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SCREENING OF SOME SORGHUM GENOTYPES FOR RESISTANCE TO SORGHUM MIDGE, *STENODIPLOSIS* (= *CONTARINIA*) *SORGHICOLA* COQILLET (DIPTERA: CECIDOMYIIDAE) UNDER GEDARIF RAINFED CONDITIONS

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ABSTRACT

Preliminary experiments were conducted at Northern area, Gedarif State during seasons of 2002-03, 2006-07.Where as advanced trials during 2008/2009 to 2012/2013 at northern and Southern areas. The objective was to evaluate selected sorghum genotypes for sorghum midge resistance. A total of 3000 accessions were obtained from Gene Bank Resources. Resistant genotype, DJ 6514 (Resistant Check already released in 2007) was obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Result showed that the midge damage rating was significantly different among genotypes. The midge damage rating scores ranged between, 1.3- 8.6; 1.1- 9.2; 1.4- 9.0; 1.1 – 9.4; and 1.2- 9.2 for all seasons (2008/09; 2009/10; 2010/11; 2011/12 and 2012/13). However, the lowest midge damage rating was recorded by DJ 6514 (Resistant check), followed by P_1 570162 (Hag Abbakar); GBM 30 (Early Feterita); Wad Baco; and Safra (1.4; 1.5; 1.5, 1.6 and 1.7), respectively. Genotypes, P_1 570162 (Hag Abbakar); GBM 30 (Early Feterita); Wad Baco; Safra and Harerai showed lowest % yield loss and performed similar to the resistant check (14.2; 14.5; 14.5; 17.0 and 17.3%), respectively. The combined analysis showed that a significant difference was observed between genotypes. The genotypes were significantly different in panicle types, compact and semi-compact headed genotypes showed lower % glumes coverage (1.3- 4.5%), while semi-compact headed genotypes ranged between 5.5 – 7.8%. Genotypes, Wad Baco; P_1 570162 (Hag Abbakar); GBM 30 (Early Feterita); Safra; Wad Ahmed; Harerai and Wad Akar showed the shortest glumes coverage (1.3; 1.3; 1.5; 1.5; 1.6; 1.7 and 1.8 %). Compact headed genotypes recorded lowest midge density (6.5 adults/ 5 heads), while the semi-compact headed genotypes were recorded 15.7 adults/ 5 heads compared with others types of heads.

Keywords: sorghum, resistance, sorghum midge, *Stenodiplosis* (=*Contarinia*) *sorghicola* Coqillet, Cecidomyiidae.

ABSTRAK

Eksperimen tinjauan dilakukan di kawasan Utara Negeri Gedarif sepanjang tahun 2002-2003 dan 2006-2007. Manakala, percubaan turut dijalankan di kawasan Utara dan Selatan sekitar tahun 2008/2009 hingga 2012/2013. Objektif kajian termasuklah menilai genotip sorgum yang menentang serangan ulat. Sebanyak 3000 sampel diperoleh dari Sumber Bank Genetik. Genotip Penentang, DJ6514 (Penyemak Penentang dilepaskan pada 2007) diperoleh dari Institut Kajian Antarabangsa Tanaman untuk Tropik Semi-arid (ICRISAT). Keputusan menunjukkan kadar kemusnahan yang disebabkan oleh ulat berbeza-beza antara genotip. Kadar pemarkahan kerosakan disebabkan oleh ulat ditetapkan antara 1.3- 8.6; 1.1- 9.2; 1.4- 9.0; 1.1 – 9.4; dan 1.2- 9.2 bagi semua musim. Namun begitu, kadar kemusnahan yang paling rendah direkodkan pada DJ6514 (Penyemak Penentang), diikuti P_1 570162 (Hag Abbakar); GBM 30 (Awal Feterita); Wad Baco; dan Safra (1.4; 1.5; 1.5, 1.6 dan 1.7). Genotip, P_1 570162 (Hag Abbakar); GBM 30 (Awal Feterita). Wad Baco, Safra dan Harerai menunjukkan kadar kehilangan hasil yang rendah dan bertindak seperti Penyemak Penentang (14.2; 14.5; 14.5; 17.0 dan 17.3%). Analisis penggabungan menunjukkan perbezaan yang signifikan antara genotip dan berbeza secara signifikan berdasarkan jenis panikel. Genotip berkepala padat dan separa padat menunjukkan julat peratusan liputan glume yang paling rendah (1.3-4.5 %) dan genotip berkepala separa padat pula dengan julat peratusan liputan glume antara 5.5-7.8%.Genotip, Wad Baco; P_1 570162 (Hag Abbakar); GBM 30 (Awal Feterita); Safra; Wad Ahmed; Harerai dan Wad Akar menunjukkan nilai liputan glume yang paling pendek(1.3; 1.3; 1.5; 1.5; 1.6; 1.7 dan 1.8 %). Genotip berkepala padat mencatat ketumpatan ulat yang rendah (6.5 dewasa/ 5 kepala), genotip berkepala separa padat dengan bacaan 15.7 dewasa/ 5 kepala berbanding dengan genotip jenis lain.

