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EFFECT OF HEAT STRESS ON THE ELITE GENOTYPES OF FABA BEAN UNDER SEMI-ARID CONDITIONS

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SUMMARY

Faba bean (*Vicia faba* L.) belongs to family Fabaceae. It is cultivated for food, feed and fodder purposes. The field experiment was conducted in RBD by using 21 newly developed genotypes of Faba bean including checks during *rabi* 2017-18 and 2018-19 at Research Farm of MAP Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar to study the impact of heat under semi-arid conditions. In the present study, wide genetic variability was observed seed yield (kg/ha). Out of 21 genotypes, the genotype HB-13-18 (30.27 q/ha) was best performing genotype, which was closely followed HB-13-43 (29.58 q/ha), HB-13-11 (29.08 q/ha), HB-13-2 (29.07 q/ha), HB-13-10 (29.07 q/ha), HB-13-20 (28.75 q/ha), HFB-1 (c) (25.28 q/ha) and Vikrant (c) (23.80 q/ha). Under heat stress condition, genotype HB-13-18 exhibited good potential for commercial cultivation as it showed less reduction in seed yield and low in HSI, but before recommendation for commercial cultivation to be tested over time and space.

Key words : Seed yield, heat stress, HSI, Fababean (*Vicia faba* L.), elite genotypes

Today, entire world is concerned about the impact of climate change on plants. In the last two centuries, climate change has been taking place so fast that certain plant species have found it hard to adapt. The climate change will have dramatic consequences for crops (Arya *et al*., 2014). The effect of climate on agriculture is related to variability's in local weather parameters rather than in global climate patterns. The earth's average surface temperature has increased by 1 degree F in just over the last century. Consequently, researchers consider any assessment has to be individually considering each location. But in order to meet the challenges of temperature ahead of global warming, concerted efforts are need to evaluate, identify and develop genotypes suitable for terminal heat stressed environment (Arya *et al*., 2016).

Faba bean (*Vicia faba* L.) is a partially allogamous crop; however, it belongs to family Fabaceae. The rate of outcrossing depends on the genotype, environmental factors, row space and the number of pollinating insects (Bishnoi *et al*., 2015). In North Africa and parts of West Asia, faba bean is a preferred pulse, but in India, it is categorized as potential legume. It is grown in Bihar, Uttar Pradesh, Himanchal Pradesh, Punjab, Madhya Pradesh, Karnatka, Chhattisgarh, Odisha, Jhadkhand and North Eastern states of India. This crop is widely grown for forage, vegetable, pulse, green manure and as a cover crop. It is a highly productive crop, and it is also higher yielder than conventional pulses (Dewangan *et al*., 2019). It is third most important feed grain legume after soybean and pea. It is also used as human food in developing countries as well as animal feed mainly for pigs, horses, poultry and pigeons. It is rich in L-dopa, a substance used medically in the treatment of Parkinson's disease. L-dopa is also a neurotic agent, which might help in controlling hypertension (Kumar *et al*., 2019).

It is mainly used as animal feed in advanced countries and food for human consumption in developing countries. Its value as a feed and food crop is due to its high lysine rich protein, vitamins, minerals, and carbohydrates (Crepon *et al*., 2010), which make it one of the best solutions to the malnutrition, mainly in developing countries of the world. It is a one of the best known ''break'' crop which enhances wheat crop yield because it decreases the occurrence of take-all and cereal cyst nematode. The crop is one of the most efficient atmospheric nitrogen fixers, contributing to soil nitrogen content improvement thus, it is an important component of crop rotations, which is almost neglected in modern cropping system, at a time when there is an urgent need to minimize the impact of chemical fertilizers on the environment, reduce emissions of undesirable grasses and to economize of the following crops (Arya, 2018). It is good for sustainable agriculture in marginal areas (Arya *et al.*, 2019). It is a winter season crop that grows well under cool and moist conditions, whereas, hot and dry weather is unfavorable and could lead to decrease in the seed yield and quality (Flores *et al.*, 2012). Identification of the superior genotypes for high temperature tolerance is essential for effective manipulation through breeding techniques (Yadav *et al.*, 2013). Therefore, keeping the above points in view, the newly developed elite faba bean genotypes were evaluated for heat stress under semi-arid conditions.

