THE EFFECT OF WATER STRESS ON MAIZE VARIETIES (*Zea mays* L) IN MINNA, NIGER STATE SOUTHERN GUINEA SAVANNA OF NIGERIA

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Abstract

Water stress is one of the major limiting factors in rain-fed agriculture resulting in reduced crop growth and productivity, use of maize varieties that can perform well under sub-optimal moisture conditions are therefore required. Field experiments were conducted in Minna, southern guinea savanna of Nigeria in the dry and rainy season of 2017 to evaluate the performance of some maize varieties. The study comprised of ten maize varieties, water stress was imposed for 23 days at pre-anthesis stage of crop growth in the dry season. The experiment were conducted in a randomized complete block design (RCBD) replicated three times. Data revealed that some growth parameters were reduced in the stressed plants. Yield components such as number of kernels per cob, kernel weight per cob, cob weight per plant, and kernel yield were significantly ($p \leq 0.05$) different. The yield attributes obtained from maize plants exposed to water stress at the pre- anthesis stage of crop development are number of kernels per cob 89.0, kernel weight per cob 21.0 (g), cob weight per plant 41.6 (g), and kernel yield kg ha^{-1} 280.6 (kg). While those obtained in the rainy season are number of kernels per cob 502.0, kernel weight per cob 137.4 (g), cob weight per plant 154.0 (g), and kernel yield kg ha^{-1} 4292.5 (kg).

Keywords: Maize, Water stress, Pre-anthesis, Growth, Yield

INTRODUCTION

Maize (*Zea mays* L) also known as corn, is a large grain plant first domesticated by the indigenous peoples in southern Mexico about 10,000 years ago (Utah, 2016). Maize has become a staple food in many parts of the world, with total production surpassing that of wheat or rice. However, not all of this maize is consumed directly by humans (Franklin, 2013). Maize is the most widely grown staple food crop in sub-Saharan Africa (SSA) occupying more than 33 million hectares each year (FAOSTAT, 2015). The crop covers nearly 17 % of the estimated 200 million hectares cultivated land in SSA, and is produced in diverse production environments and consumed by people with varying food preferences and socio-economic backgrounds. More than 300 million people in SSA depend on maize as source of food and livelihood. In developed countries, maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, maize is consumed directly and serves as staple diet for some 200 million people. Most people regard maize as a breakfast cereal. However, in a processed form it is also found as fuel (ethanol) and starch. Starch in turn involves enzymatic conversion into products such as sorbitol, dextrine, sorbic and lactic acid, and appears in household items such as beer, ice cream, syrup, shoe polish, glue, fireworks, ink, batteries, cosmetics, aspirin, and paint (du Plessis, 2003).

The National Oceanic and Atmospheric Administration (NOAA) defines drought as a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people (NOAA, 2012). Drought is a sustained and regionally extensive occurrence of below average natural water availability. Drought is a recurrent climatic phenomenon across the world. It affects humanity in a number of ways such as causing loss of life, crop failures, food shortages which may lead to famine in many regions, malnutrition, health issues and mass migration. It also causes huge damage to the environment and is regarded as a major cause of land degradation, aridity and desertification (Masih *et al.*, 2014).

MATERIALS AND METHODS

The field evaluation was conducted in Chanchaga Irrigation Scheme II, (latitude 9° 37' N and longitude 6° 30' E; 200 m above sea level), in the southern guinea savanna, Minna, Niger State, Nigeria. Ten maize cultivars (Oba 98, Oba super 2, Oba Super 6, Sammaz 14, Sammaz 15, Sammaz 17, Sammaz 24, Sammaz 27, Sammaz 34, and Sammaz 36. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The experiment involved two water regimes, the dry season and the rainy season. Irrigation water was withdrawn or drought imposed in the dry season experiment for a period of twenty three days. Data collected were subjected to analysis of variance (ANOVA), and Student Newman Keuls (SNK) Test at 5 % level of significant was used to separate the means, and to compare the agronomic performance of maize in dry and rainy seasons

RESULT

Plant height at weeks after sowing, 9 weeks after sowing and anthesis silking interval were significantly affected by water stress table 2. Growth parameters differed between the two water regimes, such that non-stressed maize plants were taller, than those grown under water stress condition table 1. Anthesis silking interval was similarly affected by season such that water stress maize had more days between anther extrusion and silk exposure table1.

