SCREENING SOME GRAIN SORGHUM (*Sorghum bicolor* L. Moench) GENOTYPES FOR GRAIN YIELD AND PLANT TOLERANCE AGAINST SPOTTED STEM BORER *Chilo partellus* (Swinhoe)

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Abstract: An experiment was conducted under irrigation at Experimental Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat in Khartoum State, Sudan for two cropping seasons (Autumn and Winter) during 2016/2017. the objectives were to screen the relative resistance / susceptibility of 22 genotypes of sorghum against stem borer (*Chilo partellus*), and for yield and its components. The plants were subjected to natural infestation by spotted stem borer. Three resistance expressing traits, i.e. percentage of infested plants(IP), percentage of plants with dead heart effect (DH) and intensity of damage (ID), Growth and grain yield traits were measured. Results showed that, genotype G.1.1.4 was found to be the most resistant with respect to all the damage types studied. The highest yielding genotypes in Autumn Were G.1.1.4(1.37t/ha), G.1.1.16(1.36t/ha) and F-3 (1.31t/ha). G.1.1.4 was a high yielding stable variety throughout the two seasons. In addition, the genotypes (G.1.1.16, F-3, Tabat and F-10) have relatively good level of resistance to infestation by stem borer (*Chilo partellus*). The genotypes gave higher yields in Autumn than in Winter probably due to the favorable environmental conditions of the rainy season and the lighter infestation by the stem borer. These genotypes might be considered potentially resistant varieties and may serve as material of interest in sorghum improvement programme.

Keywords: dead heart effect, resistance, susceptible, genotypes, stem borer.

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the most important cereal crops grown worldwide. It ranks fifth after wheat, maize, rice and barley (Doggett, 1988; FAO, 2011). More than half of the world's sorghum grow in the Semi- arid tropics (SAT)., is considered as stable human food in many parts of Asia and Africa. It is also used for animals feed as well as an industrial raw material and sometimes used as a building material source in addition to complementing other cereals as a primary food grain. Because of the importance of the sorghum and its essential components, it has been subjected to different important research topics in the tropics and subtropics. In Sudan, Sorghum is the first food crop before wheat and pearl millet. It is fully utilized; the grains are used for making Kisra (Bread from fermented dough), thick porridge (Aseeda) and soft drink (Areh). The stalks are used as building materials, fuel and animals feed (Elzein and Elasha,2005). In Sudan, the area under irrigated sorghum is about 8% while 92% is rain - fed (Fadlelmula, 2009). In Sudan Sorghum is grown in an area ranges between 4.3 and 7.1 million ha with an average of 5.2 million ha (Elzein and Elamin, 2006). The national average grain yield is 600 kg/ha which is very low compared to the world average of production 1288 kg/ha (Elzein, 2008).

The most important species is the spotted stem borers, *Chilo partellus* (Swinhoe), and *sesamia cretica* which belong to Lepidoptera, Pyralidae. Where *Chilo partellus* is predominant in central rain land, while the other is predominant in irrigated areas of northern Sudan. Symptoms of damage on leaves usually used to distinguish between the two stem borers. That *Chilo spp* makes regular holes in transverse rows where *sesamia spp.* make irregular holes distributed randomly. Where the true parameter as the result for both stem borers infestation is dead-heart effect and drying (Schmutterer,1969; Hill, 1983). Stem borers reduce grain yield through leaf feeding, deadheart and stem damage (Karaya *et al.*, 2009). The first instars larvae feed in the whole seedlings, making rows of oval perforations. Later instars tunnel into the mid-ribs and cause damage to the growing point leading to the conditioning of the dead hearts. Usually stop reproductive growth and produce more tillers without heads (Paliwal *et*, *al.*, 2000). In Khartoum state no comprehensive studies have been conducted on stem borer. From preliminary observation in sorghum grown at Shambat. it was obvious that *Chilo spp* was the most dominant species. Therefore, the present research aims: to find relative resistance of different genotypes against stem borers and for yield and its components.

