Effect of Terminal Heat Stress on Performance of Five Faba Bean (*Vicia faba* L.) Genotypes Grown Under Semi-arid Conditions of Sudan

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ABSTRACT

The objective of this study was to investigate the performance of five faba bean (*Vicia faba* L.) genotypes under end-of-season heat stress in the Demonstration Farm, Faculty of Agriculture, Shambat-Sudan. Two sowing dates were used; namely, optimum sowing date (15 November) and late sowing date (15 December) to induce heat stress at the end of the season. A split plot design with three replicates was used to lay out the experiment. Terminal heat stress (late sowing) reduced the number of pods/plant, number of seeds/pod and 100-seed weight by 26%, whereas the reduction in seed yield/plant and seed yield/ha was 46%. Under terminal heat stress, the genotype Hudeiba/93 gave the highest yield (2090.0 kg/ha) and the genotype Shabah gave the lowest yield (1198.8 kg/ha). The yield/ha for the genotypes under the optimum sowing was 3023.2 kg and 2987.2 kg, respectively. Under the optimum sowing date, the genotype Basabier gave the highest yield/ha (4053.5 kg/ha) whereas the genotype Ed-Damar gave the lowest yield (2768.7 kg/ha). The genotype × sowing date interaction showed significant differences for yield/ha. It is concluded that, although the genotypes showed great variability for the effect of end-season heat, any delay in faba bean sowing date will significantly reduce yield, irrespective of the genotypes used.

Key words: Faba bean genotypes; terminal heat stress; performance; semi-arid

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important food legumes in Sudan. The crop is considered a major source of low cost protein for the middle and low income strata of the population. It also contributes to soil fertility, through biological N- fixation, and minimises the cost of chemical fertilizers, the crop is mainly grown in Northern and River Nile states along the River Nile banks as an irrigated winter crop.

These two states are characterized by a relatively longer and cooler winter (suitable for faba bean production) compared to the central Sudan. The two states contribute about 90% of the national faba bean production. Due to the increasing demand and short supply, limited areas along the River Nile banks, and the low farmers yield

(about 1.8 t/ha depending on climatic conditions) (Salih *et al*., 1996), the production of the crop was extended into new nontraditional areas (Gezira, New Halfa and Rahad (Salih 1992). Sowing date is one of the most important cultural practices that result in great differences in growth and yield of grain legumes and it is usually used in farming systems to avoid heat stress, drought, pests or diseases which may occur early or late in the growing season (Khalil *et al*., 2010).The objective of this study was to investigate the performance of faba bean (*Vicia faba* L.) genotypes under end-of-season heat stress.

MATERIALS AND METHODS

The experiment was conducted at the Demonstration Farm, Faculty of Agriculture, University of Khartoum, Shambat (lat.15°39′ N and Long 32°30′ E, and altitude 380 m above sea level) during the winter season of 2010/2011. The climate is tropical semi-arid with annual rain fall of about 200 mm, and the mean monthly temperatures during the winter are around 20ºC. The soil of the Experimental Farm is heavy clay with alkaline p H.

The experimental material used consisted of five genotypes of faba bean (*Vicia faba* L.), namely Hudeiba/93, Seliam, Ed-Damar, Shabah and Bassabier. These genotypes differ mainly in seed size. The heat stress was simulated by using two sowing dates: 15th November (S1) (as non-stress environment) and 15th December (S2) which is considered stress environment, with terminal heat stress. Spilt- plot design with three replicates was used to lay out the experiment.

The experimental unit was a plot of 5.6 m^2 consisting of 4 ridges 70cm apart. The spacing between holes was 20 cm. Weeding was carried out as required, and the plants were irrigated equally at 10 days interval. Data were collected randomly from ten plants, each experimental unit. Traits evaluated were days to 50% flowering, plant height, number of pods/ plant, number of seeds/pod, number of seeds/plant, 100-seed weight and yield/ha. The computer program (MSTAT) was used for statistical analysis of the data. The data were analyzed according to the standard statistical procedure described for the split-plot design.

RESULTS

Analysis of variance indicated that the effect of sowing date was significant for yield and its component. On the other hand, sowing × genotype interaction showed significant differences in yield/ha only (Table 1).

Number of pods/plant was higher in the optimum sowing than in the late sowing. The mean number of pods/plant in the optimum sowing was 21.6 and 15.5 in the late one; the reduction in number of pods/plant was 26% (Table 2). In the optimum sowing, the

highest number of pods/plant was given by the genotype Bassabier and the lowest number by the genotype Selaim. In the late sowing, the genotype Hudeiba/93 gave the highest number of pods/plant and the genotype Shabah gave the lowest number (Fig.1).