Table 1 Means square of plant height at 7 weeks after sowing, 9 weeks after sowing and anthesis silking interval of maize varieties as influenced by water stress in 2017

Source of variation	DF	PH 7WAS	PH 9WAS	ASI
Season (s)	1	3588.3*	4175.0**	88.8**
Error (s)	2	112.5	124.3	0.1
Variety (v)	9	705	623.1*	0.3
S×V	9	275.2	343.2	0.6
Error	36	344	208.3	0.5

PH 7WAS = plant height at 7 weeks after sowing, PH 9WAS = plant height at 9 weeks after sowing and ASI = anthesis silking interval

Table 2 Plant height at 7 weeks after sowing, 9 weeks after sowing and anthesis silking interval in some maize varieties under water stress and non-stress conditions of 2017

Seasons	PH 7WAS	PH 9WAS	ASI
1	175.0b	186.2b	9.0a
2	190.4a	203.0a	5.0b
LSD	49.0	46.1	0.5

Means with the same letter(s) in a column are not significantly different at $p \leq 0.05$
PH7WAS = plant height at 7 weeks after sowing, PH9WAS = plant height at 9 weeks after sowing and ASI = anthesis silking interval

Number of kernel per cob, kernel weight per cob, cob weight per plant. and kernel yield ha-[1] were significantly affected by water stress table 3. Number of kernel, kernel weight per cob, cob weight per plant, and kernel yield ha-[1] differed between the water stressed, such that non-stressed plants produced more number of kernels per cob, kernel weight per cob and cob weight per plant and higher kernel yield ha-[1] compared to water stressed plants as shown in table 4.

Table 3 Means square of number of kernel, kernel weight per cob (g), cob weight per plant (g), and kernel yield ha-[1] (kg) of maize varieties as influenced by water stress in 2017

Source of variation	DF	NOK	KWC	CWP	kern yldh-[1]
Season (s)	1	2561426.8**	203502.2**	189337.8**	241435740.8**
Error (s)	2	7198.1	75.2	618.5	88607.5
Variety (v)	9	42584.2	659	622.6	123155.6
S×V	9	20878	374.4	821.6	81157
Error	36	4115.6	521.4	549.4	77221.4

NOK - number of kernel, KWC - kernel weight per cob, CW - cob weight per plant, and Kyha-[1] - kernel yield ha-[1]

Table 4 Number of kernel, kernel weight per cob (g), cob weight per plant (g), and kernel yield ha-[1] (kg) in some maize varieties under water stress and non-stress conditions of 2017

Seasons	NOK	KWC	CW	kern yldh-1
1	89.0b	21.0b	41.6b	280.6b
2	502.0a	137.4a	154.0a	4292.5a
LSD	1.5	47.4	46.0	648.1

NOK - number of kernel, KWC - kernel weight per cob, CW - cob weight per plant, and Kyha-[1] - kernel yield ha-[1]

DISCUSSION

Plant height from when irrigation water was withdrawn (with respect to water stressed maize), implies that maize grown in non-stress condition were taller compared with maize grown under water stress which produced shorter plants as reported by Aslam *et al*. (2015), which states that plant height is usually reduced under water stress conditions. Water stressed maize plants had more or longer days ranging from 1 – 3 days between anthesis and silking as presented in (table 4), which was in agreement with the findings of Dass *et al*. (2001) and Aslam *et al*. (2015) that silking is delayed by 6 – 9 days by prevalence of water stress. Delay in appearance of silk under water stress conditions is responsible for increased anthesis silking interval (Aslam *et al*., 2015). When stress coincides with the 7-10 day period prior to flowering, ear growth will slow more than tassel growth and there is a delay in silk emergence relative to pollen shed, giving rise to an interval between anther extrusion and silk exposure (Edmeades, 2013). The main reason is that water stress at tasseling stage delays tassel appearance Moradi *et al*., 2012).

The fewer number of kernels of maize subjected to pre-anthesis water stress is an indication of the deleterious effects of water stress in maize as reported by Edmeades (2013) which states that severe stress at tasseling may lead to the complete abortion of ears and the plant becomes barren. The affected ears typically have fewer kernels that will be poorly filled if water stress extends throughout grain filling (Edmeades *et al*., 2000). The disparity in kernel weight per cob between the two water regimes was as a result of poor grain filling during the critical kernel developmental stages in maize. As noted by Yadav *et al*. (2004), water stress reduces the photosynthesis and translocation of photosynthetic assimilates followed by reduced grain filling.

CONCLUSION

Water stress affects the growth, dry mater and harvestable yield in plants. Crop production will be affected by rising temperatures and by changes in the frequency and intensity of precipitation or rainfall events, as well as by the increase in seasonality and general uncertainty of these events. In this research, the non stress experiment recorded a higher yield compared to the stressed experiment.

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