CHAPTER ONE

INTRODUCTION

1.1 General introduction

Sorghum (*Sorghum bicolor* [L.] Moench) is the third most important cereal crop grown in the United States and the fifth most important cereal crop grown in the world after wheat, rice, maize, and barley in terms of production (FAO, 2012). It consists of cultivated and wild species. Sorghum bicolor *spp*. bicolor (2n= 20) is the toxin that includes five agnomonically important grain races, namely: bicolor, guinea, caudatum, durra and kafir (Doggett,1988). The size of the sorghum genome is about 750 Mbp (Klein et al., 2000). It is widely distributed from latitude 35^0 S to 35^0 N, and from zero to 2250 m above sea level. It is grown in regions receiving 300-1200 mm rainfall and soils pH 5.0 to 10.0 (Seetharama *et al*., 1990). In spite of this, sorghum yields are adversely and affected by a biotic stress, especially drought under low inputs management in the tropics.

Today, sorghum is the dietary staple of 500 million people in 30 countries in the world (FAOSTAT, 2013). More than 90% of the production was in developing countries and most of this was in the semi-arid areas of Africa and Asia (FAOSTAT, 2012). Recent statistics show that Sudan and Uganda are leading sorghum producers (FAOSTAT, 2015), Sudan accounting for 4.5 million

MT from 7.2 million Ha planted whilst Uganda accounted for 3 million MT from 3.5 million Ha (FAOSTAT, 2015). In the Sudan, Sorghum is the main staple food, and is used in different forms. In many parts the crop is wholly utilized (Ejeta, 1980). The grains are used for making “Kisra” (bread from fermented dough), and a significant portion is also used as thick porridge “Aseeda” and soft drink “Abrieh”. The stalks are used as building materials and as animal feed or as fuel (Elzein and Elasha, 2005). In Sudan sorghum is grown throughout the country in all agricultural sub-sectors (irrigated and rain-fed mechanized and traditional) from June to October. The rain-fed sector produces 90% and only 10% of sorghum is produced in the irrigated sector for food security to guard against risk of drought and environmental hazards. (Elamin and Elzein, 2006).

1.2 Problem of the study

- The drought is one of the major constraints to sorghum production in Sudan. Drought occurs as a result of inadequate, poor distribution and erratic rainfall and a short rain season which is associated with high temperature and high solar radiation. Drought is also unpredictable in its timing of occurrence, duration and intensity. Drought stress in Sudan causes a severe yield reduction. In some years its effect can cause complete crop failure especially if it occurs at post flowering growth stage.

- Sorghum is grown mostly under rain-fed conditions in the Sudan. Consequently, yield is limited by water supply and periods of drought can occur any developmental stage.

2.3 Justification of the study

- Sorghum is the major staple food for the most of the inhabitants in Sudan.
- The short rainy season and the fluctuation in rainfall expose the crop to drought stress therefore, breeding for drought tolerance and early maturity is imperative.
- Although Sudan has a large number of sorghum landraces, very little information on the genetic diversity of these landraces under stress condition is available.

2.4 The objectives of this study

1. To study effect of post flowering drought on yield and yield components among 10 sorghum genotypes.
2. To select the best sorghum genotypes through for good performance under drought stress conditions to compare with normal conditions.

CHAPTER TWO

LITERATURE REVIEW

2.1Breeding for drought tolerance

Crop production in drought prone environments may be improved and stabilized by the development and use of crop species and varieties that can tolerate or avoid water deficit. Selection for tolerance, while maintaining maximum overall productivity, has been a challenge (Rosenow et al., 1983). There are several explanations for this. First, drought tolerance can be expressed in several ways and the lack of a simple screening procedure has slowed the selection of better genotypes. Some researchers use grain yield per se to quantify drought tolerance, but selecting for grain yield under drought conditions is not efficient (Clarke et al.,1992).

Selection for drought tolerance should ideally integrate high yield potential with stability of agronomic performance across drought prone areas. The second problem in selecting for drought tolerance is that genotypes must be screened for tolerance in controlled environments where drought can routinely be imposed. Testing under dry land conditions is difficult because specific drought conditions cannot be easily and reproducibly imposed. Finally, drought tolerance is subject to strong environmental variation and genotype x environment interaction (Clarke et al., 1992). Yield is not an effectives election criterion for drought tolerance as naturally occurring environments are variable and unrepeatable and the precision of measurement of genotypic differences in yield is often poor because of low heritability (Blum, 1985).