MATERIALS AND METHODS

A field experiments were conducted at Experimental Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat (longitude 32º :31" E; latitude (15º:39" Altitude 380 m above sea level). The plant material used in this study was consisted of about 22 sorghum genotypes as shown in Table (1). The 15 genotypes are exotic materials maintained in the Forage Improve Program – Shambat (FIP). 7 genotypes provided by the sorghum Breeding Program of Agriculture Research Corporation (ARC) - Wed Medani. The origin of the genotypes is shown in (Table 1).

Two field experiments were used in this study, the first was conducted during Autumn season (kharif) and the second during Winter season of 2016/2017. The experiments were conducted under natural infestation of stem borer (*Chilo partellus*) at the Experimental Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Sudan. Sorghum were planted on 17/7/2016 and 15/11/2016 for the Autumn and Winter sowings, respectively. The experimental design was Randomized Complete Block Design (RCBD) with three replications, four rows with 2 m long and 70cm a part, 20 cm between hills and two plants were remained per hill. Five seeds were placed in holes spaced at 20 cm along the eastern side of the ridge and the seedlings were later thinned to approximately 2 plant/hole. Nitrogen fertilizer (urea 46% N) was added at the second irrigation at rate of 80 kg /feddan. In the second season the insecticides (Traicel) was sprayed to control Aphid Insect pest. Irrigation was applied at 7 to 10 days' interval. Weed population was kept at minimum by hand weeding.

Method of observation:

3.3.1 Percentage of infested plants (IP %) as follows

$$IP\% = \frac{\text{No. of infested plants/plot}}{\text{Total No. of plants /plot}} \times 100$$

Genotypes were classified according to their mean percentage of infested plants into: Resistance, R (Less than 35%) Moderately Resistance, MR (from 35% to less than 70%) Susceptible, S (70% or above) according to Al- Naggar *et, al.*, (2000).

3.3.2. Percentage of dead hearts (DH %) as follows

$$DH\ \% = \frac{\text{NO. of plant with dead hearts/plot}}{} \times 100$$

Total No. of plants /plot

Genotypes were classified according to their mean DH% into: Resistance, R (Less than 7 %) Moderately Resistance, MR (from 7% to less than 15%) and Susceptible, S (15%ormore)accordingtoAl-Naggar*etal.*, (2000).

3.3.3 Intensity of damage (ID %) as follows

Six class rating scale according to Al- Naggar *et, al.*, (2000) was used for evaluating the amount of plant injury in maize caused by *Sesamia cretica* larvae attack. The description of this scale was as follows:

Class 1: No visible injury on plants (no symptoms).

Class 2: Plants with holes less than 0.5 mm in diameter across partially or fully un folded whorl leaves.

Class 3: Several folded and unfolded whorl leaves with relatively wider round holes.

Class 4: Several folded and unfolded whorl leaves with relatively larger round or elongated holes accompanied with small yellowish- green pellets of frass aggregated in the whorl.

Class 5: Plants with relatively larger round and / elongated irregular holes, evident distortion of the leaves (most leaves have long holes), withering of whorl and accumulation of comparatively large sized pellets of frass in the whorl or on the ground around the stem.

Class 6: Plants with dead hearts.

The intensity of damage (ID)value for each plot was calculated as follows:

$$ID = \frac{ID1 + ID2 + \ldots\ldots\ldots\ldots\ldots + IDn}{N}$$

Where ID1, ID2,……IDn denote intensity of damage of the infested plant No.1,No2,…….No.n and N= number of plants / plot. Genotypes were classified according to their ID into: Resistance, R (0 to less than 1.7 ID), Moderately Resistance, MR (1.7 to less than 2.7 ID) and Susceptible, S (2.7 ID or above) according to Al-Naggar *et al.*,(2000).

Agronomic data recorded in the two growing seasons under natural infestation condition were: Plant height (cm), days to 50% flowering, 1000- grain weight (g) and grain yield (t./ha.). The collected data were statistically analyzed according to Steel and Torrie (1980). And the treatment was compared by least Significant Difference (L.S.D.) at 5% level.