Kata kunci: sorgum, rintangan, sorgum agas , *Stenodiplosis (= Contarinia) sorghicola* Coqillet, Cecidomyiidae.

INTRODUCTION

Sorghum, *Sorghum bicolor* is the fifth most important cereal crop and is the dietary staple of more than 500 million people in

30 countries. It is grown on 40 million ha in 105 countries of Africa, Asia, Oceania and the Americas. Sorghum is one among the few resilient crops that can adapt well to future climate change conditions, particularly the increasing drought, soil salinity and high temperatures. 90% of the world's sorghum areas lie in the developing countries, mainly in Africa. During 2013/2014 season an area of 32.3 million feddan (13.5 million ha.) was cultivated with sorghum in the Sudan. Productivity ranged between 166-217 kg/feddan. The Sudan contributes about 73% of the total sorghum production in Africa , an area of 5 million feddans (2.1 million ha) which equal 15.5% of Sudan cultivated area and 5% of world total area were cultivated annually with sorghum in Gedarif State (Anonymous, 2014).

Sorghum midge, *S. sorghicola* is one of the most destructive insect pest of sorghum grain worldwide and attacks the crop at the flowering stage (Fadlelmula, 2006). The larvae feed on the ovary resulting in chaffy heads. In late planting and heavy infestation the damage may reach 100% i.e. complete loss of the crop. Following the optimum sowing date and planting sorghum genotypes of similar maturity and planting of resistant genotypes, may contribute positively towards reduction of infestation and damage of sorghum midge, *S. sorghicola* (Sharma, 1993). The use of host-plant resistance in the management of sorghum midge is therefore most promising as the level of resistance is quite high (Fadlelmula, 2003). Host plant resistance is an effective means of keeping the sorghum midge populations below economic threshold levels, and breeding for resistance to sorghum midge is an integral part of sorghum improvement programs. Resistance to sorghum midge is associated with short, tight and hard glumes (Rossetto et al. 1984; Sharma et al. 1990).

The present study was designed to screen and identify resistant and susceptible sorghum genotypes to sorghum midge, *Contarinia sorghicola* under Gedarif rainfed conditions.

MATERIALS AND METHODS

The preliminary experiments were conducted at Northern area, Gedarif State during seasons 2002-03, 2006-07. Three thousands accessions obtained from Gene Bank Resources, Agricultural Research Corporation (ARC). resistant genotype, DJ 6514 (Resistant Check already released in 2007) was obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Promising accessions, i.e. P_1 570162 **(**Hag Abbakar**)** and GBM 30 (Early fetarita**)** were transformed to advanced trials during 2008/2009- 2012/2013 at northern and Southern areas, Gedarif State. Only two accessions were tested in addition to 18 genotypes. An area of one feddan was selected and divided into 84 plots. Each plot was 5.4 x 7 meters, with 7 ridges, 7 meters long and 80 cm apart. The genotypes were arranged in randomized complete block design with four replications. The genotypes were sown on 7 August, 5 August and 10 August, 31 July and 4 August in the five seasons, respectively. The plants were thinned to 2 plants/whole spacing was 20 cm15 days after emergence. Hand weeding was carried out twice.

Data were collected to represent midge damage rating (MDR) and percent yield losses. Agronomic characters as panicle type and glumes coverage. Each genotype was evaluated by rating it according to midge damage rating scale. The damage scale used was a modified of Wuensche et. al. (1981) and Fadlelmula, et. al. (2006). The rating scale used was 1- 9 (1 = 1-10; 2 = 11- 20; 3 = 21- 30; 4 = 31- 40; 5 = 41- 50; 6 = 51- 60; 7 = 61- 70; 8 = 71- 80; 9 = > 80%). Five panicles of each genotype were randomly selected and visually rated (on what basis?). Yield loss for each genotype determined by protecting some panicles from midge infestation was recorded. Five panicles of each genotype were covered by selfing bags during panicle exertion, and before flowering to avoid midge oviposition. The data was analyzed after transformation and ANOVA was used for significant differences of the treatments and Duncan's Multiple Range Test for mean separation.

