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EFFECT OF DROUGHT ON MORPHOLOGICAL CHARACTERISTICS OF HYBRID MAIZE (*Zea mays* L.)

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ABSTRACT

Maize is one of the most important crops in Nigeria having its usefulness as food for human, major feed ingredient for livestock, raw materials for agricultural industries and. The recent expansion of the poultry industry has significantly increased the demand for maize to the extent that large quantities of maize are imported annually. There is

Introduction

Maize (*Zea mays* L.), along with wheat and rice, is one of the main staple foods in the world with a global production of more than 1 × 10^9 t since 2013 (Noman et al., 2015; Zampieri et al., 2019). Maize is grown for various purposes, such as human consumption, animal feed, forage production, and renewable energy: bioenergy (Aslam et al., 2015; Ai and Jane, 2016). In Nigeria, maize is one of the most important crops and its dual rate of feeding a fast-increasing population and supporting a potentially buoyant agricultural industrialization is well recognized. The recent expansion of the poultry industry has significantly increased the demand for maize to the extent that large quantities of maize are imported annually. By 2050 the global demand for maize is projected to double (Hunter *et al.*, 2017; Ray *et al.*, 2013).

All over Nigeria, maize is a source of carbohydrates for man as well as his livestock. Fresh maize is roasted and

need to increase the production of maize to meet the increasing human population, livestock feeding, agro-industry as well as biofuel industry. One of the major challenges facing maize production is drought. Maize crops are extremely sensitive to drought especially during flowering period and can results into reduction in yield. This study aims to morphologically characterize the effects of drought on hybrid maize yield.The results showed that there was little difference on dry matter accumulation in the hybrid maize under unstressed and stressed conditionsand early water stress reduced internode extension of hybrid maize.

Keywords: *Maize, hybrid, drought, yield, population, morphological, characteristics*

boiled and can be eaten on the cob. Dry grains may be cooked with beans and eaten as ''adalu'' or ground into wet flour and processed into ''ogi'' which will later be used in making pap. Despite the tremendous progress made so far in the development of new, highly yielding varieties of maize and the recommendations on better crop husbandry, the annual production of this crop has not increased greatly in the past few years. The major setback and obstacle preventing the bumper harvest includes insufficient amount of rainfall, temperature, daylight, solar radiation humidity and soil fertility. Maize cultivation in the developing world relies heavily on rainfall (Shiferaw *et al*., 2011; Papanastassiou, 2012; BurleighDodds Science Publishing, 2017). The amount, distribution and efficiency of rainfall are highly important factors in successful maize production. Pre-planting precipitation or initial soil moisture contributes a great deal towards meeting the cop requirement of several maize growing areas of topical Africa.

Maize is most sensitive to drought during the flowering period. The most important symptoms of drought damage during flowering are the following

Maize crops are extremely sensitive to drought especiallyduring flowering period (Westgate and Boyer, 1985; Spitko*et al*., 2014;Zhao et al., 2016) when a

short spell of stress can reduce the crop yield by 30 – 50 %on average, the plants are about 2.5mm of water per day until the plants are about 25 – 30 cm tall. Plants may utilize various strategies such as improvements in water use efficiency Aslam et al., 2015; Lamaouiet al., 2018), completing reproductive processes before the onset of dry weather(Aslam et al., 2015; Khan et al., 2019) and improving drought tolerance (Ribautet *al*., 2009). According to Hussain et al. (2019), world maize yield and production are projected to decline by 15–20% per year due to heat and drought conditions, with these two factors becoming major threats to this crop. Hence, the aim of this research is to investigate the effect of droughton maize plants.
Therefore, the aim of the study is to ……..

Materials and Methods

Location

This study was carried out at the Greenhouse of the Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria.Materials used for the study include thirty–two (32) plastic cups, topsoil, ruler, watering can, field notebook, oven, weighing machine, envelopes, pencils and two improved hybrid maize cultivars: 8522-2 and 8525-23.

