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PERFORMANCE AND VARIATION OF SOME FABA BEAN GENOTYPES TO BROOMRAPE INFESTATION AND ENVIRONMENTAL CONDITIONS

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ABSTRACT

Ten field experiments were carried out in Giza-Egypt during 2018/2019 and 2019/2020 seasons to elucidate the performance and extent of variation of some faba bean varieties to broomrape infestation under wide range of environmental conditions as sowing dates. During each season, five trials as sowing dates of 2018/2019 started on October 28th, 2018, in two weeks interval, but those of second season (2019/2020) begun with October 17th, 2019. In each trial, ten faba bean genotypes having different degrees of reaction to *Orobanche* infestation were used.

The sowing date (SD) in both seasons affected significantly all the studied traits except podded hosts % and *Orobanche* tolerance index (TI) in 2nd season. Host genotypes (G) in 1st season, varied highly significantly for all traits except harvest index (HI), whereas in 2nd season, only the numbers of days to seedling emergence (DE) was affected significantly. The studied faba bean genotypes performed differently over and across the dominated climatic conditions of first season, whereas in the 2nd season for days to emergence (DE) was only significance.

The accumulated growing degree days (GDD) at *Orobanche* appearance was higher in all sowing dates of faba bean in the second season than those in the first season gradually decreased due to late sowings. The onset of faba bean plant flowering and podding occurred earlier by increasing GDD after completing seedling emergence, but seedling emergence seems to be affected by soil temperature and moisture rather than air temperatures. The rates of change of phonological stages due to increasing GDD are in harmony to the correlation coefficients with variable magnitudes which indicates that required thermal units for faba phonological developments seemed to be variable.

Faba seed yield fluctuated seemed to be more sensitive than dry matter production to environmental conditions and broomrape infestation. The interrelationships between the broomrape infestations either number or dry weight with other host traits varied in signs and significance from season to another and also due to sowing dates.

Environmental conditions that resulted in late seedling emergence or higher percentages of harvest index and higher broomrape tolerance index will be reflected in higher magnitudes of variations among varieties. Conditions that beared of higher magnitudes of variation in faba flowering, faba dry wt, *Orobanche* dry wt and podded host% will be impacted in early flowering dates, lower production of dry matter, lower broomrape infestation level and reduce pod bearing hosts%, respectively. However, the conditions of enhanced late onset of podding and broomrape appearance as well as higher seed yield of hosts will be expected to broaden variations among genotypes.

The magnitudes of genetic variation under first season are much higher under first season than those recorded in the second one for all studied traits except HI. Also the genetic variation was lacking in the 2019/2020 season for DOA, FDwtR and TISY. The heritability varied greatly in magnitude among seasons and traits, but in general the higher estimates may be considered medium percentages. These results specify that there is significant genetic variation present in these traits to guarantee selection for better performance. These traits can therefore be given special consideration for selections aimed at faba bean improvement.

***Keywords*:** Faba bean (*Vicia faba* L.), *Orobanche crenata*, GDD, Environmental conditions, Selection.

Introduction

Faba bean (*Vicia faba* L.) is an important food legume in Egypt and other Mediterranean basin. Nonetheless, there is a decrement in overall production of faba bean in several countries (Perez-de-Luque *et al*., 2010)

In Egypt, the acreage's and seed yields differ from season and location to another. Therefore, one of the drawbacks affecting this crop is its yield instability (Darwish and Abdalla, 1997). This is attributed to various biotic and abiotic limitations particularly *Orobanche* parasitism.

Broomrape (*Orobanche crenata)* is an annual obligatory parasitic plant on faba bean and other leguminous plants affecting negatively their hosts which vary according to host genotype, level of parasitism, sowing date, soil moisture and many other factors as reviewed by Abdalla and Darwish (2002). The broomrape plant produces several thousands of tinny seeds that may live dormant in the soil for about several years until germinate under the secreted stimulants by proper host plants. Therefore, the control of broomrape will help to improve the production and stability of faba bean yield. Unfortunately the majority of known control methods do not offer satisfactory results to control this parasitic weed and in some cases the problem tends to be catastrophic. Breeding resistant /tolerant genotypes may provide a reliable measure of production against *Orobanche* (Radwan *et al.*,1988a and b, Abdalla and Darwish, 1994,

1999 and 2008, Khalil *et al.*, 1994 and Saber *et al.,*1999). However, Rubiales (2020) considered broomrape as a great threat to global agriculture, not only to wide spread and infesting new fields but also its capability to infect new genotypes and crops which complicated the breeding outcomes and efforts (Rubiales, 2018).