Blum, et al. (1983), suggested that selection for drought tolerance must combine selection for yield potential in favorable conditions with selection under stress for the expression of traits thought to be associated with drought tolerance. Sinha (1987) argued that traits representing phonological and morphological adaptations are more effective than physiological and biochemical adaptations for drought resistance. Stay-green is one such trait.

Phenotypic selection for stay-green is not simple as the trait is complex (Van Osterom et al.,1996) and its expression is affected both by the degree of stress during grain filling and by the sink size (nitrogen demand) of the panicle. In breeding programs, selection for stay-green is carried out by visually rating the proportion of green leaf area in plants that have encountered post-flowering water stress. The trait is likely to be more easily manipulated using marker-assisted breeding approach for selection for specific alleles at molecular loci linked to genomic regions contributing to the stay-green trait, identified in carefully managed, replicated, multi-environment tests (Kassahun et al, 2010).

2.2Drought resistance and plant response

Drought limits agricultural production by preventing plants from expressing their full genetic potential and it is considered as the most important cause of yield reduction in crop plants (Boyer, 1982). Drought resistance can be evaluated based on the relative yield or survival of a genotype, compared with other genotypes subjected to the same drought, and where drought escape is not a major factor (Hall, 1993). Drought tolerance refers to the ability of a crop plant to produce its economic product with minimum loss in a water deficit environment (Blum, 1988; Zhang et al.,1999).Plant resistance to water deficit may arise from escape, avoidance and desiccation tolerance strategies (Levitt, 1972; Turner, 1986). In most cases, plants may combine a range of response types (Chaves et al., 2003).

2.3Drought escape

Drought escape relies on successful reproduction before the onset of severe stress. The plants combine short life cycles with high rates of growth and gas exchange, using maximum available resources while moisture in the soil lasts (Moony et al., 1987).

2.4Drought avoidance

Drought avoidance involves minimizing water loss and maximizing water uptake (Chaves et al.,2003). Water loss is minimized by closing stomata, reducing light absorbance through rolled leaves, and decreasing canopy leaf area. Increasing the sizeof the root system, reallocation of nutrients stored in older leaves, and higher rates of photosynthesis maximize water uptake.

2.5Drought tolerance

Drought tolerance appears to be the result of coordination of physiological and biochemical factors at the cellular and molecular levels. This may involve osmotic adjustment (Morgan, 1984), more rigid cell walls, or smaller cells (Wilson et al., 1980). Changes occurring rapidly at the mRNA and protein levels lead to tolerance (Ingram and Bartels, 1996).

2.6 Drought in sorghum

In sorghum, drought is a major production constraint world-wide. Drought-response to drought in sorghum has been characterized at both flowering and post flowering stage resulting in a drastic reduction in grain yield (Rosenow,1987). In case of post flowering drought, lodging further aggravates the problem resulting in total loss of crop yield in mechanized agriculture (Kedede et el., 2001). Improving drought tolerance is an important objective in many crop breeding programs, however, selection for drought tolerance is difficult because of inconsistency in testing environments and interaction between stages of plant growth and (Sanchez et al., 2002). The genetic mechanisms that condition the expression of drought in crop plant are poorly understood (Bohnert et al., 1995). Since drought tolerance is a complex trait controlled by many genes and is depending on the timing and severity of moisture stress (Ludlow and Muchow, 1990), it is one of most difficult traits to study and characterize. Sorghum lines with distinct phenotypic response to pre-flowering and post flowering drought have been characterized, and excelled sources of resistance to each type of stress have been identified (Rosenow, 1993).

Per-flowering drought stress response in sorghum occurs when plants are under significant tress prior to flowering, especially from panicle differentiation or shortly thereafter until flowering. This type of stress directly affects panicle size, grain number and grain yield. Post –flowering drought causes premature leaf senescence leading to stalk lodging, stalk rot disease and significant yield losses in sorghum (Rosenow and Clark, 1995).

