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Evaluation of Some Chickpea *(Cicer arietinum* L.*)* Genotypes for Yield, Yield Components and Resistance to Pod Borer under Kassala State Environment, Sudan.

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ABSTRACT

This research was conducted to evaluate some chickpea *(Cicer arietinum* L.*)* genotypes for yield, yield components and resistance to pod borer under Kassala State environment, Sudan. The experiment was set in a randomized complete block design (RCBD) replicated thrice for three consecutive seasons (2016/ 2017, 2017/018 and 2018-019), respectively. The results of the combined analysis revealed significant differences in 50% days to flowering, 100 seed weight, and infestation by American Boll Worm (ABW) as well as yield of different tested chickpea varieties. Wad Hamid, Atmoor, Matama and Jabal Mara genotypes recorded the least number of days to 50% flowering fluctuated between 38 – 41 days. Salwa, Wad Hamid, Matama and Burgaig gave the highest 100 seed weights with 21.9, 21.5, 12.2 and 21.0 grams, while the best yielders were Matama, Atmoor, Wad Hamid and Jabal Mara with 1200.7, 1022.5, 867.7 and 866.3 (Kg/feddan) respectively. Hawata, Shandi, Wad Hamid and Burgaig are the least infested varieties by ABW with 2.7, 3.0, 4.2

and 4.5 larvae, respectively. Therefore, conclude these three varieties, (Wad Hamid, Matama and Atmoor) can be used in Kassala State for their yield performance.

Keywords: *Chick pea; Genotypes; Yield; Yield components and Pod Borer.*

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world, after dry bean and field bean (FAOSTAT, 2012). The crop accounts for 12 % of the world pulses produced (Khan *et al.,* 2011). It is grown in the arid and semi-arid regions of the world with a total global production of 11.6 million tons from 13.2 million hectares in 2011 (FAOSTAT, 2012). Desi and Kabuli types are the two main types of chickpea cultivars grown all over the world. The total yield production is quite low in most chickpea growing countries and a wide gap exists between the potential (5 ton ha $^{-1}$) and actual (0.96 ton ha^{-1}) yields (FAOSTAT, 2012). The low yields have been attributed to low genetic diversity of cultivated chickpea for yield and yield components (Malik *et al.,* 2014) and various biotic factors such as Pod borer, As chochyta blight, fusarium wilt and dry root rot etc., and a biotic like drought, extreme temperatures, salinity stresses (Millan *et al.,* 2006 and Upadhyaya *et al.,* 2008).

Chickpea is a multipurpose crop grown for dry seeds as pulse, green pods as vegetable source of food for human and also feed for livestock due to its high protein, vitamins, minerals and fiber contents. Chickpea seeds contain potassium calcium, sodium, magnesium, iron, copper and zinc which make it nutritionally the best edible pulse (Ferial & Esmat, 2011). The crop enhances intensive utilization of land in areas where land is limited and it can be grown as a second crop using residual moisture.

Chickpea requires no nitrogen fertilizers due to its ability to fix atmospheric nitrogen. It returns a large amount of residual nitrogen to the soil and adds organic matter. Fatima *et al*. (2008) reported that the crop fixes 68 –138 kg nitrogen ha^{-1} per growing season.

According to lack of protein source crops in Kassala State and the presence of malnutrition diseases and deficiency of minerals among the Bedouins and tribes living in the state, Kassala and Gash Research

Station initiated a program for introduction of different legume crops by testing different released genotypes of mung bean, phaseolus and chickpea looking for high yield ones with resistance or tolerance to the most important pests and diseases especially pod borers. Therefore the objective of this study was evaluation of some chickpea genotypes for yield, yield components and resistance to pod borer under Kassala State environment, Sudan.

2. MATERIALS AND METHODS

Plant Materials

The plant materials used in this experiment was consisted of eight varieties of chick pea, namely, Shandi, Atmoor, Matama, Jabal Mara, Wad Hamid, Salwa, Burgaig and Hawata, they were provided by chickpea breeder of Agricultural Research Corporation (ARC), Sudan.