Climate change stemmed currently in multiplying broomrape damages on many likely and strategic crops with an ever-increasing infestation level of many fields disheartening farmers to grow any more susceptible crops especially legumes.

However, the performance of selected material fluctuated among environments. The host genotype, environmental conditions and interaction were highly significant sources of variation in faba beans behaviour across broomrape fields (Darwish, 1992 and 1996, AbouTaleb and Darwish, 2003 and Abdalla *et al.,* 2006).

The unsatisfactory results of utilizing tolerant/resistant faba bean varieties may be attributed to huge factors of host/parasite system. These may include variable mechanisms by the host genotypes, the quantitative genetic backgrounds that controlling host reactions, variation of parasitic capabilities and environmental conditions on the host and the parasite. Such factors complicated the outcomes of faba bean-crenata system.

Thus the present investigation planned to elucidate the performance and extent of variation in reaction of recent faba bean varieties to broomrape infestation under wide range of environmental conditions as sowing dates.

Materials and Methods

Ten field experiments were carried out in the Experimental and Research Station of the Faculty of Agriculture, Cairo University; Giza during 2018/2019 and 2019/2020 seasons. In each trial, ten faba bean genotypes having different degrees of reaction to *Orobanche* infestation were used. Five (Cairo4, Cairo5, Cairo25, Cairo30 and Cairo49), four (Misr3, Giza429, Giza 843 and Nubaria 3) and one (Mariot2) of these varieties were provided by the Agronomy Department (Faculty of Agriculture., Cairo University), Food legumes Section (Field Crops Research Institute, ARC), and Desert Research Center (Ministry of Agriculture and Land Reclamation), respectively. All of these varieties were considered as broomrape resistant/ tolerant except Nubaria 3 and Mariot 2.

Experimental procedures

The five sowing dates of 2018/2019 started on October 28th, 2018, in two weeks interval, but those of second season (2019/2020) begun with October 17th , 2019 (Table 2).

Each trial in each sowing date was conducted by using the Randomized Complete Block Design (RCBD) with three replicates. The experimental plot consists of three ridges, one of which was treated by Roundup herbicide (48%) with dose 167 ml/ha twice starting of 25%flowering as recommended dose for controlling broomrape to generate free parasite plants. Each ridge was 4m long and 65 cm apart and sown with 2-seed hills distanced 20 cm by using dry planting.

Data collection and statistical analysis

Days to emergence (DE), Days to onset of flowering (OF), days to onset of podding (OP), days to onset *Orobanche* appearance (DOA) were recorded.

At harvest the number of podded faba Bean plants as well as their percentages (Podded%), air bundle dry weights faba bean plants per ridge (FDwtR), g , seed yield per ridge (SYR), g and air bundle dry weight per ridge, g (2.6 m^2) were determined. The percentages of seed yield to dry weight were calculated as harvest index. The seed yield of herbicide free and applied plots of the same genotype were used for estimating the tolerance to *Orobanche* of the given genotype (TI_i) following Darwish *et al.* (2016) as follows:

$$TI_i = \frac{(Y_iHA)(Y_iHF)}{(YHA^-)2}$$

where:

Y_{iHA} = the yield of genotype i of herbicide applied plot (considered as broomrape free plot).

Yi_{HF} = the yield of genotype I of herbicide free plot (considered as *Orobanche* infested plot).

Y_{HA}^- = mean yield of all genotypes under herbicide applied plots in the given replicate and sowing date.

The genotype of larger value of TI may be possesses higher tolerance coupled with yield potential (under normal environment).

Data were analyzed using MSTATC (version 1.41) software and significant means were separated using LSD at 5% level of probability. Due to the normality tests, the raw data were transformed prior statistical analysis as podded % (arcsine), faba dry and seed weight (sqrt), *Orobanche* number and dry wt (log (x+1) as well as HI and TI (Log (x+10)) but actual means will be tabulated (Darwish, 1991).