Table 1: Sorghum genotypes used in the study (2016-2017, Shambat)

Entry code	Genotypes	Source
1	F -1	*(FIP) – Shambat
2	F -2	(FIP) – Shambat
3	F -3	(FIP) – Shambat
4	F -4	(FIP) – Shambat
5	F -5	(FIP) – Shambat
6	F -6	(FIP) – Shambat
7	F -7	(FIP) – Shambat
8	F -8	(FIP) – Shambat
9	F -9	(FIP) – Shambat
10	F -10	(FIP) – Shambat
11	F -11	(FIP) – Shambat
12	f3 -12	(FIP) – Shambat
13	F-13	(FIP) – Shambat
14	F -14	(FIP) – Shambat
15	F -15	(FIP) – Shambat
16	G.1.1.4	**(ARC) - wed madani
17	G.1.1.16	(ARC) - wed madani
18	G.2.13.5	(ARC) - wed madani
19	G.1.1.13	(ARC) - wed madani
20	Tabat	(ARC) - wed madani
21	W.Ahmad	(ARC) - wed madani
22	Arfgadamk	(ARC) - wed madani

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Table 2: Average of infested plants and plants with dead hearts percentages and intensity of damage under natural infestation with stem borer during (Autumn- Winter) seasons 2016/2017

Ent. No.	Genotypes	Infested plant						Plants with Dead hearts						Intensity of damage					
		Autumn	Scale	Winter	Scale	Mean	Scale	Autumn	Scale	Winter	Scale	Mean	Scale	Autumn	Scale	Winter	Scale	Mean	Scale
		IP%		IP%		IP%		DH%		DH%		DH%		ID		ID		ID	
1	F -1	31.99	R	38.81	M	35.4	M	13.2	M	14.3	M	13.75	M	2.55	S	2.71	S	2.63	M
2	F -2	40.60	M	45.85	M	43.23	M	14.4	M	18.2	S	16.3	S	2.82	S	2.89	S	2.86	S
3	F -3	41.66	M	43.32	M	42.49	M	8.5	M	19.8	S	14.15	M	2.94	S	2.98	S	2.96	S
4	F -4	36.37	M	40.26	M	38.32	M	11.6	M	19.7	S	15.65	S	2.56	S	2.61	M	2.59	S
5	F -5	32.35	R	36.74	M	34.55	R	9.8	M	15.13	M	12.465	M	2.44	S	2.3	M	2.37	S
6	F -6	61.59	M	59.15	M	60.37	M	17.7	S	24.9	S	21.3	S	4.01	S	4.06	S	4.04	S
7	F -7	35.69	M	36.15	M	35.92	M	6.9	R	14.7	M	10.8	M	2.65	S	2.74	M	2.70	S
8	F -8	50.64	M	56.36	M	53.50	M	12.1	M	16.9	S	14.5	M	3.27	S	3.29	S	3.28	S
9	F -9	50.69	M	50.38	M	50.54	M	9.1	M	14.1	M	11.60	M	3.26	S	3.33	S	3.30	S
10	F -10	33.12	R	34.27	R	33.70	R	9.7	M	16.7	S	13.20	M	3.23	S	2.61	M	2.92	S
11	F -11	47.91	M	57.28	M	52.60	M	10.5	M	17.5	S	14.00	M	2.97	S	3.00	S	2.99	S
12	F -12	32.38	R	38.23	M	35.31	M	9.7	M	19.2	S	14.45	M	2.47	S	2.52	M	2.50	S
13	F-13	45.47	M	50.83	M	48.15	M	8.8	M	14.3	M	11.55	M	3.07	S	3.10	S	3.09	S
14	F -14	48.57	M	55.36	M	51.97	M	14.6	M	19.2	S	16.9	S	3.08	S	3.15	S	3.12	S
15	F -15	50.06	M	64.33	M	57.20	M	12	M	21.4	S	16.70	S	3.27	S	3.29	S	3.28	S
16	G.1.1.4	12.18	R	15.12	R	13.65	R	7.1	M	9.7	M	8.40	M	1.48	M	1.52	R	1.50	M
17	G.1.1.16	22.24	R	22.65	R	22.45	R	7.5	M	10.8	M	9.15	M	1.81	S	1.98	M	1.90	M
18	G.2.13.5	31.19	R	38.11	M	34.65	R	11.2	M	19.7	S	15.45	S	2.43	S	2.53	M	2.48	S
19	G.1.1.13	47.29	M	49.73	M	48.51	M	10.1	M	20.2	S	15.15	S	3.04	S	3.07	M	3.06	S
20	Tabat	14.50	R	25.77	R	20.14	R	7	R	10	M	8.50	M	2.41	S	2.48	R	2.45	M
21	W.Ahmad	42.82	M	43.48	M	43.15	M	8.3	M	19.1	S	13.70	M	2.87	S	2.89	S	2.88	S
22	Arfgadamk	36.28	M	47.09	M	41.69	M	6.6	R	18.9	S	12.75	M	2.82	S	2.91	S	2.87	S
	Mean	**38.43**		**43.16**		**40.795**		**10.28**		**17.026**		**13.653**		**2.79**		**2.81**		**2.80**	
	c.v	**9.22**		**9.48**		**9.35**		**29.72**		**29.07**		**29.395**		**4.81**		**4.34**		**4.58**	
	SE+	**2.892**																	
		4		**3.34**		**3.115**		**2.49**		**4.04**		**3.265**		**0.1098**		**0.0998**		**0.10**	