Table 1. Mean squares from the analysis of variance of sowing date, genotype and their interaction for five traits of five faba bean genotypes evaluated at Shambat, Sudan

Character	Sowing date (S) df=1	Genotype (G) df= 4	Sowing × genotype df=4
Number of pods/plant	252.3**	11.76**	6.2
Number of seeds/plant	1217.3*	522.8**	139.0
100-seed weight (g)	1771.0*	520.8**	136.9
Seed yield/plant (g)	1444.9*	37.0*	25.9
Seed yield/ha (kg)	17570.7*	6935.2*	6413.1*

*, ** = Significant at the 5% and 1% probability level, respectively

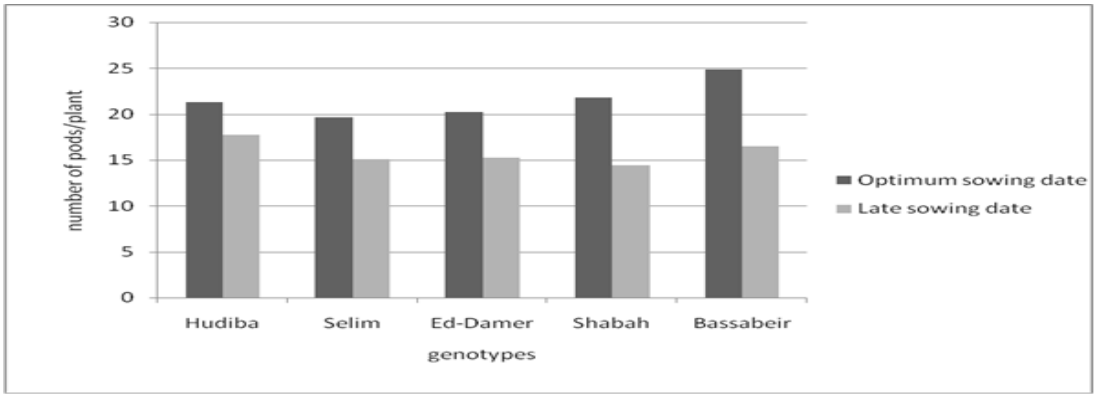

Fig. 1. Number of pods /plant of five faba bean genotypes evaluated under optimum and late sowing at Shambat in 2010/2011 season

Number of seeds/plant was higher in the optimum sowing than in the late sowing. The mean number of seeds/plant was 48.3 for optimum sowing and 35.8 for late sowing (Table 2). The relative reduction due to late sowing was 26%. The highest number of seeds per plant (66.9) was recorded for Bassabier in the optimum sowing and the lowest (34.2) was recorded for Shabah (Fig. 2). In the late sowing the highest number of seeds/plant was given by the genotype Hudeiba/93 and the lowest by Shabah. The genotype Hudeiba/93 gave similar number of seeds/plant under both optimum and late sowings.

100-seed weight (g) was higher in optimum sowing compared to that in late sowing. The mean 100-seed weight was 59.6 g for optimum sowing and 44.2 g for late one (Table 2); the reduction in seed weight was 26%. The highest reduction in seed weight was recorded for the genotype Selaim and the lowest was for the genotype Basabier (Fig. 3).

Table 2. Means of yield and its components of five faba bean genotypes evaluated under stress and non-stress environments (15^{th} Nov. and 15^{th} Dec. sowing) at Shambat, Sudan

Character	**Sowing date**		**Reduction (%)**	**C.V.**	**L.S.D. (0.05)**
	15^{th} Nov.	15^{th}Dec.			
Number of pods/plant	21.5	15.9	26	21.8	2.1
Number of seeds/plant	48.3	35.8	26	29.3	10.3
100-seed weight (g)	59.6	44.2	26	17.2	14.9
Seed yield/plant (g)	27.7	13.9	46	21.6	11.0
Seed yield/ha (kg)	3322.2	1793.5	46	24.2	1059.0