2.7 Effects of drought on yield and yield components

The basic aim of all research activities in agriculture and crop sciences is to increase grain yield of crops under environmental constraints (Majid et al., 2007; Sharafizad et al., 2013). Post flowering drought stress significantly decreases grain yield as compared to pre-flowering drought stress due to failure in pollen grain fertility and improper grain filling (Shamsi et al., 2010). In sorghum cultivars biological yield, 100-grain weight and grain yield showed significant difference between genotypes in irrigated and non-irrigated condition (Vinodhana and Ganesamurthy, 2010; Shamsi et al., 2010; Farshadfar et al., 2013).Grain yield had the highest decrease percent of traits under drought stress condition that it was due to reduction in biological yield, number of seeds under drought stress (Malala, 2010).In sorghum genotypes 100-grain weight reduced by drought stress these were due to decrease in the assimilation rate and lower photo assimilate translocation to physiological sinks and shortening the grain-filling period (Malala, 2010).The reason for this reaction is decrease in competition for gaining photosynthetic substances, where as exerting drought stress at grain filling stage reduces the capacity of transferring photosynthetic substances to grain meaningfully and decreases the weight of 100 grains (Hossain et al ., 2010; Zare et al., 2011; Sharafizad et al., 2013; Blum, 2009).

According to Rostampour et al. (2012) drought affect both relative water content and chlorophyll content as a result dry matter yield is negatively affected these is also correlated with stomatal conductivity and accessibility of plant to carbon dioxide as a consequence dry matter production decreases. Besides the other factors, leaf area during grain filling is considered to be the most important character for high yielding under drought stress condition while low yielding cultivars of grain sorghum have smaller leaf area at flowering and at early grain filling stages (Nagarjuna, 2007; Vinodhana and Ganesamurthy, 2010). In a condition of most favorable water availability, plants fill their grains using a combination of current photosynthesis and translocation of carbohydrates from other parts of the plant of source (Jordan, 2009). However, drought stress occurrence during post-flowering stage (during grain filling) the amount of photosynthesis is reduced in response to low water availability as a result of lower supply of water to the demand of photosynthetic activity (Kapanigowda et al., 2012). The plant responds to this reduction in photosynthetic capacity by increasing the amount of stem reserves translocated from other parts of the plant such as the stem, roots and leaves.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of the experiment

The experiment was conducted in the kharif season 2019 at the demonstration farm of the Sudan University of Science and Technology, College of Agriculture, Shambat. It is located latitude15^{0} 40N, longitude 32^{0} 32́ E and 380 meters above the sea level. The soil at Shambat site is heavy clay with Ph value from 8.5to 8.6.

3.2 Experimental material

Ten sorghum accessions from plant Genetic Resources Unit (Gene-Bank), collected from sorghum areas in Kordofan, Sudan (Table 1)

3.4 Treatments and experimental lay out

Split plot design was used by setting two main plots, fully irrigated and stress plots with three replications. The spacing between the irrigated and stressed replications was two meters. The sub plots were the 10 genotypes. The materials were sown on the 24 of July 2019, were planted in the plot size was 2 rows x 3meters long x 0.8 meters between rows. The plants were 30cm apart. Five or four seed were planted per hill and were thinned to 3plants per hill, three weeks later urea fertilizer of 2N rate was applied in split doses, one after thinning and the other before booting stage. Weeding was done by hand after two weeks. In order to impose drought stress, the genotypes were subjected to two conditions: normal irrigation and drought stressed at reproductive phase. All the genotypes in both irrigated and drought stress treatments were fully irrigated until booting to early flowering stage. At flowering stage water was withheld for 21 days for the drought stress treatment, while the control treatment received regular irrigation throughout the experiment.

Table 1. Sorghum genotypes used in the study.

No.	Genotypes	region	Status
1	HSD 3243	North Kordofan	Landrace
2	HSD 3249	North Kordofan	Landrace
3	HSD 4033	North Kordofan	Landrace
4	HSD 4161	South Kordofan	Landrace
5	HSD 4201	South Kordofan	Landrace
6	HSD 4241	South Kordofan	Landrace
7	HSD 6029	West Kordofan	Landrace
8	HSD 6145	West Kordofan	Landrace
9	HSD 6149	West Kordofan	Landrace
10	HSD 6775	West Kordofan	Landrace

H= Horticulture and **SD**= Sudan

3.5 Data Collection

3.5.1Head Length (cm)

length measurement (cm)from the base of the panicle to the tip from three randomly selected plants per plot at maturity.

3.5.2 Head exertion(cm)

The average length of the node between the flag leaf and the base of the panicle measured in cm from 3 randomly selected plants at maturity.

3.5.3 Head width(cm)

panicle width measurement(cm)in the widest diameter of the panicle on five randomly selected plants per plot at maturity.