R = resistant M = moderate S =susceptible

Table 3: Performance of Twenty-two sorghum genotypes during two successive seasons (Autumn – Winter)2016/2017

Genotypes	Plant height (cm)		Days to 50%flowering		1000- grain weight (g)		Yield (ton/ha)	
	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter
F -1	181.07CD	183.3AB	73.3DEF	67.3EF	38.3CDEF	36.13CD	1.27ABC	1.2ABC
F -2	149.6HI	176.3ABC	80.3AB	82.6AB	39ABCDE	38.6BCD	1.15ABCDE	1.12ABCDEF
F -3	168.7EF	185AB	70.3EFGH	64.3FG	44.8AB	43.2AB	1.383A	1.28AB
F -4	155GH	190A	78.3ABCD	81.6AB	39.4ABCDE	38.7BC	1.053CDEFG	1.03BCDEFG
F -5	197A	189A	69.0EFGH	71.6CDE	35.16EF	34.6CDEF	1.103BCDEF	1.08GH
F -6	193.6AB	190A	75.3BCDE	74.3B	42.7ABCD	42.1AB	1.343AB	1.36A
F -7	177.6DE	177ABC	65.6HI	69DEF	33.8EF	33DEF	1.050CDEFG	1.02 BCDEFG
F -8	184.7BCD	186A	78.3ABCD	70.3CDE	44.4AB	43.5AB	1.223ABCD	1.19ABC
F -9	192.3ABC	192A	73.6CDEF	70.6CDE	36.6DEF	35.6CDE	1.216ABCD	1.18ABCD
F -10	161.7FG	164BCD	78.6ABC	79.3B	39 ABCDE	43AB	1.043 CDEFG	1.01CDE
F -11	148.3HI	150DE	81.6A	85A	36.8CDEF	36CDE	1.083 BCDEFG	1.05BCD
F -12	180DE	182ABC	74.6CDE	73CD	44.8AB	44.2AB	1.170ABCD	1.14ABCDE
F -1 -13	158FGH	161CD	82.3A	83.6AB	31.1FG	30EF	0.836BCDEFG	0.8GH
F- 1- 14	138.3IJ	139EF	73.3DEF	73.2CD	41ABCDE	39.7ABC	0.896BCDEFG	0.86FGH
F -15	187.3ABCD	195A	81.3A	83.7AB	43ABCD	42AB	1.050 CDEFG	1.02 BCDEFG
G- 1.1.4	121KL	124FG	67.0GHI	71.6CDE	46.1A	45A	1.373A	1.35A
G-1.1.16	113.3LM	115GH	77.6ABCD	80.3AB	31.2FG	30.3EF	0.906EFGH	0.87EFGH
G- 2.13.5	118KL	119FGH	66.3HI	74C	43.1ABCD	42AB	0.956DEFGH	0.92DEFGH
G- 1.1.13	113LM	117GH	71.6EFG	69.6DEF	46A	44.9A	1.086 BCDEFG	1.05 BCDEFG
Tabat	104.6MN	100H	72.3EF	68.6DEF	44.1ABC	43AB	1.086 BCDEFG	1.05BCDEFG
W.Ahmad	128JK	98H	69.0FGHI	72.6CD	31.1FG	30.3EF	0.996DEFGH	0.96CDEFGH
Gadam	**99N**	**102H**	64.3I	**59.6G**	**23.9G**	23.2G	**0.76**	0.74H
Mean	**153.19**	**156.45**	**73.8**	**73.8**	**38.94**	**38.29**	**1.092**	**1.0627**
CV	**4.54**	**8.21**	**4.25**	**3.98**	**11.44**	**9.05**	**14.89**	**15.21**

Means followed by the same letter (s) in each column within each treatment are not significant.