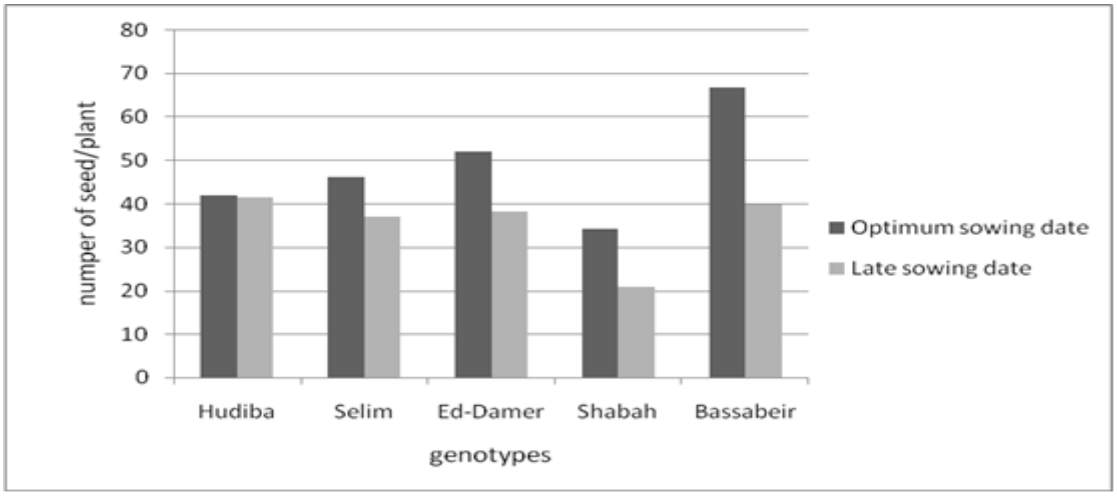

Fig. 2. Number of seeds/plant of five faba bean genotypes evaluated under optimum and late sowing at Shambat in 2010/2011 season

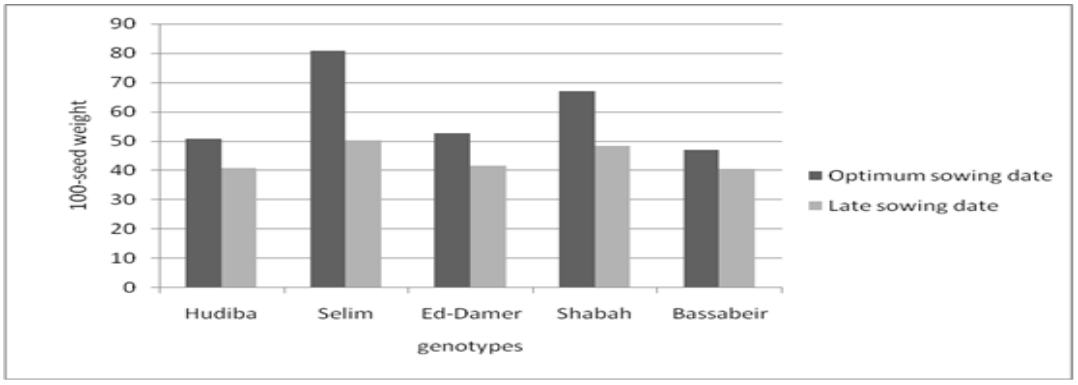

Fig. 3. 100-seed weight of five faba bean genotypes evaluated under optimum and late sowing at Shambat in 2010/2011 season

Seed yield/plant (g) exhibited lower mean in late sowing than in optimum. The mean seed yield/plant was 27.7 g for optimum sowing and 13.9 g for late sowing. The late sowing reduced seed yield per plant to up to 46%. The highest reduction in seed yield/plant was recorded for genotype Shabah (Fig 4).

Seed yield (kg/ha) was higher in optimum sowing date than in late sowing date. The mean yield/ha was 3322.3 kg/ha under optimum sowing and 1793.5 kg/ha. The late sowing reduced the seed yield by 46%. The highest reduction was shown by the genotype Shabah (Fig 5).