3.5.4 100-Seed weight(g)

Was determined by taking the weight of a random sample100 seeds from the bulked grain of each plot.

3.5.5 Grain yield(kg/ha)

Total grain weight per plot in gram after threshing then converted in to kilo gram per hectare.

3.6 Data Analysis

The data on yield and yield components related to drought collected in this study was entered into an excel spread sheet and analyzed using Genstat® 14EditionStatistical software (Payne et al., 2011).

CHAPTER FOUR

RESULTSAND DISCUSSION

4.1RESULTS

The phenotypic variability of the five traits: Head Length (cm), Head exertion(cm), Head width(cm), 100-Seed weight(g)and Grain yield (kg/kg)for sorghum genotypes were shown as rang, general means, standard error (S.E) of means, and coefficient of variation (CV%) in (Table 2).The results of the present study showed significant difference(P<0.001),for most of the traits studied as well as difference reduction among genotypes under non-stressed and drought stressed conditions (Tables 3,4 and 5).

4.1.1 Head length

The genotype HSD 6029, scored the highest head length (25.5 cm) and lowest by HSD 6775 (15.4cm) under drought stress condition. While the genotypes HSD 6029,HSD 4161 and HSD 6145scored highest head length (28.2cm), (27.4cm) and (27.2cm) respectively, lowest by HSD 6775 (17.3 cm) under normal condition (Table 3).Reduction in head length observed in most of the genotypes when compared with the fully irrigated. The general mean value reduction in head length for all genotypes was(11.8%), the highly reduction value was scored by genotype HSD 6149 (15.3%), while the low reduction values were recorded by genotypes HSD 3243(9%),HSD6029 (9.6%) and HSD 4161 (9.9%) in(Table 3).

4.1.2Head exertion(cm)

Under drought stress condition, the genotypes HSD 4201and HSD 4033, scored the highest head exertion (9.5cm) and (8.8cm) respectively, lowest by HSD6149(3.6cm).Under normal condition, the genotype HSD 4201 highest head exertion (13.7cm), followed by genotypes HSD4033 and HSD 3243were scored same values (12cm),lowest by HSD 6775 (5.5cm) in(Table 3).

The general mean value reduction in head exertion for all genotypes was (32.5%), the genotype HSD 6775 (18.1%) was less affected by drought stress. While the genotypes HSD6145, HSD 3249, HSD 6149 and HSD 3243 were recorded highly reduction values (40%), (39.3%), (38.7%) and (37.4%) respectively, these genotypes had high affected by drought stress in(Table3).

4.1.3 Head width(cm)

Under drought stress condition, the genotypes HSD 4241,HSD 3243and HSD 3249, scored the highest Head width (9.8cm), (9.4cm) and (8.8cm) respectively, lowest Head width scored by HSD 6149 (5.1cm).

Under normal condition, the genotype HSD4241 scored highest Head width (14cm), followed by genotype HSD3243 was scored (13cm) and lowest scored by genotype HSD 6149 (7.5cm), while the genotypes HSD 4201 and HSD 6775, There were no significant differences recorded among the genotypes for Head width because were scored same values (11cm)(Table 3).

The general mean of reduction in head width (28.3%), drought stress causes a significant reduction in Head width, it compares with normal (well watered) condition. The genotype HSD6145 recorded highest value of reduction in head width was (34.5%) followed by genotype HSD6775 (33.4%).On the other hand, the genotypes HSD 4241 and HSD 6029 were recorded the same value reduction in head width was (30%) and lowest reduction recorded by genotype HSD 4033 was (15%) (Table 4).

4.1.4 100-Seed weight(g)

Under drought stress condition, the genotype HSD 4161 scored highest100 grain weight was(2.5g), while the genotypes HSD 6029, HSD 6145, HSD 6149, HSD 6775 and HSD 3243showed no significant difference because were scored similar values in 100 grain weight. Under normal condition, the genotype HSD4161 scored highest100 grain weight (3.3g), followed by genotype

HSD6029 was scored (30g) and lowest scored by genotype HSD 4241 (1.4g) (Table 4).

Post flowering drought stress cause a significant reduction in 100 grain weight, it compares with normal (well watered) condition. The general mean of reduction was (26%),the genotypes HSD 6029, and HSD 3249 were recorded high value reduction in 100 grain weight (34.9%), (34%), while the genotypes HSD 3243 and HSD 6149 were recorded lowest values of reduction in 100 grain weight (15.6%), and (16.3%) respectively(Table 4).

