a
D*T				
D1*T	27.71a	27.93a	4.35a	3.17a
D2*T	28.46a	27.88a	3.96a	3.42a
D1*DT	28.42a	26.18b	4.65a	2.94a
D2*DT	27.67a	28.20a	3.97a	2.93a
T*V				
T*DMRLSR-W	26.67a	27.58a	3.85b	2.91a
T*OBASUPER-1	29.42a	27.09a	4.09b	2.99a
T*OBASUPER-2	27.58a	29.62a	3.83b	2.69b
T*SUWAN-1	28.67a	27.33a	4.87a	3.62a
DT*DMRLSR-W	27.50a	27.19a	4.46a	3.37a
DT*OBA SUPER-1	31.33a	27.52a	4.32a	3.15a
DT*OBA SUPER-2	27.17a	27.42a	4.59a	3.33a
DT*SUWAN-1	26.17a	26.63a	3.87a	2.84b
Mean	28.06	27.55	4.23	3.11

Interaction. Means designated with the same alphabets along the same column are not significantly different (P<0.05) according to LSD. 100-GWT=Weights of 100-grains, GMC=Grain moisture content, FWT=Fresh Harvest Weight and GY=Grain yield. [Source of data: Anjorin, F.B in press]

Table 3: Comparison of the effect of detasseling on grain yield of maize at each level of Varieties

	Maize varieties			
Tasseling	**DMR-LSR**	**OBA SUPER-1**	**OBA SUPER-2**	**SUWAN-1**
Non-detasselled (T)	2.91a	2.99a	2.69b	3.62a
Detassel (DT)	3.37a	3.15a	3.33a	2.84b
Mean	3.14	3.07	3.01	3.23

Means with the same letter are not significantly different according to LSD (P<0.05)

Table 4: Comparison of the maize varieties at each level of tasselling on grain yield of maize

Varieties	DT Group	T Group
DMR-LSR	3.37a	2.91b
OBA SUPER-1	3.15a	2.99ab
OBA SUPER-2	3.33a	2.69b
SUWAN-1	2.84a	3.62a
Mean	3.17	3.05

Means with the same letter are not significantly different according to LSD (P<0.05), DT= Detasselled, T=Non-detasselled

Table 5: Comparison of detasseling effects on biomass yield of maize at each level of Varieties

	Maize varieties			
Tasseling	**DMR-LSR**	**OBA SUPER-1**	**OBA SUPER-2**	**SUWAN-1**
Non-detasseled (T)	3.85a	4.09a	3.83b	4.87a
Detasseled (DT)	4.46a	4.32a	4.59a	3.87b
Means	4.20	4.20	4.21	4.4

Means with the same letter are not significantly different according to LSD (P<0.05)

Table 6: Comparison of Varieties at each level of tasselling on biomass yield of maize

Varieties	**T Group**	**DT group**
DMR-LSR	3.85b	4.46a
OBA SUPER-1	4.09b	4.32a
OBA SUPER-2	3.83b	4.59a
SUWAN-1	4.86a	3.87a
Means	4.16	4.31

Means with the same letter are not significantly different according to LSD (P<0.05). T=Non- detasselled, DT= Detasselled