RESULTS AND DISCUSSIONS

Results presented in Table 1 showed that mean midge damage rating was significantly differences among genotypes. The midge damage rating scores ranged between, 1.3- 8.6; 1.1- 9.2; 1.4- 9.0; 1.1 – 9.4; and 1.2- 9.2 for all seasons (2008/09; 2009/10; 2010/11; 2011/12 and 2012/13), respectively. Genotypes, Korakolo, Ajeb Sedo, AG Commercial, Tetron and AG ASCO recorded the highest midge damage rating (8.6; 7.9; 6.5 and 6.2, respectively). The lowest midge damage rating was recorded by DJ 6514 (Resistant check), followed by P_1 570162 (Hag Abbakar); GBM 30 (Early Feterita); Wad Baco; and Safra (1.4; 1.5; 1.5, 1.6 and 1.7), respectively, similar to the resistant check. Data on percent yield loss for five seasons in Table 2 showed that significant differences between genotypes were recorded. Percent yield loss for genotypes was ranged between, 13- 86.7; 12.0- 92.0; 13.3- 90.0; 12.3- 94.6 and 12.5- 92.6for the five seasons (2008/09; 2009/10; 2010/11; 2011/12 and 2012/13), respectively. Genotypes, P_1 570162 (Hag Abbakar); GBM 30 (Early Feterita); Wad Baco; Safra and Harerai showed the lowest % yield loss and performed similar to the resistant check (14.2; 14.5; 14.5; 17.0 and 17.3%), respectively. Combined analysis showed that a significant difference was observed between genotypes. The yield loss of genotypes ranged from 12.4- 86.8%. In combined mean, genotypes P_1 570162 (Hag Abbakar); Wad Baco; GBM 30 (Early Feterita); Safra; Harerai and Mugud showed the lowest % of yield loss (< 19%), while Gadambalia bloom; Korakolo; Ajeb Sedo; AG Commercial, Tetron and AG ASCO displaced the highest % yield loss (70.4- 90.4%).

Agronomical characters; panicle type and glumes coverage were presented in Table 3 where significant differences between genotypes were observed. Genotypes were significantly different in panicle types, compact and semi-compact headed genotypes showed lower % of glumes coverage (1.3- 4.5%), while Semi-compact headed genotypes hada range of5.5 – 7.8%. Genotypes, Wad Baco; P_1 570162 (Hag Abbakar); GBM 30 (Early Feterita); Safra; Wad Ahmed; Harerai and Wad Akar were found to have the shortest glumes coverage (1.3; 1.3; 1.5; 1.5; 1.6; 1.7 and 1.8 %), respectively. The genotypes Aros Arremal, Gadambalia bloom, Daber baladi, Daber Kasa, AG ASCO, AG Commercial, Ajeb Sedo and Korakolo had the longest glumes coverage (7.8; 7.7; 7.5; 7.5; 7.5; 7.5; 7.3 and 7.2%), respectively. Table 4 showed that compact headed genotypes recorded the lowest midge density (6.5 adults/ 5 heads), while semi-compact headed genotypes recorded 15.7 adults/ 5 heads. However, Semi-loose headed genotypes had the highest midge density (21.4 adults/ 5 heads).

Table 1. Mean % of sorghum midge damage rating on different genotypes during 2008/09- 2012/13 seasons