The genotypic and phenotypic parameters were estimated using the partitions of expected mean square of RCBD of combined analysis across sowing dates of the same season after testing the homogeneity of error terms. The form of expected mean squares of evaluation faba bean genotypes (G) combined across the five sowing dates (SD) in each season will be presented as follows:

S.V	df	MS	EMS
SD	sd-1		
Reps.(SD)	sd(r-1)		
G	l-1	MS_g	$\delta^2_e + r\delta^2_{g.sd} + r.sd\ \delta^2_g$
G xSD	(sd-1)(l-1)	$MS_{g..sd}$	$\delta^2 e + r\ \delta^2_{g.sd}$
Error	(r-1)(l-1)	MS_e	$\delta^2\ e$

Where:

$\delta^2 e = MS_e/r.sd$ = Error mean square.

$\delta^2 g = (MS_g - MS_{g.sd})/r.sd$ =Genotypic mean square.

$\delta^2 g.sd = (MS_{g.sd} - MS_e)/r$ = Genotype x sowing date interaction variance.

$\delta^2 ph = \delta^2 e + \delta^2 g.sd + \delta^2 g$= Phenotypic mean square.

Broad sense heritability (h^2), genotypic and phenotypic coefficients of variations and expected gain of advance (GA) of selecting the best 10% of lines was calculated as follows:

$$PVC\% = \left(\sqrt{\delta^2 ph / X^-}\right) \times 100$$

$$GCV\% = \left(\sqrt{\delta^2 g / X^-}\right) \times 100$$

$$h^2\% = \frac{\delta^2 g}{\delta^2 ph} \times 100$$

$$GA = K \times h^2 \times \sqrt{\delta^2 g}\ ,$$

where:

PCV%= phenotypic coefficient of variations.

GCV%= genotypic coefficient of variations.

K is the constant of Z distribution due to the selection intensity (10%) and =1.755.

h^2%= broad sense heritability.

GA= expected gain of advance.

The relative of GA (RGA) was calculated to corresponding mean performance for expressing the remaining variability among the tested faba bean genotypes.

Results and Discussion

Significance of mean squares

The summary of significance presented in Table (1) indicated that sowing date (SD) in both seasons affected significantly (highly) all studied traits except podded hosts % and *Orobanche* tolerance index (TI) in 2nd season. Host genotypes (G) in 1st season, varied highly significantly for all traits except harvest index (HI), whereas in 2nd season, only the numbers of days to seedling emergence (DE) was affected significantly. For GxSD interaction as a source of variation varied in the first season significantly for all studied traits except days of *Orobanche* appearance (DOA), Faba bundle dry wt (FDwtR), *Orobanche* bundle dry wt (ODW) and tolerance index (TI) in the 1st season. However, in the 2019/2020 season only this interaction was significance for DE. That is means that the studied faba bean genotypes performed differently over and across the dominated climatic conditions of first season, whereas in the 2nd season only days to emergence (DE) recorded this significance.

Table 1 : Significance of mean squares due to combined analyses across sowing dates of 2018/2019 and 2019/2020 seasons for studied traits under broomrape naturally infested conditions of Giza location.

Trait	2018/2019 Season			2019/2020 Season		
	SD	G	G x SD	SD	G	G x SD
DE	**	**	**	**	*	*
OF	**	**	**	**	ns	Ns
OP	**	**	*	**	ns	Ns
DOA	**	**	ns	**	ns	Ns
FDwtR	**	**	ns	**	ns	Ns
SYR	**	**	**	*	ns	Ns
ODW	**	**	ns	**	ns	Ns
Podded%	*	**	**	ns	ns	Ns
HI	*	ns	*	**	ns	Ns
TI	*	**	ns	ns	ns	Ns

ns, * and ** indicate insignificance, significance at 5% level and at 1% level of probability.

Climate characterization of sowing dates

The dominated averages, differences ofair-temperatures (°C) during 2018/2019 and 2019/2020 seasons at 15 days intervals (I.) from mid-October to the end of January will be presented in Figs.1 and 2.