MATERIALS AND METHODS

To conduct the field experiment, 21 newly developed elite genotypes of faba bean (*V. faba* L.) were grown in RBD on 7th November 2017 (Normal sown) during *rabi* 2017-18 and on 28 November 2018 (Late sown) during *rabi* 2018-19 at Research Farm of MAP Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar located 29º10′ N latitude and 75º46′′ E longitude with an elevation of 215.2m above the mean sea level. The plot size was kept 4.0 x 1.2 m2 with spacing 30 x 10 cm2. The soil of experimental site was sandy loam in texture, medium in organic carbon (0.46 %), available nitrogen (141.0 kg/ha), available phosphorus (14.0 kg/ha) and available potassium (240.0 kg/ha). Weekly weather parameters data recorded from research area during 2017-18 and 2018-19 given in Fig. 1 & 2. Each genotype was planted in six rows of four meter length spacing 30cm apart to each other. All the recommended package of practices was carried out to raise a good

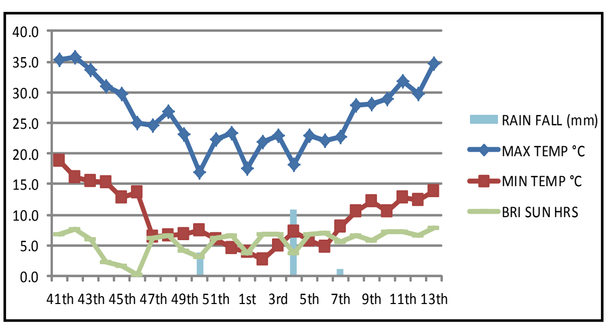

Fig. 1. Weekly weather parameters data recorded at Hisar during crop season, *rabi* 2017-18.

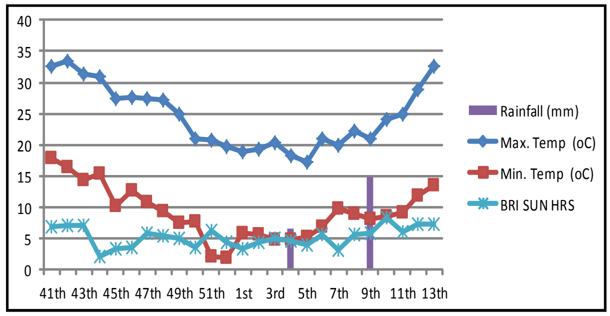

Fig. 2. Weekly weather parameters data recoded at Hisar during crop season, *rabi* 2018-19.

crop. Data were recorded on five randomly selected plants for seed yield (kg/ha). The data were subjected was subjected statistical analysis as per standard procedure.

Heat susceptibility index (HSI) was calculated for grain yield and other quantitative traits over high temperature stress (very late sown) and non-stress environment (normal sown) by using the formula as suggested by Fisher and Maurer (1978). HSI = [l-YD/YP]/D Where, YD = mean of the genotypes in stress environment. YP = mean of the genotypes under non-stress environment. D = 1-[mean YD of all genotypes/mean YP of all genotypes].

RESULTS AND DISCUSSION

High temperature is a major factor affecting seed yield and quality in rabi pulses. Increases in air temperature, even by one degree above a threshold level, is considered heat stress in plants (Teixeira et al., 2013). Heat stress for most of subtropical and tropical crops is detrimental when temperatures increase above 32–35ºC (Bita and Gerats, 2013); however, a daily maximum temperature above 25ºC is considered the upper threshold for heat stress in cool-season crops (Wahid *et al.*, 2007). The impact of heat stress depends on the intensity, duration of exposure, and the degree of the elevated temperature.