Experimental Site

The field experiments were conducted at the experimental farm of Kassala and Gash Research Station (Takroof area) during the period from November to March of the seasons (2016-2017, 2017-2018 and 2018-2019), respectively.

Land Preparation and Sowing

Land was prepared using disc plough, then harrowed and ridged. Seeds of eight genotypes of chickpea were sown in rows 80 cm apart and 20 cm between hills. After emergence of plants, seedlings were thinned to one plant per hill. All cultural practices were applied as recommended by ARC, Sudan. Each genotype was represented by a plot of four rows of five meter length. Hand weeding was executed at 2^{nd}, 6^{th} and 8^{th} weeks after planting to keep plots free of weeds. All tested genotypes were replicated thrice in a randomized complete block design.

Weather Data

Weather data recorded at Kassala State Meteorological Station for three winter seasons of 2016/2017, 2017/2018 and 2018/2019. The average maximum and minimum temperature degrees and relative humidity for the mentioned seasons are showed in (Table 1).

Statistical Analysis

Analysis of variance for yield parameters and infestation by American Boll Worm (ABW) was computed for each season solely and also data of all seasons were combined and analyzed. Means were separated by Turkey test using SAS 2004 computer based program.

Table 1. Weather data recorded at Kassala State meteorological station during three seasons of 2016/2017, 2017/2018 and 2018/2019.

Data	Seasons	Months					
		November	December	January	February	March	April
Mean max. Temperature (C°)	Season2016/2017	38.1	36.3	36.3	34.6	38.9	42.1
	Season2017/2018	37.5	36.9	32.5	38.9	39.3	40.7
	Season2018/2019	23.0	20.6	16.6	20.9	23.4	23.3
Mean min. Temperature (C°)	Season2016/2017	23.0	21.3	19.7	18.9	21.3	26.6
	Season2017/2018	37.2	35.0	36.3	36.6	37.5	41.4
	Season2018/2019	21.5	19.3	18.8	19.7	19.3	23.2
Monthly relative humidity (%)	Season2016/2017	46	45	43	40	25	27
	Season2017/2018	37	37	45	32	27	20
	Season2018/2019	45	58	59	50	38	19.7

3. RESULTS AND DISCUSSION

Agronomic Traits of Chickpea

The success in genetic improvement of chickpea greatly relies on the availability of genetic resources and their genetic variations. Knowledge of genetic variations among genotypes and relationships of economic traits would assist chickpea breeders to formulate suitable breeding strategies and to develop adapted and productive varieties. The genotypes evaluated in this study showed a wide range of genetic variability for all characters under studied during the three consecutive seasons, indicating the existence of wide diversity among the germplasm can be used in crossing/evolving new chickpea varieties. The diversity for various traits is as described below:

Days to 50% Flowering

Statistical analysis demonstrated high significant differences among varieties of chickpea for the number of days to 50% flowering for the three consecutive seasons and their combined data. The genotypes Wad Hamid, Atmoor, Matama and Jabal Mara recorded the least number of days to 50% flowering fluctuated between 38 – 41 days while varieties

Salwa (46.2), Burgaig (46.0), Hawata (44.7) and Shandi (42.3) had the largest number of days to 50% flowering (Table 2). Earliness character is important in chickpea crop breeding. Information on the variation available for days to flowering could be enabled chickpea germplasm collections to be efficiently conserved and exploited in future breeding programme. The results from this study showed highly significant variation among varieties for days to 50 % flowering (Table 2). The top four varieties with least number of days to 50% flowering were Atmoor (36.7), Wad Hamid (37.3), Jabal Mara (39.3), and Matama & Salwa (41.0) in season one, while in season two were Wad Hamid (37.7), Matama & Atmoor (40.7), and Jabal Mara (41.7) and in season three were Wad Hamid & Matama (40.7), Atmoor (40.3) and Jabal Mara (41.3) (Table 2). Studies on chickpea by Gul *et al.* (2013) and Tesfamichael *et al*. (2014) reported a significant and wide range of variation for days to 50 % flowering among chickpea germplasms. However, the current results were not agreed with those of Zelalem (2014) who reported non-significant variations for days to 50%flowering. Thus early flowering genotypes from this study could be used as parent for hybridization by chickpea breeders in the region to develop varieties with modest flowering and reasonable yield traits.