Experimental design

The experiment was randomized complete block design (RCBD) with four replicates (Table 1). The first planting was done on 14thJanuary 2021 and the second on 14th April, of the same year. The thirty-two cups were filled with topsoil collected around the greenhouse premises. The filled cups were placed on benches and the planting was done following day to allow enough evaporation to take place and to have almost equal amount of moisture content in all the cups under given set of environmental conditions.There were two experiments for this study. The first experiment designated ''A'' consisted of four cups per replicate with its plants watered to saturation every other day stating from day 2; and the other designated ''B'' with its plants watered every four days to saturation stating from Day 4. There were four cups per replicates.

Three seeds were planted to a depth of 2cm per cup because of the high viability of the seeds and later thinned to two stands per cup after a week. Un-germinated plants or were not supplied. The cups distance was maintained at 18cm within and 21cm between.

Table 1:.Treatments within the replicates

Replicate	Varieties			
i	a	b	a	B
ii	a	a	b	B
iii	a	b	b	A
iv	b	a	b	A

Source: Data Analysis, 2021

Data Collection

Data were collected on the following parameters:day to emergence (emergence count was done per cup at four, five and six days after planting); leaf number(numbers of leaves per stand and per cup were counted at seven days interval till forty-five days after planting); internodes length (internode length was measured per stand and per cup with ruler at seven days interval till forty-five days after planting); fresh weight (At forty-five days after planting, the root was carefully uprooted from the cups and each plant root was rinsed in water to remove adhering soil particles. The plants were then spread on envelopes for two minutes to remove the water films on the roots. This was done in the greenhouse. The plants were then packed into the correspondinglabelled envelopes and finally transferred for weighing. The envelope was fist weighed and the weight was recorded and then, the envelope with the enclosed plant. This was done for all samples. The difference between the two weighed samples accounted for the fresh weight of each plant sample); and dry weight(all the enclosed plants in their separate envelopes were then transferred into an oven for two days with temperature at 70 °C. At the end of 48 hours, the samples were re-weighed with the weight

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of dry plants separately. The difference then accounted for the dry weight. The experiment was repeated once).

Statistical Analysis

Data were analysed, using analysis of variance(ANOVA) to obtain significant differences in the experiments.The F ratio at 5% level of significant was calculated.

Results and Discussion

Data from the dry matter accumulation, internode length and analysis of variance of the internode length in greenhouse studies of hybrid maize under different conditions were presented.The result of chemical analysis of plant matter are usually expressed based on dry weight rather than the fresh weight basis because fresh plant weight is highly variable changing with the time of the day, the amount of moisture available in the soil, the temperature and wind velocity. The result of dry matter accumulation of the plants in response to the treatment is shown on table 2. There was little difference on dry matter accumulation in the hybrid maize under unstressed condition compared with those under stressed condition. Bassou*et al.*, 2012reported that increasing water deficits induced a relative reduction in dry matter yield and plant height.

Table 2: Dry matter accumulation of hybrid maize under different conditions

Conditions	Fresh weight (gm)	Dry weight (gm)	%Dry Matter
Unstressed	11.5	2.2	19.1
	10.7	1.9	17.8
	11.9	2.5	21.0
	9.8	1.9	19.4
Stressed	7.9	2.1	26.6
	6.6	1.5	22.7
	7.8	2.0	25.6

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	5.9	1.5	25.4

Source: Data Analysis, 2021

Table 3 showed the difference in the internode length of the hybrid maize under the two conditions. There was difference in the first, second and sixth internodes length of hybrid maize under unstressed and stressed conditions while the third, fourth and fifth internodes length were almost equal in length. The first, second and sixth internode length of hybrid maize under unstressed condition is longer than the internode length of hybrid maize under stressed condition. This show that early water stress reduced internode extension. The third, fourth and fifth internode length of the hybrid maize under the two conditions were almost equal. The results agree with Bassou*et al*., 2012 reported that during the first period of growth, different irrigation modesshowed no significant effect.Bennouna*et al*., 2004 also stated that maize is apparently more droughts resistant in the early stages of growth than when fully developed.