Seed yield performance

The analysis of variance revealed the significant differences among the genotypes for the seed/yield (kg/ha), which reflects the presence of genetic variability for the character. In the present investigation, it was revealed from table 1 that during *rabi* 2016-17, the genotype HB-13-11was highest seed yield (38.19 q/ha), followed by HB-13-38(36.22 q/ha), HB-13-48(34.32 q/ha), HB-13-10(35.37q/ha), HB-13-16(33.67 q/ha), HB-13-20 (33.49 q/ha), against

TABLE 1
Performance of genotypes of faba bean during 2017-18 and 2018-19 at Hisar

S. No.	Genotypes	Pedigree	Seed yield (q/ha)			Heat susceptibility index
			2017-18	2018-19	Mean	
1.	HB-13-2	HB 85 X Vikrant	31.61	**26.53**	**29.07**	0.49
2.	HB-13-6	HB 603 X Vikrant	31.71	17.69	24.70	1.35
3.	HB-13-9	EC 243770 X Vikrant	33.43	22.06	27.75	1.04
4.	HB-13-10	HB (M)-1 X Vikrant	**35.37**	22.76	**29.07**	1.09
5.	HB-13-11	HB 73 X Vikrant	**38.19**	19.97	**29.08**	1.45
6.	HB-13-15	IC329424 X Vikrant	32.21	23.68	27.95	0.81
7.	HB-13-16	HB 40 X Vikrant	**33.67**	**24.53**	**29.10**	0.83
8.	HB-13-18	HB 70 X Vikrant	30.40	**30.14**	**30.27**	**0.03**
9.	HB-13-20	HB 617 X Vikrant	33.49	**24.00**	**28.75**	0.86
10.	HB-13-26	EC117792 X Vikrant	28.46	**24.82**	26.64	0.39
11.	HB-13-28	EC248710 X Vikrant	29.48	22.10	25.79	0.76
12.	HB-13-38	EC248710 X HB 180	**36.22**	18.90	27.56	1.46
13.	HB-13-40	EC248710 X HB 182	32.26	15.75	24.01	1.56
14.	HB-13-41	EC248710 X HB 502	29.40	16.13	22.77	1.37
15.	HB-13-43	Vikrant X EC 117799	32.87	**26.29**	**29.58**	0.61
16.	HB-13-45	Vikrant X Mutant -II	26.09	**26.03**	26.06	**0.01**
17.	HB-13-46	EC248710 X Mutant -I	29.18	13.69	21.44	1.62
18.	HB-13-48	Vikrant X HB 204	**34.32**	19.71	27.02	1.30
19.	HB-13-49	Vikrant X EC 329675	32.07	21.19	26.63	1.03
20.	Vikrant	National check	**32.21**	15.38	23.80	1.59
21.	HFB-1	National check	30.75	19.81	25.28	1.08
	Mean		**32.07**	**21.54**	**26.81**	1.00
	Range		26.09-38.19	13.69-30.14	21.44-30.27	0.01-1.59
	CD (5%)		2.32	1.39	-	-
	CV		4.56	3.54	-	-

national checks,Vikrant (32.21 q/ha), HFB-1 (30.75 q/ha). Likewise, during *rabi* 2017-18, the genotype HB-13-18 was highest seed yield (30.14 q/ha), followed by HB-13-43 (26.29 q/ha), HB-13-2 (26.53 q/ha), HB-13-45 (26.03 q/ha), HB-13-26 (24.82 q/ha), HB-13-16 (24.53 q/ha), HB-13-20 (24.00 q/ha), against national checks, Vikrant (c) (15.38 q/ha) and HFB-1 (c) (19.81 q/ha). On an average basis, HB-13-18 (30.27 q/ha) was best performing genotype, which was closely followed HB-13-43 (29.58 q/ha), HB-13-11 (29.08 q/ha), HB-13-2 (29.07 q/ha), HB-13-10 (29.07 q/ha), HB-13-20 (28.75 q/ha), Vikrant (c) (23.80 q/ha), HFB-1 (c) (25.28 q/ha). During 2018-19, the average seed yield was low (21.54q/ha) as compared to 2017-18 (32.07q/ha) due to heat stress experienced at later stages of plant growth after flowering and before maturity. At these stages, high temperature drastically affected flower initiation, pollen viability, stigma receptivity, ovule viability, fertilization, seed set, grain filling, and seed quality. This ultimately leads to heavy flower dropping and low seed setting. Above findings were supported by Barnabás *et al*., 2008. The seed yield of crop genotypes is the combined reflection of contributing traits, which depends on plant phenology along with environmental conditions (Bishnoi *et al*., 2015; Arya, 2018). Generally, the high temperature higher than the optimum shortened the growing period of crops, resulting in a shorter time of biomass accumulation, which ultimately responsible for low grain yield as well as low fodder yield (Arya *et al*., 2010; Yadav *et al*., 2016).