RESULTS AND DISCUSSION

The experiment was conducted to screen 22 Sorghum [*Sorghum bicolor* (L.) Moench] genotypes against stem borer (*Chillo partellus,* Swinhoe) during *(Autumn –Winter)* seasons 2016/2017. The performance was determined on the basis of leaf damage, dead hearts formation and intensity of damage. The observations were recorded on infestation caused by stem borer (*Chilo partellus* Swinhoe). The results obtained are presented in Table (2):

Infested Plants (%)

Results in Table (2) showed that, in Autumn season infestation, only eight genotypes, i.e. G.1.1.4, Tabat, G.1.1.16, G.2.13.5, F-1. F-5, F-12 and F-10 were significantly resistance, while all the other genotypes were moderately resistance. However, in Winter season infestation only four genotypes, i.e. G.1.1.4, G.1.1.16, Tabat and F-10 were significantly resistance, while all the other genotypes were significantly moderately resistance. No strong consistency was found for results of resistance under Autumn and Winter season for this traits. The mean data across the two seasons indicated that, six resistance genotypes were detected (G-1.1.4, Tabat, G-1.1.16, F-10 F-5 and G-2.13.5) with an average (13.65.20.14, 22.44, 33.69, and 34.45) respectively and 16 moderately resistant genotypes (F-12, F-1, F-7, F-4, Arfa gadamk, F-3, W. Ahmad, F-2, F-1-13, G-1.1.13, F-9, F-1-14, F-11 , F-8, F-15,F-6) with an average of (35.15,35.03,35.4,35.5, 35.92,38.31,41.68,42.49,43.15,43.22,48.15, 48.51, 50.53 ,51.96 ,52.59 , 53.5 , 57.12, 60.37). (Fig. 1).

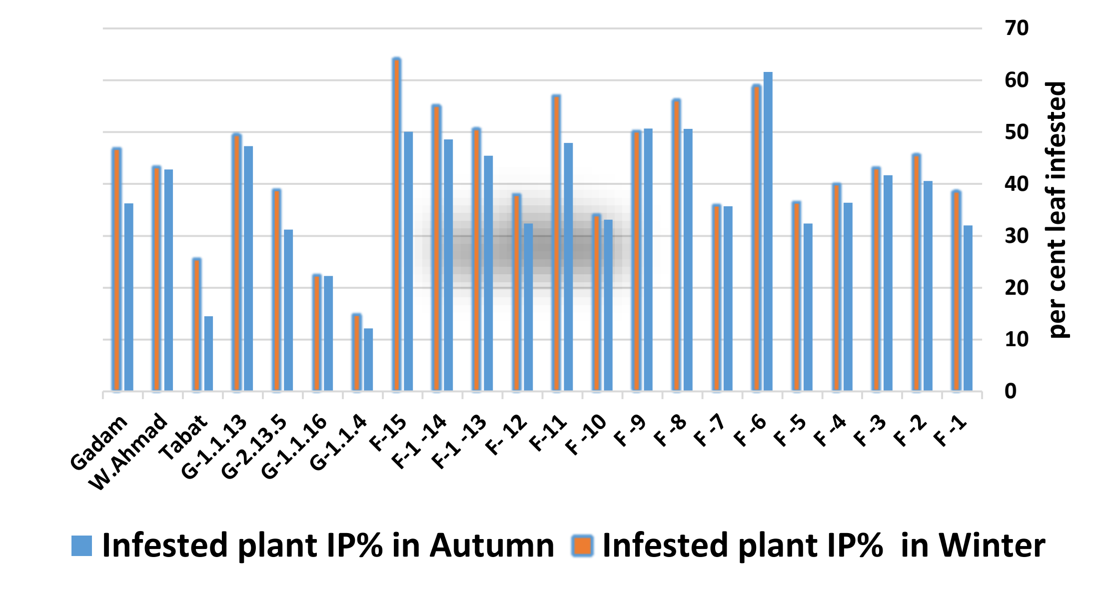

Fig. 1: Per cent plant infested by stem borer in different genotypes of Sorghum at (Autumn- Winter)

