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Effects of Water Stress on Physiological Seed Quality of Soybean Genotypes (*Glycine max* (L) Merril) in Makurdi, Nigeria

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Abstract

A screen house and Laboratory experiments were conducted during the 2017 cropping season at the Teaching and Research Farm as well as the Plant Breeding and Seed Science Laboratory of the Federal University of Agriculture, Makurdi, Benue state, to investigate the effects of water stress on seed quality of soybean genotypes in Makurdi. The screen house experiment was basically to generate seeds for the Laboratory experiment. The experiment consisted of three soybean genotypes (TGX-1448-2E, TGX-1835-10E and TGX-1951-3F) which were subjected to water deficit stress at three different growth stages which included; early vegetative growth stage, 50% flowering stage, early pod filling stage and a well-watered treatment to serve as a control. The experiments were conducted in a Completely Randomized Design (CRD) with three replications. Parameters evaluated were germination percentage (G %), germination index (GI), germination rate index (GRI) and vigor index (VI). All data collected were subjected to the Analysis of Variance using Genstat 10.3DE package and significant means were separated using Fischer's Least Significant Difference (FLSD) at 5% level of probability. Results from Analysis of Variance (ANOVA) showed that; Water stress highly significantly ($p \leq 0.01$) affected all seed quality parameters evaluated. Genotypic effect was also highly significant ($p \leq 0.01$) for all seed quality attributes evaluated. Germination percentage, germination index and germination rate index were highest in TGX-1448-2E. Water stress at the early pod filling stage significantly ($p \leq 0.01$) reduced seed quality in terms of germination percentage, germination index, germination rate index and vigor index in TGX-1951-3F but did not significantly affect seed quality in TGX- 1835-10E and TGX-1448-2E. TGX-1835-10E and TGX-1448-2E were therefore, more tolerant to water stress while TGX-1951-3F was the least tolerant.

Keywords

Genotype, Stress, Ontogeny

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1. Introduction

Soybean (*Glycine max (L) Merrill*) is one of the most important leguminous crops globally known by different names in different countries of the world, such as Chinese pea, Chariabean, Cinderalla crop, soyabean, or soybean. In global rating, it is among the top ten of the most widely grown crops with a total grain production of over 260 million tons in 2010 [6]. The United States is the leading soybean producing country in the world with a volume of 106.93 million metric tons in 2017 and is forecasted to reach some 120.59 million metric tons in 2020. The total land area under soybean cultivation in Africa is about 1.3 million hectares with South Africa, Nigeria, Zambia, Uganda and Egypt [13]. Soybean cultivation in Nigeria has increased in the last two decades in the savannas because of its usage as a major cash crop in the food and animal feed industry [10]. It also constitutes an important component of the smallholders

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cropping systems and holds considerable potential for arresting soil fertility decline and reducing Striga infestation on farmers' fields [3].

Water stress (drought), is a serious problem limiting soybean production especially in the semi-arid regions. It can occur at any time of the cropping season and at any stage of the crop's growth and development. Reports on effect of water stress on physiological seed quality of soybean have been scarce and conflicting [7; 11 and 4]. Therefore, it is imperative to assess the effect of water stress on the physiological seed quality of soybean.

2. Materials and Methods

Three soybean genotypes consisting of TGX-1448-2E, TGX-1835-10E and TGX -1951-3F were obtained from the Seed Center of the Federal University of Agriculture Makurdi during the 2017 cropping season. These genotypes were selected based on their promising agronomic attributes and prevalence of cultivation in the soybean-producing areas of the Guinea Savanna region. Ten seeds each of the three soybean genotypes consisting of TGX-1448-2E, TGX-1835-10E and TGX-1951-3F were planted separately each in a pot. All the pots were watered and maintained consistently at field capacity until the commencement of water stress treatment two weeks after sowing when watering was stopped for the water stress treatment except for the control. The genotypes were subjected to water stress at three different growth stages - early vegetative stage (T_1) 2 weeks after sowing (WAS), 50% flowering stage (T_2) and early pod fillings stage (T_3). The water stress period lasted for ten days for water stress treatments after which watering resumed. Thinning to reduce the seedling population to six plants per pot was done two weeks after sowing. The screen house experiment was carried out in the screen house at the Teaching and Research Farm whereas the laboratory experiment to determine the physiological seed quality was conducted at the Plant Breeding and Seed Science Laboratory all of the Federal University of Agriculture Makurdi located at Latitude 07°41'N, Longitude 08°37'E in the Southern Guinea Savanna agro-ecological zone of Nigeria. The screen house was basically used to generate seeds for laboratory seed quality evaluation. The treatments were arranged in a Completely Randomized Design (CRD) replicated three times.

The germination response of seeds of various soybean genotypes which were subjected to drought treatments was determined by taking 50 seeds from each treatment and replicated three times. Seeds from each treatment were counted and placed on germination paper in Petri dishes arranged in a Completely Randomized Design (CRD). Petri dishes were then moistened with distilled water. Incubation was done at room temperature of about 30°C for seven days. Germination count was done for each day and the following determined after 7 days;

Germination characteristics

Percentage germination (G%) and germination rate index (GRI) were calculated based on the formulae adopted from [5] while germination index (GI) was determined using a formula by [1] as follows:

$$G\% = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} \text{ x } 100 \text{ [5]}$$

$$GI = \frac{number\ of\ germinated\ seeds}{days\ of\ first\ count} + \cdots + \frac{\text{number of germinated seeds}}{days\ of\ final\ count} \text{ [1]}$$

$$GRI = \frac{\text{GI}}{\text{G\% (in decimal)}} \text{ [5]}$$

Seedling Vigor index

Seedling Vigor Index I, was calculated by multiplying the germination percentage with the mean shoot and root length after 7 days of germination.