Cool-season food legumes are more sensitive to heat stress than warm-season food legumes. The threshold temperatures of faba bean is 25ºC reported by Bishop *et al*., 2016. In present investigation, during 2018-19, faba bean crop was planted late in November thus it faced high temperature at the maturity thus reduction in seed yield was noticed when compared with early sown crop of 2017-18. According to Yadav *et al*. (2016), change in temperature regime from the optimum range during plant growth adversely affected the duration of phenophases and finally the yield of the crop due to changes in physiological processes.

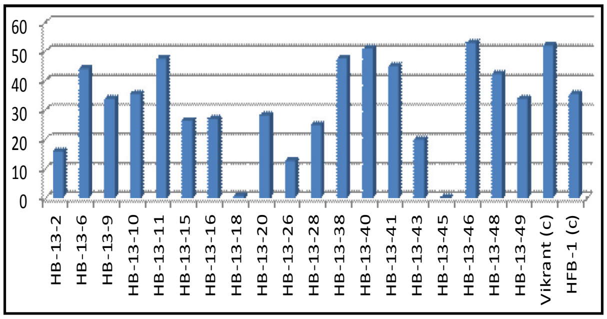

Fig. 3. Percent reduction in seed yield in faba bean genotypes due to heat stress at Hisar.

Percent reduction in seed yield under stress

Heat stress imposes challenges for legume crops and has deleterious effects on the morphology, physiology, and reproductive growth of plants. High-temperature stress at the time of the reproductive stage is becoming a severe limitation for production of grain legumes as their cultivation expands to warmer environments and temperature variability increases due to climate change (Sita *et al*., 2017). But, behavior of different genotypes under the heat stress was not uniform; some genotypes adversely affected while some genotype able to combat with stress. In present investigation some genotypes exhibited the minimum percent reduction in seed yield which were HB-13-45 (0.23%), HB-13-18 (0.85%), HB-13-26 (12.79%), HB-13-2 (16.07%), HB-13-43 (20.02%), HB-13-28 (25.03%), HB-13-15 (26.48%), HB-13-16 (27.15%) as compared to national check, Vikrant (52.25%) and HFB-1(35.58%).

Heat susceptibility index

Heat susceptibility index (HSI) is also an important tool to identify the heat tolerant genotypes (Suresh *et al*., 2018). In the present investigation, minimum HSI was recorded in HB-13-45 (0.01) and closely followed by HB-13-18 (0.03), HB-13-2 (0.49), HB-13-43 (0.61), against national check, Vikrant (1.59) HFB-1 (1.08), therefore, the genotype HB-13-45 and HB-13-18 considered heat tolerant genotypes and may be utilized crop improvement programme for the development of heat stress tolerant cultivars. Research on high temperature tolerance or susceptibility and its association with seed yield and other related traits would help in the development of heat tolerant genotypes (Yadav *et al*., 2013 & 2014).

High temperature stress at later stages, may adversely affect photosynthesis, respiration, water relations and membrane stability, and also modulate levels of hormones and primary and secondary metabolites. Furthermore, throughout plant ontogeny, enhanced expression of a variety of heat shock proteins, other stress-related proteins, and production of reactive oxygen species (ROS) constitute major plant responses to heat stress (Wahid *et al*., 2007). In order to cope with heat stress, plants implement various mechanisms, including maintenance of membrane stability, scavenging of ROS, production of antioxidants, accumulation and adjustment of compatible solutes, induction of mitogen-activated protein kinase (MAPK) and Ca-dependent protein kinase (CDPK) cascades, and, most prominently, chaperone signaling and transcriptional activation (Yadav *et al*., 2016). All these mechanisms, which are regulated at the molecular level, may enable HB-13-18 and HB-13-45 genotypes to thrive under heat stress.

It is concluded that HB-13-18 was found superior on basis of average of both the years as well as in the stress condition. It also exhibited minimum HSI and very low reduction in seed under stress; therefore, it may be recommended for commercial cultivation after testing over time and space.

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