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Original Paper

Effect of water regime on seed germination of five sorghum (*Sorghum bicolor* (L.) Moench) genotypes growing in the field

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This study was designed to examine the effect of water regime on seed quality of five sorghum genotypes. Two laboratory experiments were conducted in two successive seasons (2014/2015–2015/2016) at the Regional Seed Center Laboratory, Agriculture Research Station (ARC), Elobied. The laboratory treatments were conducted as factorial experiments in a Randomized Complete Block Design (DCBD) with four replications. The estimated quality included seed germination test. The results showed that water regimes had significant effects on germination (%). The highest seedling length was recorded by well-watered plant. The highest seedling growth rate was recorded by plants under well-watered regime. Also the results revealed that genotypes were differing in germination percent, seedling length and seedling growth rate. The results indicated that Taggat genotypes scored the highest values of most seeds quality trials were measured in this study and it might be suitable for high quality and production under rain-fed condition.

Keywords: sorghum, *Sorghum bicolor* (L.) Moench, water regime, germination, seed vigor

1 Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) it is the world's fifth most commonly grown cereal crop after wheat, rice, maize and barley (Hamid, 2001). Globally sorghum is cultivated over an area of about 42.7 million ha with a production of about 58.7 million tonnes in many parts of the world (AghaAlikhani et al., 2012). Sorghum is capable to grow and produce yield at low rainfall areas. The crop is cultivated in areas considered to be too dry and hot for other cereals, because of its tolerance to drought and heat stress (Kenga et al., 2006). Grain sorghum, a well-adapted crop for central Sudan, is grown extensively under irrigated and dry land conditions. Abdalla and Gamar (2011) stated that the total area under sorghum production in the Sudan is estimated to be about 6.0 million ha, which is 73% of the total cropped area. Only 10% of this area is irrigated and 90% under rain-fed conditions. Water deficit (commonly known as drought) can be defined as the absence of adequate moisture necessary for a plant to grow normally and complete its life cycle (Moosavi et al., 2011). Seed is the basic unit which determines the stand establishment and possibly the growth and yield of all crops. Therefore, the use of high quality seeds for planting is a major requirement for high and reliable yield of crops. High quality seed is characterized as being the seed that has the ability to establish a full stand of vigorous and uniform seedling that will grow into productive mature plant (Declouche, 1969). Seed quality includes several attributes that lead to near maximum germination capacity to produce seedlings, which emerge rapidly from the seedbed and continue to grow uniformly thereafter (Harrington, 1971). Sorghum seed with either limited or fully controlled conditions maintained seed moisture, viability, germinability and field emergence close to that of newly harvested seed (Ahmed and Alamam, 2010). The highest germination and vigor of sorghum were obtained in the harvested seed in physiological maturity stage. Withholding irrigation at eight-leaf and flowering stages did not reduce germination of sorghum. Also seedling growth rate was not significantly affected by irrigation levels (Younesi and Moradi, 2009). The reduction in seedling growth under water stress was expected because the growth rate of plant cells and the efficiency of their physiological processes are highest when the cells are at maximum turgor (Achakzai, 2009, Achakzai and Bazai, 2007). Other researchers reported that drought stress during seed development reduced seed vigor but had no effect on seed germination (Fougereux et al., 1997, Samarah and Alqudah 2009). The yield of viable and vigorous seed is an important goal for sorghum seed producers and farmers. This implies good

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understanding of how stress affects seed viability and vigor. Water stress effects on grain yield, plant growth and development were thoroughly studied, but little information is available about its effects on physiological qualities of the seeds (Younesi and Moradi, 2009). Therefore, they need more investigations. The objective of this study is estimation the effect of water regimes on seed quality of five sorghum genotypes harvested during seed filling stage.

2 Material and methods

Two laboratory experiments were conducted in two successive seasons (2014/015–2015/016) at the Regional Seed Center Laboratory, Agriculture Research Station (ARC), Elobied. The experimental material used in this study consisted of five genotypes of sorghum seeds, which it sown in the field under three water regimes:

a) well watering (every seven days) as control (IR_0),
b) withholding irrigation at three-leaf stage for 21 days as stress one (IR_1),
c) withholding irrigation at eight-leaf stage for 21 days as stress two (IR_2).

In this experiment 20 grams of grains were harvested from each plot at physiological maturity stage.

2.1 Germination test (%)

This test was estimated from 20 grams of seed samples from each plot. Seeds were germinated in double filter papers and placed in Petri dishes and then transferred into a germinator at a constant 25 °C for 7 days according to (AOSA, 1988). At the end of the incubation period, the number of normal seedlings was recorded and the germination percentage was calculated as follows:

$$\textit{Germination}\ (\%) = \textit{number of normal seedling} \times 100/\textit{number of seeds planted}$$

2.2 Seedling length (cm)

At the end of incubation period, length of 7 days seedling were measured from the point of attachment to the seed up to the tip of the seedling, and the average shoot length of five seedlings was calculated by dividing the total shoot length of normal seedlings measured, to examine seed germination test.