Table 3: Internode length (cm) of hybrid maize under different conditions

		INTERNODE 1					INTERNODE 2					INTERNODE 3				
Treatment	Wks	1	2	3	4	∑	1	2	3	4	∑	1	2	3	4	∑
Unstressed	1	3.5	4.8	5.2	4.9	18.4	-	-	-	-	-	-	-	-	-	-
	2	4.0	4.8	5.2	4.9	18.9	3.1	3.7	4.8	4.1	15.7	-	-	-	-	-
	3	4.4	5.0	5.5	5.3	20.2	3.5	4.0	5.0	4.3	16.8	1.9	1.8	1.9	1.5	7.1
	4	4.6	5.3	5.8	5.5	21.2	3.8	4.3	5.2	4.7	18.0	2.2	2.4	2.4	1.8	8.8
	5	4.7	5.6	5.9	5.6	21.8	4.0	4.5	5.3	4.8	18.6	2.4	2.6	2.6	2.1	9.7
	6	4.9	5.6	5.9	5.6	22.0	4.1	4.7	5.4	4.9	19.1	2.6	3.1	2.9	2.4	11.0
Stressed	1	2.8	3.9	3.4	3.8	13.9	-	-	-	-	-	-	-	-	-	-
	2	3.2	4.2	2.8	4.2	15.4	2.9	3.1	4.5	4.1	14.6	-	-	-	-	-
	3	3.5	4.5	3.9	4.4	16.3	3.4	3.4	4.9	4.3	16.0	1.6	2.3	2.8	2.6	9.3

	4	3.7	4.6	4.1	4.5	16.9	3.6	3.7	5.2	4.4	16.9	2.3	2.7	3.2	3.1	11.3
	5	3.9	4.7	4.2	4.5	17.3	3.8	4.0	5.5	4.5	17.8	2.5	3.0	3.5	3.4	12.4
	6	4.0	4.4	4.2	4.5	17.1	3.8	4.1	5.5	4.6	18.0	2.7	3.2	3.6	3.7	13.2
∑		47.2	57.3	57.1	57.7	219.4	86	39.5	51.3	44.7	171.5	18.2	21.1	22.9	20.6	82.8
		INTERNODE 4					**INTERNODE 5**					**INTERNODE 6**				
Treatment	Wks	1	2	3	4	∑	1	2	3	4	∑	1	2	3	4	∑
Unstressed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	1.8	1.9	2.0	2.1	7.8	-	-	-	-	-	-	-	-	-	-
	5	2.1	2.0	2.5	2.4	9.0	1.8	2.2	2.4	2.3	8.7	-	-	-	-	-
	6	2.3	2.8	2.9	2.7	10.7	2.3	2.7	2.8	2.7	10.5	2.4	3.2	3.0	3.8	12.4
Stressed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	1.7	1.5	2.3	2.7	8.2	-	-	-	-	-	-	-	-	-	-
	5	2.1	2.0	2.8	2.9	9.8	2.5	2.1	3.2	2.6	10.4	-	-	-	-	-
	6	2.3	2.3	3.0	3.2	10.8	2.9	2.1	3.5	3.0	11.5	2.3	2.5	2.9	2.8	10.5
∑		12.3	12.5	15.5	16.0	56.3	9.5	9.1	11.9	10.6	41.1	4.7	5.7	5.9	6.6	22.9

Source: Data Analysis, 2021

Table 4, 5, 6 and 7 showed the analysis of variance of the internode length. The effects of treatment, week, density, and replicate were seen to have significant differences in the internode extension of hybrid maize under the two conditions. The results showed the first, second, third and fourth internode length of the hybrid maize under stressed and unstressed conditions differ significantly ($p<0.05$) based on the treatment and weeks the stress occurred.

The fifth and sixth internode length did not show any significant difference (p>0.05). The exposure of these two internode length was so short to cause any significant difference.Daryanto*et al*., 2016 results showed that maize experiencing drought during their reproductive phase had greater yield loss than those experiencing drought during their vegetative phase ($P < 0.05$), although greater amount of available water during vegetative phase likely contributed to the greater yield

Table 4: Analysis of variance ofthe first internode length (cm) in greenhouse studies of hybrid maize under different conditions.

SV	DF	SS	MS	F
Total	47	27.0192	0.5749	
Replicate	3	5.5617	1.8539	21.5821*
Treatment	11	18.6242	1.6931	19.7102*
Week (W)	5	4.8167	0.9633	11.2142*
Density (D)	1	13.6553	13.6553	158.9674*
W x D	5	0.1522	0.0304	6.3539
Error	33	2.8332	0.0859	

*Significant at P = 0.05 level

Source: Data Analysis, 2021

Table 5: Analysis of variance of the second internodes length (cm) in greenhouse studies of hybrid maize under different conditions.