Genotype	% Mean midge damage rating					Combined means
	2008/09	2009/10	2010/11	2011/12	2012/13	
AG ASCO	5.6^{b}	6.2^{bc}	7.1^{b}	6.4^{bc}	5.7^{bc}	6.2^{ab}
AG commercial	7.5^{ab}	6.1^{bc}	7.0^{b}	5.6^{bc}	6.8^{b}	6.6^{ab}
Korakolo	8.4^{a}	9.0^{a}	8.5^{a}	7.8^{ab}	9.2a	8.6^{a}
Ajeb Sedo	7.5^{ab}	6.7^{bc}	8.0^{ab}	9.3^{a}	7.8^{ab}	7.9^{ab}
Teteron	6.0^{b}	7.2^{b}	6.5^{bc}	6.8^{bc}	6.2^{bc}	6.5^{ab}
Safra	1.7^{cd}	1.8	2.0^{e}	1.6^{e}	1.5^{de}	1.7^{d}
GBM 30 (Early Feterita)	1.5^{cd}	1.3e	1.4^{e}	1.2^{e}	1.7^{de}	1.5^{d}
Wad Ahmed	2.4^{cd}	2.7^{de}	2.0^{e}	2.5^{de}	1.9^{de}	2.3^{cd}
Wad Akar	3.0^{c}	2.9^{de}	2.5^{e}	2.3^{de}	2.7^{de}	2.7^{cd}
Daber baladi	4.2^{bc}	5.1^{c}	4.5^{cd}	3.8^{d}	4.0^{cd}	4.3^{bc}
Daber Kasa	5.2^{b}	3.8	4.8^{cd}	4.0^{cd}	4.6^{cd}	4.5^{bc}
Gadambalia B.	8.6^{a}	9.2^{a}	9.0^{a}	9.4^{a}	8.4^{ab}	8.9^{a}
Aros Arremal	2.5^{cd}	2.8	4.2^{cd}	3.5^{d}	3.0^{d}	3.2^{cd}
P_1 570162 (Hag Abbakar)	1.4^{cd}	1.3^{e}	1.6^{e}	1.4^{e}	1.3^{de}	1.4^{d}
Faki mustahi	3.2^{c}	3.7^{d}	4.0^{cd}	4.4^{c}	4.8^{cd}	4.0^{bc}
Harerai	1.6^{cd}	1.8^{e}	1.7^{e}	1.6^{e}	1.5^{de}	1.6^{d}
Wad Baco	1.3^{d}	1.7^{e}	1.5^{e}	1.2^{e}	1.6^{de}	1.5^{d}
Mugud	2.5^{cd}	2.8^{de}	2.3^{e}	2.1^{de}	2.8^{de}	2.5^{c}

Bashair	-	4.2^{cd}	5.0^{c}	4.6^{cd}	4.8^{cd}	4.7^{bc}
Butana	-	3.2^{de}	4.1^{cd}	3.6^{d}	3.4^{d}	3.6^{c}
DJ6514 (Resistant check)	1.3^{d}	1.1^{e}	1.4	1.1^{e}	1.2^{e}	1.2^{d}
S.E$\pm$	0.53	0.52	0.54	0.62	0.56	0.79
C.V.%	14.8	13.1	12.7	16.6	14.1	11.7

*Means with same letter(s) are not significantly different at 5% level according to Duncan's Multiple Range Test

Table 2. Percent mean yield loss of different genotypes during 2008/09- 2012/2013 seasons

Genotype	Mean % yield loss					Combined means
	2008/09	2009/10	2010/11	2011/12	2012/13	
AG ASCO	68.5^{bc}	69.7^{bc}	71.4^{bc}	65.3^{bc}	77.2^{ab}	70.4^{b}
AG commercial	75.8^{ab}	67.0^{bc}	74.2^{ab}	67.5^{bc}	70.1^{b}	71.2^{b}
Korakolo	85.4^{a}	90.6^{a}	87.3^{ab}	78.1^{ab}	92.6^{a}	86.8^{ab}
Ajeb Sedo	77.6^{ab}	72.5^{b}	80.7^{abc}	93.3^{a}	78.4^{ab}	80.5^{ab}
Teteron	65.5^{bc}	72.7^{b}	68.6^{bc}	63.8^{b}	71.2^{b}	70.7^{b}
Safra	18.6^{ef}	14.7^{fg}	16.3	15.5^{de}	20.1^{de}	17.0^{ef}
GBM 30 (Early Feterita)	15.0^{ef}	13.2^{g}	14.7	12.0^{e}	17.5^{ef}	14.5^{f}
Wad Ahmed	24.2^{ef}	27.1^{ef}	20.0	25.6^{cd}	19.8^{def}	23.3^{de}
Wad Akar	30.3^{de}	29.5^{def}	25.8^{ef}	23.4^{cd}	27.0^{de}	27.2^{de}
Daber baladi	45.4^{de}	52.5^{d}	44.6^{cde}	38.1^{cd}	42.2^{cd}	44.6^{c}
Daber Kasa	52.8^{cd}	42.4^{de}	49.7^{cde}	41.2^{cd}	45.6^{cd}	46.3^{c}
Gadambalia B.	86.7^{a}	92.0^{a}	90.5^{a}	94.6^{a}	88.3^{ab}	90.4^{a}
Aros Arremal	26.5^{ef}	28.8^{ef}	34.2^{e}	32.5^{cd}	31.0^{de}	30.6^{cd}