2.3 Seedling growth rate

The seedlings growth rate were determined by weighing the fresh and dried seedlings in oven at 70 °C for 24 hr after removing the cotyledons of normal seedlings by sensitive balance, then It was obtained by the following formula:

$$\textit{Seedling growth rate} = \textit{fresh seedlings weight}\ (\text{g})/\textit{dry seedlings weight}\ (\text{g})$$

Analysis of variance was carried out for treatments and means were tested and separated using Duncan Multiple Range Test (DMRT) at $P = 0.05$.

3 Results and discussion

Table 1 showed that water regime, genotypes and their interactions had significant effects on mean germination percent in both seasons. Well-watered plant recorded the highest estimate in both seasons (88 and 89% respectively). This was because, water limitation might lower the level of seed mass due to its effect on amount of starch to produced. The result agree with Drummond et al. (1983) who reported that standard germination, was lower for seeds harvested from plants under drought than seeds harvested from irrigated plants. Regarding to genotypes, Taggat 10 scored the highest germination percent in the two seasons. The differences on germination percent among genotypes could be due to its response to water regime during growing season.

Table 1 Effect of water regime and genotypes on germination test (%) during 2014–2015 season

Treatments	Season 2014				Season 2015			
	water regimes				water regimes			
Genotypes	IR_0	IR_1	IR_2	mean	IR_0	IR_1	IR_2	mean
Taggat 9	90.0	90.0	90.0	90.0	88.0	88.0	80.0	85.0
Taggat 10	90.0	90.0	90.0	90.0	93.0	93.0	85.0	90.0
Taggat 14	90.0	90.0	70.0	83.0	93.0	85.0	82.0	87.0
Taggat 19	90.0	70.0	80.0	80.0	88.0	85.0	87.0	87.0
Gadambalea	80.0	90.0	80.0	83.0	83.0	88.0	82.0	84.0
Mean	88.0	86.0	82.0	...	89.0	88.0	83.0	...
Grand mean				87.00				86.5

Table 2 Effect of water regime and genotypes on seedling length (cm) during 2014–2015 season

Treatments	Season 2014				Season 2015			
	water regimes				Water regimes			
Genotypes	IR_0	IR_1	IR_2	mean	IR_0	IR_1	IR_2	mean
Taggat 9	13.82	13.70	12.96	13.49	16.15	15.63	14.48	15.42
Taggat 10	18.77	17.77	14.32	16.95	20.86	18.30	17.83	19.09
Taggat 14	16.86	15.60	14.38	15.61	19.27	15.60	16.57	17.15
Taggat 19	9.51	13.55	10.62	11.23	19.23	17.23	16.80	17.75
Gadambalea	15.53	13.25	10.16	12.98	14.08	12.60	13.13	13.27
Mean	14.90	14.77	12.49	...	17.92	15.87	15.76	...
Grand mean				14.05				16.52

Table 3 Effect of water regime and genotypes on seedling growth rate during 2014–2015 season

Treatments	Season 2014				Season 2015			
	water regimes				water regimes			
Genotypes	IR_0	IR_1	IR_2	mean	IR_0	IR_1	IR_2	mean
Taggat 9	0.13	0.05	0.07	0.08	0.09	0.07	0.08	0.08
Taggat 10	0.24	0.26	0.24	0.24	0.08	0.08	0.08	0.08
Taggat 14	0.03	0.11	0.06	0.07	0.09	0.08	0.08	0.07
Taggat 19	0.11	0.14	0.03	0.09	0.09	0.09	0.08	0.09
Gadambalea	0.12	0.10	0.11	0.11	0.09	0.09	0.09	0.09
Mean	0.13	0.13	0.10	...	0.09	0.08	0.08	...
Grand mean				0.12				0.08

3.2 Seedling length (cm)

Data presented in table 2 indicated that the highest seedling length was scored by well-watered plants (between 14 and 18 cm) in the two seasons. On the other hand, the lowest estimates (between 12 and 16 cm) were recorded by plants in stress II in both seasons. This finding is similar to that obtained by Achakzai (2009) who found that seedling shoot length, seedling root fresh weight and seedling shoot fresh weight recorded higher value by increasing water potential levels. Taggat 10 recorded the highest estimates (between 16 and 20 cm in season one and two). In contrast, the lowest estimates (between 12 and 14 cm) were recorded by Gadambalea in the two seasons. The significant difference among the five studied sorghum genotypes in their means seedling lengths could be reflected to their resistance to moisture stress.

3.3 Seedling growth rate

Table 3 revealed that the highest estimates were recorded by plants in well-water and plants in stress IR_1 (0.13). This might be attributed to the effect of water stress by reduction plant cells and their physiological processes. Similar results were obtained by Achakzai, 2009; Achakzai and Bazai, 2007. In contrary, Mutava (2009), reported that seedling growth rate was not significantly affected by irrigation levels. Taggat 10 in season one and Gadambalea in season two recorded the highest estimates (0.24 and 0.09, respectively). On the other hand, Taggat 14 recorded the lowest one in both seasons (0.07). The interaction of Taggat 10 in the same water regime scored the highest estimates (0.26) while Taggat 9 in stress I scored the lowest (0.05). These differences could be attributed to genetic factors in resistance to seedling growth rate in moisture stress.

4 Conclusions

It could be concluded that most of seed quality reduced by withholding irrigation at eight-leaf stage. Among the tested genotypes, Taggat genotypes produced higher values of most seed quality than all other genotypes.

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