SV	DF	SS	MS	F
Total	39	18.4437	0.4729	
Replicate	3	13.2967	4.4322	177.288*
Treatment	9	4.4712	0.4968	19.872*
Week (W)	4	3.8575	0.9644	38.576*
Density (D)	1	0.6002	0.6002	24.008*
W x D	4	0.0135	0.0034	0.1360
Error	27	0.6758	0.0250	

*Significant at P = 0.05 level

Source: Data Analysis, 2021

Table 6: Analysis of variance of the third internode length (cm) in greenhouse studies of hybrid maize under different conditions.

SV	DF	SS	MS	F
Total	31	10.4150	0.3360	
Replicate	3	1.4075	0.4692	4.9968*
Treatment	7	7.0350	1.0050	10.7029*
Week (W)	3	4.1325	1.3775	14.6699*
Density (D)	1	2.8800	2.8800	30.6709*
W x D	3	0.0225	0.0075	0.0799
Error	21	1.9725	0.0939	

*Significant at P = 0.05 level

Source: Data Analysis, 2021

Table 7: Analysis of variance of thefourth internode length (cm) in greenhouse studies of hybrid maize under different conditions.

SV	DF	SS	NS	F
Total	31	4.6396	0.1497	
Replicate	3	1.8946	0.6315	17.5905*
Treatment	7	1.9922	0.2946	7.9276*
Week (W)	3	1.8909	0.6303	17.5571*
Density (D)	1	0.0704	0.0704	1.9610
W x D	3	0.0309	0.0103	0.2869
Error	21	0.7529	0.0359	

*Significant at P = 0.05 level

Source: Data Analysis, 2021

Table 8 and 9 showed the results of the analysis of variance of the fifth and sixth internode length (cm) in greenhouse studies of hybrid maize under different conditions respectively. . The treatment did not have significant difference (p>0.05) of the length of the fifth and sixth internode of the hybrid maize under stressed and unstressed condition.

Table 8: Analysis of variance of the fifth internode length (cm) in greenhouse studies of hybrid maize under different conditions.

SV	DF	SS	Ms	F
Total	15	2.9940	0.1996	
Replicate	3	1.1819	0.3940	4.42*
Treatment	3	1.0119	0.3373	3.79
Week (W)	1	0.5257	0.5257	5.90*
Density (D)	1	0.4557	0.4557	5.00
W x D	1	0.0305	0.0305	0.34
Error	9	0.8660	0.890	

*Significant at P = 0.05 level

Source: Data Analysis, 2021

Table 9: Analysis of variance of the sixth internode length (cm) in greenhouse studies of hybrid maize under different condition.

SV	DF	SS	MS	F
Total	7	1.6787	0.2398	
Replicate	3	0.9237	0.3079	3.04
Treatment / Density	1	0.4512	0.4512	4.45
Error	3	0.3038	0.1013	

*Significant at P = 0.05 level

Source: Data Analysis, 2021

Conclusion

Drought period of a few days on maize plant after planting have little influence on the dry matter accumulation and cannot produce any significant reduction in gain yield.Early water stress reduced internode expansion, leaf expansion, leaf area and reduced relative growth rate which was related to reduction in both net assimilation rate and leaf area ratio. The overall effect of stress on all the above parameter is reduction in grain yield.The seed emergent and the rate of leaf appearance were not affected but stress reduced the rate of leaf senescence.Hence, severe droughts applied over a period of a few days may have various effects on the development ofmaize, depending on the stage of development of the plant when drought occurred.

References

Ai, Y., and Jane, J. L. (2016). Macronutrients in corn and human nutrition. *Comp. Rev. Food Sci. F* 15, 581–598. doi: 10.1111/1541-4337.12192

Aslam, M., Maqbool, M. A., and Cengiz, R. (2015). *Drought Stress in Maize Zea Mays L.).* Cham: Springer International Publishing AG.

Bassou, B., Dimitry, X., Ahmed, B., Pierre, R. and Jean-Claude, M. (2012). Effect of water stress on growth, water consumption and yield of silage maize under flood irrigation in a semi-arid climate of Tadla (Morocco). Biotechnol. Aron. Soc. Environ, 16(4): 468-477.