Plant with Dead Hearts (DH)

Results for resistance in Autumn season on the percent dead heart showed that only four genotypes, i.e. Arfa gadamk, F-7, Tabat and G.1.1.4 were significantly resistance, while all the other genotypes were moderately resistance except F-6 Whereas, maximum and significantly higher dead heart formation (17.7%) which was susceptible or highly susceptible. In Winter season data recorded on the percent dead heart only Seven genotypes, i.e. (G.1.1.4, Tabat, G.1.1.16, F-9, F-1, F-13 and F-7) were moderately resistance, while the other genotypes were highly susceptible (Table 2)

The mean data across the two seasons in the same table ranged from G.1.1.4 (8.4%) to F-6 (21.25 %). 15 genotypes were moderately resistance (G.1.1.4, Tabat, G.1.1.16, F- 7, F-9, F -13, F-5, Arfa gadamk, F-10, W. Ahmad, F- 1, F-11, F-3, F-12 and F-8) with an average of (8.4, 8.5, 9.15, 10.8, 11.55, 11.6, 12.46, 12.75, 13.2, 13.7, 13.75, 14, 14,15, 14.45 and 14.50%) respectively. 7 genotypes were Susceptible (G.1.1.13, G.2.13.5, F-4, F-2, F- 15, F-14 and F-6) with dead hearts average of (15.15, 15.45, 15.65, 16.3, 16.7,16.9 and 21.25%) respectively. (Fig. 2).

Similar to the present findings Singh *et al*. (1968), who rated the degree of resistance on the basis of dead heart damage, recorded 507 sorghum varieties to be resistant. Singh *et al*. (1991) also reported least dead heart in IS 2205. Teli *et al*. (1983) reported 19.99 to 84.78% dead heart in different cultivars. Kishore (1991) also reported 28.6 to 39.4%, Bhadviya (1995) 34.26 to 63.59% and Gour (1995) 1.58 to 5.46% dead heart caused by stem borer.