P_1 570162 (Hag Abbakar)	14.3^{f}	13.0^{g}	16.4^{f}	14.2^{e}	13.4^{e}	14.2^{f}
Faki mustahi	24.2^{ef}	21.7^{fg}	23.6^{ef}	21.5^{de}	25.4^{de}	23.3^{de}
Harerai	17.5^{ef}	19.6^{fg}	15.3^{f}	16.2^{de}	17.8^{ef}	17.3^{ef}
Wad Baco	13.0	16.5^{fg}	15.7^{f}	12.3^{e}	14.6^{e}	14.4^{f}
Mugud	19.5^{ef}	21.3^{fg}	18.4^{f}	19.5^{de}	16.2^{ef}	18.8^{ef}
Bashair	-	44.2^{de}	52.1^{cd}	45.4^{c}	49.6^{c}	47.8^{c}
Butana	-	37.5^{e}	44.4^{de}	39.7^{cd}	35.7^{cd}	39.3^{cd}
DJ6514 (Resistant check)	13.0^{f}	11.2^{g}	14.5^{f}	11.0^{e}	12.5^{e}	12.4^{f}
S.E±	5.5	4.8	5.6	5.8	5.4	5.3
C.V.%	13.5	12.0	13.3	14.8	13.1	12.8

*Means with same letter(s) are not significantly different at 5% level according to Duncan's Multiple Range Test

Table 3. Panicle type and % mean glumes coverage of different genotypes during 2008/2009-2012/2013 seasons

Genotype	Panicle type *	% Glumes coverage**
AG ASCO	2^{b}	7.5^{a}
AG commercial	2^{b}	7.5^{a}
Korakolo	3^{a}	7.2^{ab}
Ajeb Sedo	3^{a}	7.3^{ab}
Teteron	3^{a}	6.9^{ab}

Safra	1^{c}	1.5^{cd}
GBM 30 (Early Feterita)	2^{b}	1.5^{cd}
Wad Ahmed	2^{b}	1.6^{cd}
Wad Akar	2^{b}	1.8^{cd}
Daber baladi	3^{a}	7.5^{a}
Daber Kasa	3^{a}	7.5^{a}
Gadambalia B.	3^{a}	7.7^{a}
Aros Arremal	2^{b}	7.8^{a}
P_1 570162 (Hag Abbakar)	1^{c}	1.3^{d}
Faki mustahi	1^{c}	4.5^{a}
Harerai	1^{c}	1.7^{cd}
Wad Baco	1^{c}	1.3^{d}
Mugud	1^{c}	4.1^{bc}
Bashair	3^{a}	5.5^{b}
Butana	3^{a}	6.4^{ab}
DJ 6514 (Resistant check)	1^{c}	1.3^{d}
S.E±	0.2	0.6
C.V.%	9.2	13.6

*Panicle type (1 = Compact; 2= Semi-compact; 3= semi-loose and 4= loose).
**Glumes coverage (1= 10%; 2= 20%; 3= 30%; 4= 40%; 5= 50%; 6= 60%; 7 = 70% ; 8= 80%; 9= 90% and 10= 100%).
Means with same letter(s) are not significantly different at 5% level according to Duncan's Multiple Range Test

Table 4. Comparison between panicle type, adult midge density, midge damage rating, and % yield loss for some sorghum genotypes during the period of 2008/2009- 2012/2013 under Gedarif rainfed conditions

Panicle type	Midge density	Midge damage rating	Yield loss
Compact	6.5	2.2	17.3
Semi-compact	15.7	3.8	39.5
Semi-loose	21.4	6.1	63.3
Overall mean	14.5	4.0	40.0

CONCLUSION

The genotypes Wad Baco, Hag Abbakar- P_1 570162**,** Safra, GBM 30 (Early Feterita) and Harerai showed resistance against sorghum midge damage and yield loss. Panicle types and percentage glumes coverage had showed clear impact on resistance and can use as morphological resistance factors that limit the insect oviposition. These characters can be use as selection criteria for breeding sorghum midge resistance genotypes.

Based on the results mentioned above we recommend the following landraces Wad Baco, P_1 570162 (Hag Abbakar), GBM 30 (Early Feterita), Safra; Harerai, for late planting and for use as sources of resistance for improved sorghum midge, *S. sorghicola.*

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