Table 2. Means of days to 50% flowering for chickpea varieties in Kassala State (2016-2017, 2017-2018 and 2018-2019) and their combined analysis

Entries	Number of days to 50% flowering			
	2016-2017	2017-2018	2018-2019	Combined
Shandi	42.3 ^{bc}	42.7 ^{bc}	42.0 ^{bdc}	42.3 ^{b}
Atmoor	36.7 ^{e}	40.7 ^{dc}	40.3 ^{d}	39.2 ^{cd}
Salwa	41.0 ^{dc}	46.7 ^{a}	44.6 ^{ba}	46.2 ^{a}
Jabal Mara	39.3 ^{dce}	41.7 ^{c}	41.3 ^{dc}	40.8 ^{cb}
Matama	41.0 ^{dc}	40.7 ^{dc}	40.7 ^{d}	40.8 ^{cb}
Wad Hamid	37.3 ^{de}	37.7 ^{d}	40.7 ^{d}	38.6 ^{d}
Burgaig	47.0 ^{a}	46.0 ^{ba}	45.0 ^{a}	46.0 ^{a}
Hawata	45.0 ^{ba}	45.3 ^{ba}	43.7 ^{bac}	44.7 ^{a}
Means	42.0	42.7	42.3	42.3
Standard Error ±	0.9	0.7	0.4	0.4
Coefficient of Variation	3.1	2.9	2.3	2.9
Probability	0.0001	0.0001	0.0001	0.0001

Figures not sharing the same letters differ significantly at $p< 0.05$.

Weight of 100 Seeds (gm)

Significant differences were observed between the genotypes of chickpea in the season 2016-2017 and on the combined analysis of the three seasons on the Weight of 100 seeds while no significant differences between them were observed for the second and third season on the same parameter. Varieties; Salwa, Wad Hamid, Matama and Burgaig gave the highest 100 seed weights with 21.9, 21.5, 12.2 and 21.0 grams, respectively, while varieties Shandi (17.9 gm), Hawata (17.7gm), and Atmor & Jabal Mara (16.7) had the lowest combined 100 seed weights (Table 3).

Seed weight is one of the most important yield related traits in pulse crops including chickpea and determines the final seed yield. The evaluated genotypes showed significant variation with respect to100 seed weight (Table 3). The top four varieties with highest 100 seed weights were Salwa (24.0), Burgaig (21.9), Matama (20.9) and Wad Hamid (20.8) grams, in season one, while in season two were Wad Hamid (21.3), Matama (21.2), Salwa (20.6) and Burgaig (19.5) grams and in season three were Wad Hamid (22.4), Matama (22.1), Burgaig (21.6)and Salwa (20.7) grams. Similarly Ramanappa *et al*. (2013), Atta *et al*. (2008), and Tesfamichael *et al.* (2014) reported wide and significant variation for 100 seed weight among chickpea germplasm.

In the current study large- seeded genotypes gave more 100 seed weight compared to small- seeded genotypes. The recorded significant variation for 100 seed weight could be attributed to diverse genotypes for seed size. The variation in seed size and seed weight could contribute significantly to final seed yield ha $^{-1}$. B. Tuba (2009) reported 4 -6 % increase in seed weight from large seeded genotypes compared to medium seeded genotypes in chickpea germplasm.