4.1.5 Grain yield (kg/ha)

The grain yield of all genotypes subjected to post-flowering drought stress was significantly lower than those under well irrigated growing condition and significant difference has shown for genotypes between the two water regimes at ($p< 0.01$) in(Table 5).For under drought stress condition, the genotypes HSD 6029, and HSD 4241, scored the highest Grain yield were (3783 kg/ha), and (3329 kg/ha) respectively, Grain yield scored by HSD 6775 (1556 kg/ha). For under normal condition, the genotype HSD 6029 scored highest Grain yield (4044 kg/ha), while lowest scored by genotype HSD 6775 (1762 kg/ha)(Table 5).

Post flowering drought has found to decrease the Grain yield of among genotypes, the general mean of reduction in head width

(8%).The genotype HSD 6145 recorded highest value of reduction in Grain yield was (12.3%) followed by genotype HSD6775 (11.7%). while the genotypes HSD4161, HSD3243and HSD3249 were recorded lowest values of reduction in Grain yield (4.1%), (5.1%) and (5.8%) respectively in(Table 5).

4.2DISCUSSION

Drought is one of the most damaging abiotic stresses affecting crop yield especially when it occurs during the reproductive stage. The water requirement increases from the boot stage after anthesis. The impact of drought stress on crop plants can be partly mitigated through genetic improvement. The results of the experiment showed a genetic variability in the response of studied genotypes under water stress conditions, reflected in a significant decline in the studied traits, compared with normal conditions.

For head related traits, the genotypes showed high values reduction for the head related traits like its (Head length, Head exertion, and Head width, under the drought stress condition tested**.**

This further confirmed the previous results that have also described the importance of these traits in contributing towards the overall diversity of the sorghum germplasm landraces (Ayana & Bekele, 1999).

For 100 seed weight, the genotypes showed the highest reduction in this traits. The reason for this reaction is decrease in competition for gaining photosynthetic substances, where as exerting drought stress at grain filling stage reduces the capacity of transferring photosynthetic substances to grain meaningfully and decreases the weight of 100 grains. This study is in agreement with the study by (Malala, 2010) and (Hossain et al., 2010; Zare et al., 2011; Sharafizad et al., 2013; Blum, 2009).

For grain yield, in this study the most of the genotype showed highest reduction in this traits. The reason for this reaction to failure in pollen grain fertility and improper grain filling. this the result agreement with the study by (Shamsi et al., 2010) and (Malala, 2010).

Table2. Phenotypic variability for five traits of10 sorghum genotypes, grown under drought stress and Normal conditions, at Shambat in season 2019.

Traits	S-N	Range	Mean	SE±	C.V%
Head length(cm)	**S**	(15 – 26)	20.9	0.64	4.9
	N	(17 – 28)	23.5	0.11	6.7
Head exertion(cm)	**S**	(2.9 – 12.6)	6.0	1.47	24.2
	N	(4.3 – 18)	8.9	1.46	16.6
Head width(cm)	**S**	(5 – 10)	7.6	0.37	4.9
	N	(6.7 – 10.9)	10.6	0.71	6.7
100- Seed weight(g)	**S**	(1–2.5)	1.7	0.28	16.5
	N	(1.3 –3.4)	2.3	0.26	11.3
Grain Yield (kg/ha)	**S**	(1454 - 3905)	2678	449.0	16.8
	N	(1625 – 4383)	2897	471.7	16.3

S= Stress (water stressed) and **N**= Normal (fully Irrigated).

Table3. Mean genotypes values for Head length(cm), Head exertion(cm) and Reduction (%), under drought stress and normal conditions, grown at Shambat in season 2019.