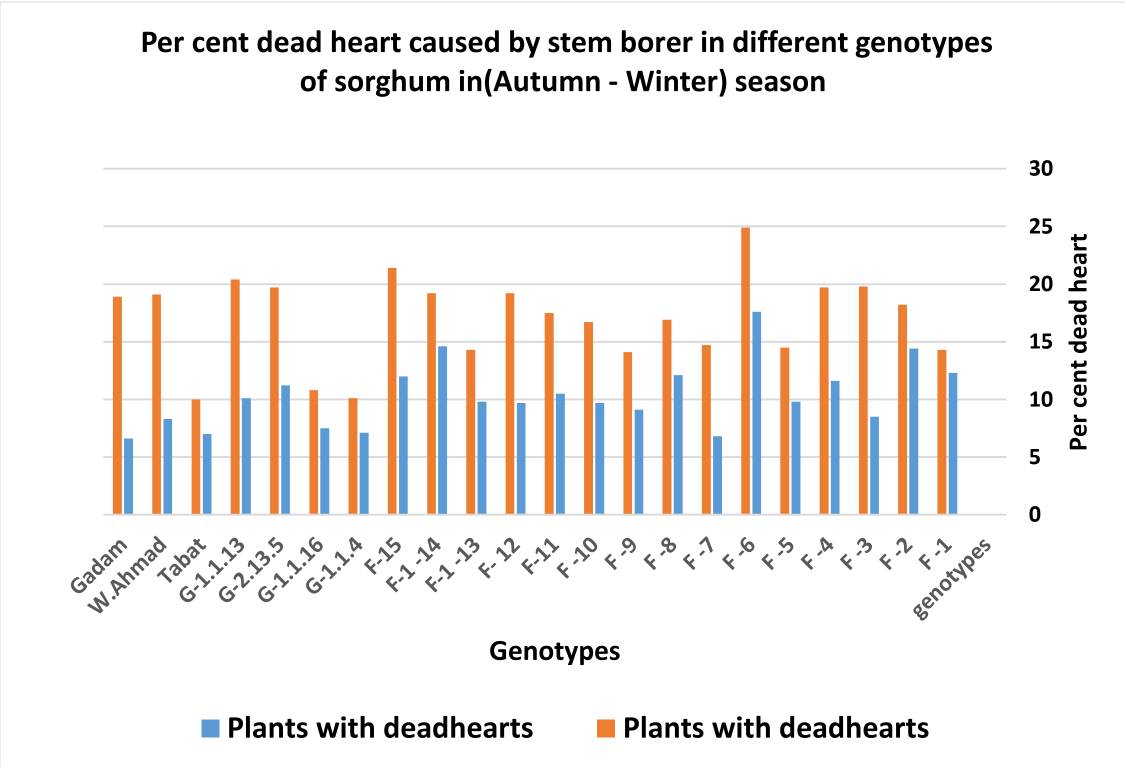

Fig No.2 Per cent dead hearts caused by stem borer in different genotypes

Intensity of damage (ID)

Results on intensity of damage (Table 2) revealed that, in Autumn seasons only one population (G.1.1.4) was resistance, six genotypes were moderately resistance while all other genotypes were susceptible. Results in Winter season showed that only one population (G.1.1.4) was significantly resistance, eight genotypes (G.1.1.16, F-5, Tabat, F-12, G.2.13.5, F-4, G.1.1.13, F-10, and F-4) were moderately resistance, while all other genotypes were susceptible.

Data mean across the two seasons showed that, only one population (G.1.1.4) was resistance, eight populations were moderately resistance (G.1.1.16, F- 5, Tabat, G.2.13.5, F-12, F-4, F-1 and F- 7) with an average of (1.90, 2.37, 2.45, 2.48, 2.50, 2.58,2.63 and 2.70 respectively. and 13 genotypes were susceptible (F-2, Arfa gadamk, W. Ahmad, F-10, F-3, F-11, G.1.1.13, F-13, F-14, F-15, F-8, F-9 and F-6) with an average of (2.86, 2.87, 2,88, 2.92, 2.96, 2.99, 3.06, 3.9, 3.13, 3.28, 3.28, 3.30 and 4.04) respectively. Results showed also that. scores for the three resistance traits

were much higher in Winter as compared to Autumn season infestation.

Results revealed also that. out of the twenty-two sorghum genotypes only four genotypes had relatively good level of resistance to (*Chilo partellus*). Similar to the present findings Pradhan, (1971), (Jotwani, (1978), Jotwani and Davies (1980), Jotwani and Agarwal (1982) screened 6243 lines available in the world germplasm collection and finally selected 26 lines. Singh *et al.* (1983) Screened 70 germplasm lines, Sharma et al., (1983) Screened 14000 germplasm lines.

Yield and Yield components

The performance of the genotypes which were evaluated in the two successive growing seasons and the mean analysis are presented in Table

(3). There were significant differences among the genotypes in all studied traits.

The tallest restore genotype was (F- 5, (193cm) followed by F-9 (192cm), while the earliest flowering maintainer genotype was Arfa gadamk, (61 days), followed by F-7(67.3days) and F- 3 (67.3 days). For 1000 –grain weight restore genotype (G.1.1.4, G.1.1.13 and F-12) were (45.55, 45.45, and 44.5 g) respectively. The results of grain yield showed that the resistance genotype (G.1.1.4, F -3 and F-6) had the highest grain yield (1.37, 1.36 and 1.31 to/ha). These results are in agreement with those obtained by Mourad *et al., (*1999).

Generally, genotypes G.1.1.4 and F-3 is considering a high resistance genotypes to stem borer *Chilo partellus* with high grain yield in Autumn and Winter, while The Genotype F-6 was susceptible highest infested plant by stem borer in two seasons but had highest grain yield (1.31 to/ha).

Based on this criterion, genotype G.1.1.4 was considered of usefulness and could be integrated in the national sorghum breeding program for developing sorghum hybrids with resistance to infestation by larvae of *Chilo partellus* well as high yield potentiality.

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