Seed Yield (Kg/Feddan)

Table (4) showed high significant differences on the yield of the test genotypes for the first and the second seasons as well as the combined. The varieties exhibit fluctuation of combined yield between 652.4 to 1200 kg/feddan. The varieties, Matama, Atmoor, Wad Hamid and Jabal Mara were best yielder among others with 1200.7, 1022.5, 867.7 and 866.3 Kg/feddan, respectively, while varieties Hawata (784.0 kg)

Burgaig (685.5 kg), Shandi (652.4 kg) and Salwa (618.3 kg), had the lowest combined yield.

Table 3. Means Weight of 100 Seeds (gm) of chickpea varieties in Kassala State (2016-2017, 2017-2018 and 2018-2019) and their combined analysis

Entries	100 seeds weight			
	2016-2017	2017-2018	2018-2019	Combined
Shandi	**16.9** [b]	**17.9**	**19.0**	**17.9** [bac]
Atmoor	**15.8** [b]	**15.1**	**19.3**	**16.7** [c]
Salwa	**24.0** [a]	**21.2**	**20.7**	**21.9** [a]
Jabal Mara	**16.3** [b]	**16.7**	**17.2**	**16.7** [C]
Matama	**20.9** [ba]	**20.6**	**22.1**	**21.2** [ba]
Wad Hamid	**20.8** [ba]	**21.3**	**22.4**	**21.5** [ba]
Burgaig	**21.9** [ba]	**19.5**	**21.6**	**21.0** [ba]
Hawata	**17.3** [ba]	**17.5**	**18.2**	**17.7** [bc]
Means	**19.3**	**18.7**	**20.1**	**19.4**
Standard Error ±	**0.7 1**	**0.7**	**0.6**	**0.4**
Coefficient of Variation	**12.5**	**16.7**	**13.9**	**13.9**
Probability	**0.0107**	**0.2680**	**0.2**	**0.0033**

Figures not sharing the same letters differ significantly at $p< 0.05$.

Yield trait is a quantitative variable and is the result of several physiological and biochemical processes in the crop growth and development stages. The results from this study indicated substantial differences among varieties for seed yield/ha (Table 4). During the first season higher seed yield ha^{-1} was recorded by Matama (1153.8 kg) Atmoor (926.1 kg) Jabal Mara (860.4 kg) and Shandi (666.3), while in season two were Atmoor (857.8kg), Matama (851.7 kg), Wad Hamid (755.3 kg) and Jabal Mara (724.3 g) and in Season three were Matama (1596.7 kg), Wad Hamid (1308.4 kg), Atmoor (1283.7) and Hawata (1068.6 kg). The presence of wide variations for seed yield/feddan showed the potential of the evaluated germplasms to develop high yielding varieties for specific and broad adaptation. In chickpea, previous studies have reported significant variation for seed yield (Malik *et al.*, 2009, Tesfamichael *et al*., 2014). However, the present results contradict those of Oladejo *et al*. (2011) who reported non-significant differences for seed yield. These indicated that the genotypes and environment effect played a great role for seed yield and genotypes showed specific adaptation to particular environment. The ranking of varieties for seed yield ha^{-1} varied across environments. The evaluated varieties showed

different responses which indicate no specific genotypes were superior across environments. High seed yield ha $^{-1}$ is one of the main criteria for identifying and selecting superior varieties for release to farmers. Genotypes with reasonable seed yield ha $^{-1}$ combined with moderate maturity could be selected for future hybridization Thus, high yielding varieties from the studied germplasms could be used directly by the farmers or used for future improvement of chickpea in the region.