No.	Genotypes	Head length(cm)			Head Exertion(cm)		
		S	**N**	**R(%)**	**S**	**N**	**R(%)**
1	HSD 3243	22.3	24.5	9.0	7.3	12	37.4
2	HSD 3249	23.7	26.3	10.0	5.0	8.2	39.3
3	HSD 4033	19.5	22.4	13.1	8.8	12	25.0
4	HSD 4161	24.7	27.4	9.9	6.2	8.6	28.2
5	HSD 4201	17.8	20.2	11.7	9.5	13.7	30.7
6	HSD 4241	15.8	18.3	13.5	6.0	8.1	25.8
7	HSD 6029	25.5	28.2	9.6	3.8	5.9	35.7
8	HSD 6145	24.3	27.2	10.7	4.8	8	40.0
9	HSD 6149	19.6	23.2	15.3	3.6	5.8	38.7
10	HSD 6775	15.4	17.3	11.0	4.5	5.5	18.1
Mean		**20.9**	**23.5**	**11.8%**	**6.0**	**8.9**	**32.5%**
SE±		**0.64**	**0.11**	**-**	**1.47**	**1.46**	**-**
Sig.level		***	***	-	***	***	-
CV%		**3.1**	**0.5**	**-**	**24.2**	**16.6**	**-**

*****,** Significant at 0.001probility levels. **S**= Stress, **N**= Normal (fully Irrigated) and **R**=Reduction (%).

Table4. Mean genotype values for Head width(cm), 100- seed weight(g)and Reduction (%),under drought stress and normal conditions, grown at Shambat in season 2019.

No.	**Genotypes**	**Head width(cm)**			**100- Seed weight(g)**		
		S	**N**	**R(%)**	**S**	**N**	**R(%)**
1	HSD 3243	9.4	13.0	27.6	1.8	2.1	14.3
2	HSD 3249	8.8	12.0	26.5	1.2	1.9	36.8
3	HSD 4033	8.3	9.9	15.9	1.3	1.8	27.8
4	HSD 4161	6.3	8.4	24.4	2.5	3.3	24.2
5	HSD 4201	7.7	11.3	32.3	1.3	1.7	23.5
6	HSD 4241	9.8	14.0	30.0	1	1.4	28.6
7	HSD 6029	6.2	8.9	30.0	2	3	33.3
8	HSD 6145	6.5	10.0	34.5	1.9	2.5	24.0
9	HSD 6149	5.1	7.5	32.1	1.9	2.3	17.4
10	HSD 6775	7.3	11.0	33.4	1.8	2.4	25.0
Mean		**7.6**	**10.6**	**28.3%**	**1.7**	**2.3**	**26%**
SE±		**0.37**	**0.71**	**-**	**0.28**	**0.26**	**-**
Sig.level		*******	*******	**-**	*******	*******	**-**
CV%		**4.9**	**6.7**	**-**	**16.5**	**11.3**	**-**

*****,** Significant at 0.001probility levels. **S**=Stress, **N**= Normal (fully Irrigated) and**R=**Reduction (%).

Table5. Mean genotype values for Grain yield (kg/ha) and Reduction (%), under drought stress and normal conditions, grown at Shambat in season 2019.

No.	**Genotypes**	**Grain Yield (kg/ha)**		
		S	**N**	**R(%)**
1	HSD 3243	2225	2578	13.7
2	HSD 3249	2400	2726	12.0
3	HSD 4033	2373	2871	17.3
4	HSD 4161	2555	3008	15.1
5	HSD 4201	2225	2650	16.0
6	HSD 4241	3120	3607	13.5
7	HSD 6029	3380	4044	16.4
8	HSD 6145	2508	3089	18.8
9	HSD 6149	2308	2632	12.3
10	HSD 6775	1556	1762	11.7
Mean		**2243**	**2897**	**23%**
SE±		**449.0**	**471.7**	-
Sig.level		**	**	-
CV%		**16.8**	**16.3**	-

****,** Significant at 0.01probity levels. **S**=Stress, **N**= Normal (fully Irrigated) and **R**=Reduction (%).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 CONCLUSIONS

- In this study the result of analysis showed highly significant differences for most of the traits.

- The genotypes showed different responses under post-flowering drought to compare with normal conditions.

- The genotypes (HSD 3243, HSD 6029 and HSD 4161) showed low reduction values in head length were (9%), (9.6) and (10%), respectively.

- The genotypes HSD 6775, HSD3249 and HSD6149 showed low reduction in grain yield (11.7),(12.3)and(12%), respectively these genotypes had the lowest affected by drought stress. While the genotypes HSD 6145, HSD 4033 and HSD 4201 showed high reduction in grain yield (18%), (17%) and (16%), respectively. these genotypes had highest affected by drought stress.

5.2Recommendation

- The genotypes (HSD 3243, HSD 6029 and HSD 4161), could be used promising genotypes to development for post flowering drought in sorghum breeding program.

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