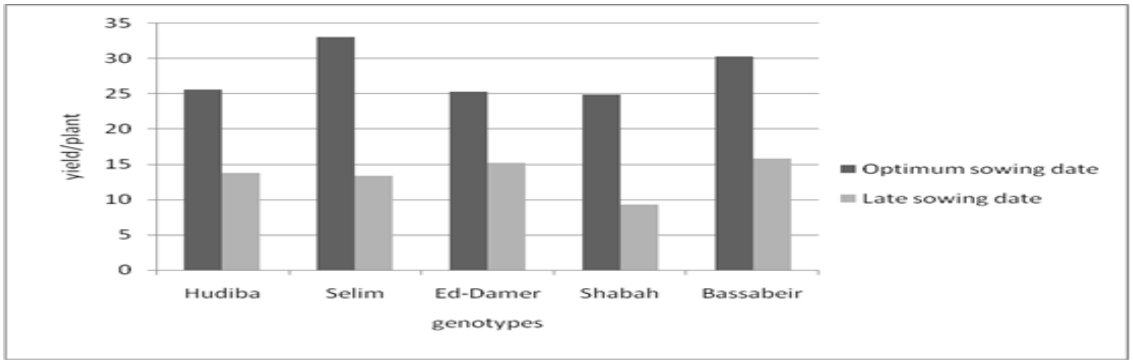

Fig. 4. Yield/plant of five faba bean genotypes evaluated under optimum yield and late sowing at Shambat in 2010/2011 season

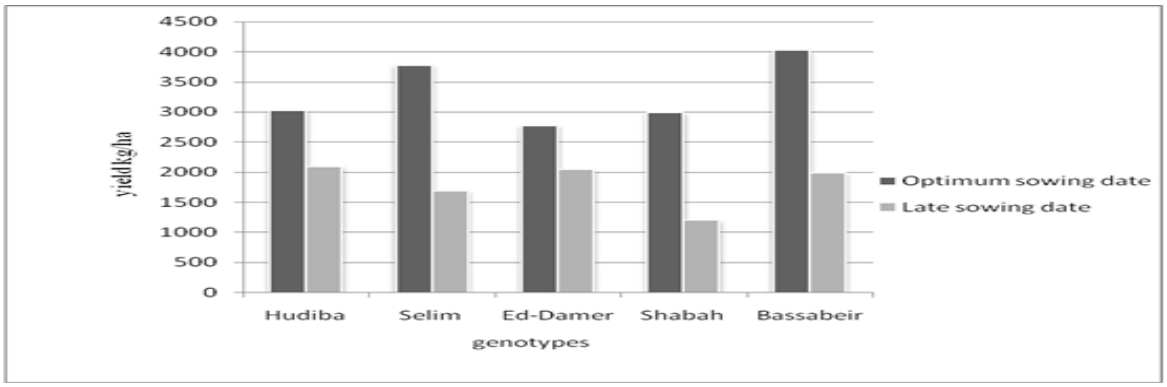

Fig. 5. Yield (kg/ha) of five faba bean genotypes evaluated under optimum and late sowing at Shambat in 2010/2011 season

DISCUSSION

Generally, the low performance in yield and its components among the genotypes as a result of late sowing indicates their sensitivity to high temperature at late season. Similar results were reported by Siddigue *et al.* (1999) and Tilal and Ghalib (2006) who found heavy yield losses in pulse legumes through flower drop and pod abortion. The higher number of pods/plant for genotype Hudeiba/93 in optimum and late sowing dates, compared to other genotypes, indicates the adaptation of this genotype to the extreme environments with respect to this trait. The decrease in number of seeds/plant in the optimum than in late sowing dates is in accordance with that of Baldwin (1980) and Hatam, *et al*. (1999) who reported on the decrease of seeds/plant as a result of the effect of high temperature. Moreover, Bakheit and Mahdy (1988) and Hebblethwaite *et al*. (1991) found the number of seeds/plant to decrease as a result of the delay in sowing date one week after the optimum sowing. The significant differences among the genotypes in

optimum and late sowing dates for 100- seed weight may be due to the fact that these genotypes have seeds of different sizes (Salih and Salih, 1996). The significant reduction in seed yield/ plant and yield/ ha in late sowing than in optimum sowing in each genotype may be due to the less pods/ plant produced in late sowing (Tilal and Ghalib (2006), and as a result low yield/ ha, as reported by Khalil *et al.* (2010). Taha *et al.* (1982) reported that high temperature in late sowing may have hindered the normal flowers and pods setting, increased the rate of powdery mildew infestation and resulted in low yield. On the other hand, the high yield from early sown crop might be due to the fact that early planted crop had a sufficient longer vegetative period and better utilization of water and nutrients (Khalil *et al.,* 2010). Moreover, the reduction in yield in late sown crop may be due to poor growth, shorter grain filling duration and maturity period and less number of pods/ plant (Berhe, 1998; Sahile *et al*., 2008). The low yield of the genotype Shabah compared to the other genotypes indicates its sensitivity to high temperature due to late sowing.

CONCLUSION

Based on the obtained results, it could be concluded that faba bean yields are influenced and are very sensitive to planting dates, irrespective of the genotypes used.

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