Table 4. Seed yield (kg/feddan) of chickpea varieties in Kassala State (2016-2017, 2017-2018 and 2018-2019) and their combined analysis

Entries	Yield Kg/feddan			
	2016-2017	2017-2018	2018-2019	Combined
Shandi	**666.3** ^{ba}	**512.8**	**778.1** ^{b}	**652.4** ^{b}
Atmoor	**926.1** ^{ba}	**857.8**	**1283.7** ^{ba}	**1022.5** ^{ba}
Salwa	**420.0** ^{b}	**552.5**	**882.5** ^{b}	**618.3** ^{b}
Jabal Mara	**860.4** ^{ba}	**724.3**	**1014.3** ^{ba}	**866.3** ^{ba}
Matama	**1153.8**^{a}	**851.7**	**1596.7** ^{a}	**1200.7** ^{a}
Wad Hamid	**539.6** ^{b}	**755.3**	**1308.4** ^{ba}	**867.7** ^{ba}
Burgaig	**594.0** ^{b}	**500.4**	**962.0** ^{b}	**685.5** ^{b}
Hawata	**659.6** ^{ba}	**623.9**	**1068.6** ^{ba}	**784.0** ^{b}
Means	**727.58**	**672.4**	**1111.7**	**837.2**
Standard Error ±	**59.5**	**66.5**	**63.4**	**42.8**
Coefficient of Variation	**26.2**	**52.6**	**19.1**	**32.8**
Probability	**0.0073**	**0.8142**	**0.0046**	**0.0005**

Figures not sharing the same letters differ significantly at $p< 0.05$.

Number of Pod Larva/Plant

All chickpea varieties tested in this study were susceptible to the ABW infestation and represented significant differences on the mean number of the larvae of the pest for the three consecutive seasons and their combined. Hawata is the least infested variety among all test varieties, followed by Shandi, Wad Hamid and Burgaig with 2.7, 3.0, 4.2 and 4.5 numbers of larvae respectively (Table 5).

Table 5. Means number of larvae on chickpea varieties in Kassala State (2016-2017, 2017-2018 and 2018-2019) and their combined analysis

Entries	Mean No of ABW			
	2016-2017	2017-2018	2018-2019	Combined
Shandi	**3.6**^{dc}	**2.5** ^{c}	**2.9** ^{bc}	**3.0** ^{d}
Atmoor	**5.5**^{a}	**5.5** ^{a}	**5.5** ^{a}	**5.5** ^{a}
Salwa	**5.2**^{ba}	**4.8** ^{ba}	**5.9** ^{a}	**5.0** ^{bac}
Jabal Mara	**4.9**^{ba}	**5.4** ^{ba}	**5.3** ^{a}	**5.2** ^{ba}
Matama	**5.6**^{a}	**4.9** ^{ba}	**5.4** ^{a}	**5.3** ^{ba}
Wad Hamid	**4.3**^{bc}	**3.9** ^{bc}	**4.5** ^{ba}	**4.2** ^{c}
Burgaig	**4.7**^{ba}	**3.9** ^{bc}	**4.8** ^{ba}	**4.5** ^{bc}

Hawata	**3.1 d**	**2.6 c**	**2.4 c**	**2.7 d**
Means	**4.6**	**4.2**	**4.5**	**4.4**
Standard Error ±	**0.3**	**0.3**	**0.2**	**0.1**
Coefficient of Variation	**7.5**	**12.9**	**15.4**	**12.5**
Probability	**.0001**	**.0001**	**0.0007**	**.0001**

Figures not sharing the same letters differ significantly at p< 0.05.

Data on pod damage (Table 6) indicate that the lowest damage of ABW was recorded near the maturity of crop in genotype Hawata (8.7%), Shandi (10.6%) and Wad Hamid (18.4), whereas the highest damage was recorded in genotype Atmoor (30.5%), Matama (28.3), Jabal Mara (26.5), Salwa (25.2) and Burgaig (21.6) on combined basis.

Results of our study are contrary to those reported by Chhabra and Kooner, (1980). No infestation in resistant genotypes and 30-40% infestation in susceptible genotypes using different lines. Our findings in the present study are in line with results reported by Srivastava and Srivastava, (1989) who found ABW damage from 3.5 to 21.6% in different chickpea strains. Our findings are in the line to the work of Shafique *et al.* (2009), who reported 13.3 to 22.7% pod damage by screening 13 Kabuli genotypes. Similarly Shafique *et al.* (2009) have reported 10.9 to 22.8% pod damage, which is in agreement with our results.