Bennouna, B., Lahrouni, A., Bethenod, O., Fournier, C., Andrieu, B. and Khabba, S. (2004). Development of Maize Internode under Drought Stress. Journal of Agronomy, Vol 3(2): 94-102.

BurleighDodds Science Publishing. 2017. Delivering knowledge for theglobal scientific community- Maize: Key challenges. BDS Publishing. http://bdspublishing.com/_webedit/uploaded-Files/All%20Files/Maize%20blog%20key%20challenges.pdf (accessed 24 Nov. 2017).

Daryanto, S., Wang, L. and Jacinthe, P.A. (2016). Global Synthesis of Drought Effects on Maize and Wheat Production. PloS ONE 11(5): e0156362. Doi: 10,1371/journal pone 0156362

Hunter, M.C., Smith, R.G., Schipanski, M.E., Atwood, L.W. and Mortensen, D.A. (2017). Agriculture in 2050: Recalibrating targets for sustainable intensification. Bioscience 67, 386–391.

Hussain, H. A., Men, S., Hussain, S., Chen, Y., Ali, S., Zhang, S., et al. (2019). Interactive effects of drought and heat stresses on morpho–physiological attributes, yield, nutrient uptake and oxidative status in maize hybrids. *Sci. Rep.* 9, 1–12.

Khan, S., Anwar, S., Ashraf, M. Y., Khaliq, B., Sun, M., Hussain, S., et al. (2019). Mechanisms and Adaptation Strategies to Improve Heat Tolerance in Rice. *A Rev.. Plants* 8:508. doi: 10.3390/plants8110508

Lamaoui, M., Jemo, M., Datla, R., and Bekkaoui, F. (2018). Heat and drought stresses in crops and approaches for their mitigation. *Front. Chem.* 6:26. doi: 10.3389/fchem.2018.00026

Noman, A., Ali, S., Naheed, F., Ali, Q., Farid, M., Rizwan, M., et al. (2015). Foliar application of ascorbate enhances the physiological and biochemical attributes of maize (Zea mays L.) cultivars under drought stress. *Arch. Agron. Soil Sci.* 61, 1659–1672. doi: 10.1080/03650340.2015.1028379.

Papanastassiou, N.J. (2012). Crop-environment interactions in sub-Saharan Africa In: Colby Environmental Policy Group, Environmental policy update 2012. Development strategies and environmental policy in East Africa. Colby College Environ. Studies Group, Water-ville, ME. Ch. 3.

Ray, D.K., Mueller, N.D., West, P.C. and Foley, J.A. (2013). Yield trends are insufficient to double global crop production by 2050. PLoS ONE 8, e66428.

Ribaut, J.M., Betran, J., Monneveux, P., and Setter, T. (2009). "Drought tolerance in maize" in *Handbook of Maize: Its Biology*, eds Bennetzen J., Hake S. (New York, NY: Springer;, 311-344. 10,1007/978-0-387-70418-1_16.

Shiferaw, B., Prasanna, B.M., Hellin, J. and Banziger, M. (2011). Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. Food Security 3:307-327, doi:10.1007/s12571-011-0140-5.

Spikto, T., Nagy, Z., Zsubori, Z.T., Halmos, G., Banyai, J. and Marton, C.L. 2014. Effect of drought on yield components of maize hybrids (Zea mays L.). Mydica 59(2): 161-169.

Westgate, M.E. and Boyer, J.S.1985. Carbohydrate reserves and reproductive development at low leaf water potentials in maize. Crop Science 25, 782-769.

Zampieri, M., Ceglar, A., Dentener, F., Dosio, A., Naumann, G., Van Den Berg, M., et al. (2019). When will current climate extremes affecting maize production become the norm? *Earths Future* 7, 113–122. doi: 10.1029/2018EF000995

Zhao, F., Zhang, D., Zhao, Y., Wang, W., Yang, H., Tai, F., et al. (2016). The difference of physiological and proteomic changes in maize leaves adaptation to drought, heat, and combined both stresses. *Front. Plant Sci.* 7:1471. doi: 10.3389/fpls.2016.01471