Vigor index I= germination percentage × seedling shoot length (cm) + seedling root length (cm) [2].

Data collected on all parameters were subjected to the Analysis of Variance (ANOVA) using the Genstat 10.3DE package. Significant means at 5% Probability level were separated using Fischer Least Significant Difference (FLSD).

3. Results and Discussion

Mean values for the effect of water stress on physiological seed quality attributes of soybean evaluated are presented in Table 1. The result indicated that germination percentage was highest in water stress at the vegetative stage. This was not significantly different from the well-watered control and 50% flowering stage but was significantly different from water stress at the early pod filling stage. A similar trend was observed in the germination index. Water stress at the vegetative growth stage recorded the highest germination rate index followed by well-watered control, 50% flowering stage and early pod filling stage. A similar trend was observed in the vigor index. Mean effect of genotype on seed quality attributes of soybean (Table 2) showed that, germination percentage was highest in TGX -1448-2E followed by TGX-1835-10E. TGX-1951-3F recorded germination percentage significantly lower than the other genotypes. A similar trend was observed for germination index and germination rate index. TGX-1835-10E recorded the highest vigor index not significantly different from TGX-1448-2E but was significantly different from TGX-1951-3F. Mean values for effect of water stress x genotype interaction presented in Table 3 indicated that TGX-1951-3F recorded significantly lowest germination percentage, germination index, germination rate index and vigor index when water stress was imposed at early pod filling stage. TGX-1835-10E recorded the highest vigor index which was significantly different from TGX- 1448-2E and TGX-1951-3F except at the early pod filling stage where TGX-1835-10E recorded vigor index not significantly different from TGX-1448-2E but were significantly different from TGX-1951-3F at various stages of water stress treatments. Water stress at the pod filling stage significantly reduced seed yield. This is as a result of the high water demands by soybean plants during reproductive ontogeny especially at seed filling stages. This agrees with previous reports by [8] and [9] who reported that pod number and seed yield were significantly reduced when drought occurred at pod filling stage compared to that of vegetative and flowering stages.

A highly significant difference observed for seed quality of soybean under drought showed that TGX-1951-3F produced seeds lowest in quality in terms of germination percentage, germination index, germination rate index and vigor index than TGX-1448-2E and TGX-1835-10E when drought occurred during the pod filling stage. Similar findings have also been reported by [12] that the effect of drought on soybean seed quality is more severe when drought occurred during the pod filling stage. They however concluded that this is more severe in some genotypes than others and it is caused by the increased proportion of hard and shrivelled seeds that are resistant to water imbibition and thus reduce the speed and totality of germination.

Table 1. Mean effect of water stress at different growth stages on seed quality of soybean in Makurdi, 2017.

Water stress	Germination %	Germination index	Germination rate index	Vigor index
Control (T_0)	93.17	8.95	460.60	1348.00
Vegetative stage (T_1)	94.30	9.53	471.60	1355.00
50 % flowering stage (T_2)	93.09	9.31	390.70	1289.00
Pod filling stage (T_3)	54.04	4.64	294.10	987.00
LSD (0.05)	2.22	1.64	47.60	68.80

KEY
T_o= Well-watered control
T_1 = Water stress at vegetative stage
T_2 = Water stress at 50% flowering stage
T_3 = Water stress at early pod filling stage

Table 2. Mean effect of Genotype on seed quality of soybean in Makurdi, 2017.

Genotypes	Germination %	Germination index	Germination rate index	Vigor index
TGX 1448-2E	93.77	9.45	432.80	1488.00
TGX 1835-10E	93.60	9.35	417.70	1513.00
TGX 1951-3F	56.28	4.67	347.30	890.00
LSD (0.05)	1.92	1.42	41.22	59.60

Table 3. Effect of Genotype x Water stress interaction on seed quality of soybean in Makurdi, 2017.

Gen	X	Ws	Germination %	Germination index	Germination rate index	Vigor index
		T_o	94.90	9.36	450.30	1471.00
TGX	1448-2E	T_1	93.84	9.41	485.00	1433.00
		T_2	93.66	8.87	462.60	1473.00
		T_3	93.59	8.76	456.20	1407.00
		T_o	94.63	8.60	435.00	1522.00
TGX	1835-10E	T_1	94.39	8.36	482.10	1574.00
		T_2	94.46	8.13	398.20	1505.00
		T_3	93.63	8.11	392.50	1423.00
		T_o	95.10	8.79	426.50	1461.00
TGX	1951-3F	T_1	94.97	8.73	477.80	1420.00
		T_2	93.06	8.78	371.40	1410.00
		T_3	57.10	4.57	113.70	851.00
LSD	(0.05)		3.84	2.84	82.45	119.10

KEY
T_o = Well-watered control T_2= Water stress at 50% flowering stage Ws= Water stress Gen= Genotype
T_1 = Water stress at vegetative growth stage T_3= Water stress at early pod filling stage

4. Conclusion

The results of this study showed that TGX-1951-3F was the most vulnerable genotype to water stress compared to TGX-1835-10E and TGX-1448-2E especially at early pod filling stage where physiological seed quality was significantly reduced. Water stress therefore affected physiological seed quality. The effect was however not universal to all genotypes but was more severe in TGX-1951-3F than the other two genotypes.

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