Table 6. Number of larvae/ of African boll worm on chickpea varieties evaluated in Kassala State for three consecutive seasons (2016/2017, 2017/2018 & 2018/2019) and their combined analysis

Entries	Number of ABW			
	2016-2017	2017-2018	2018-2019	Combined
Shandi	**13.5 c d**	**8.3 c**	**10.1 b c**	**10.6 d**
Atmoor	**30.7 a**	**30.6 a**	**30.3 a**	**30.5 a**
Salwa	**26.7 b a**	**23.1 b a**	**25.6 b a**	**25.2 a b c**
Jabal Mara	**25.6 b a**	**28.2 b a**	**25.7 b a**	**26.5 a b**
Matama	**31.4 a**	**24.9 a**	**28.6 a**	**28.3 a b**
Wad Hamid	**18.9 c b d**	**15.3 b c**	**21.1 a b c**	**18.4 c**
Burgaig	**22.9 b a c**	**16.8 b a**	**25.1 b c**	**21.6 b c**
Hawata	**11.3 d**	**8.0 c**	**6.9 c**	**8.7 d**
Means	**7.7**	**9.2**	**9.7**	**8.9**
Standard Error ±	**1. 6**	**1.9**	**1.9**	**1.0**
Coefficient of Variation	**14.9**	**15.8**	**16.2**	**22.7**
Probability	**.0001**	**0.0003**	**0.0032**	**.0001**

Figures not sharing the same letters differ significantly at p< 0.05.

4. CONCLUSION

- The varieties Wad Hamid, Atmoor, and Matama Jabal Mara recorded the least number of days to 50% flowering.
- The varieties Matama, Atmoor and Wad Hamid gave the highest seed yield.
- The present study concludes that, genotype Hawata, Shandi and Wad Hamid are highly resistant genotypes, showing the lowest pod damage.
- Therefore, conclude that these varieties (Wad Hamid, Matama and Atmoor) can be selected by farmers to be cultivated at Kassala State, Sudan.

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المستخلص

تم إجراء هذا البحث لتقييم بعض الطرز الوراثية للحمص*(Cicer arietinum L.)* من حيث الإنتاجية، مكونات الإنتاجية ومقاومة حفار القرون في بيئة ولاية كسلا، السودان. تمت التجربة بتصميم القطاعات العشوائية الكاملة (RCBD) بثلاثة مكررات لمدة ثلاثة مواسم متتالية. أظهرت نتائج كل موسم والتحليل المجمع اختلافات معنوية في 50٪ يوم من الإزهار، ووزن 100 بذرة، والإصابة بدودة اللوز الأمريكية وكذلك محصول أصناف مختلفة من الحمص. وسجلت ود حامد، عتمور، متمة وجبل مرة أقل عدد من الأيام إلى 50٪ مزهرة متذبذبة بين 38 – 41 يومًا. سلوى، ود حامد، متمه وبرقيق سجلت أعلى وزن 100 بذرة بأوزان 21.9، 21.5، 20.2 و20.0 جرام على التوالي بينما كانت أفضل إنتاجية متمه، عتمور، ود حامد وجبل مرة بأوزان 1200.7، 1022.5، 867.7 و866.3 كجم / فدان على التوالي. يعتبر حواتة، شندي، ود حامد وبرقيق أقل إصابة بالدودة الإفريقية 2.7 و3.0 و4.2 يرقات على التوالي. يُوصى بتربية الأصناف الثلاثة ود حامد، متمه وعتمور حسب أداء المحصول في ولاية كسلا.

الكلمات المفتاحية: *الإنتاجية؛ الحمص؛ الطرز الوراثية.*