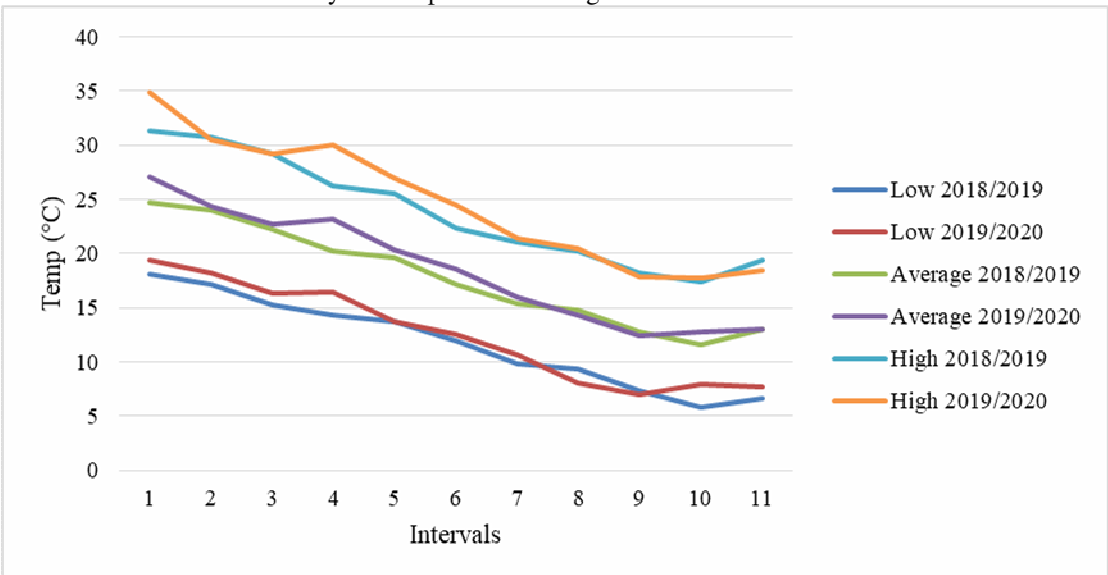

Fig. 1: Low, average and high of air temperatures from mid-October (1) to end-January (11) of 2018/2019 and 2019/2020 seasons at experimental fields of Giza location. (Source: NASA POWER VIEWER).

Table 2 : Mean performance and accumulated growing degree days (GDD) of faba bean phonological stages and number of days to broomrape appearance (DOA) across the five sowing dates of 2018/2019 and 2019/2020 seasons.

Sowing Dates	DE		OF		OP		DOA	
	Mean	GDD	Mean	GDD	Mean	GDD	Mean	GDD
Oct, 28th 018	10.1	214.6	36.3	680.0	62.1	1025.2	90.2	1233.9
Oct, 17th 019	7.0	167.7	27.5	616.7	51.5	1045.6	111.3	1743.0
Nov, 11th 018	8.0	142.6	39.3	627.4	64.6	861.8	104.4	1142.4
Oct, 31th 019	9.0	192.7	30.9	621.0	53.2	939.1	98.6	1458.7
Nov, 22th 018	9.1	159.5	41.1	580.6	65.4	754.0	99.1	1032.3
Nov, 14th 019	7.4	138.5	35.2	578.8	58.8	847.7	91.6	1232.0
Dec, 3rd 018	10.7	146.9	47.1	503.8	63.6	638.2	93.7	903.3
Nov, 28th 019	8.3	133.7	41.4	545.4	63.7	802.6	88.6	1107.0
Dec, 13th 018	11.9	162.5	47.5	453.0	65.1	600.3	103.0	921.4
Dec, 12th 019	11.0	144.8	46.0	530.2	64.6	757.7	87.4	1062.8

The estimates of accumulated growing degree days(GDD) at DOA were higher in all faba bean sowing dates of second season than those of first season (Table 2). These higher percentages of heat unites of second season equal 1743.0, 1458.7, 1232.0, 1107.0 and 1062.8 from earlier to late sowing dates of 2019/2020 season comparing to 1233.9, 1142.4, 1032.3, 903.3 and 921.4 of first season respectively. It is worth to observe that the GDD were gradually decreased due to late sowing of faba bean.

Table 3 : The correlation and regression coefficients among mean of studied traits and differences and accumulated GDD of sowing dates during both seasons.

Comparison	DE		OF		OP		DOA	
	b	r	b	r	b	r	b	r
Means vs Diff GDD	---	**---**	-0.084	**-0.700***	-0.044	**-0.795****	0.033	**0.611ns**
Means *vs.* acc GDD	0.011	**0.181ns**	-0.077	**-0.760***	-0.024	**-0.692***	0.014	**0.466ns**
Mean *vs.*%GDD	0.517	**0.854****	0.707	**0.547ns**	-0.563	**-0.450ns**	0.675	**0.555ns**
Means *vs.*Day-100 GDD	-0.004	**-0.678***	-0.025	**-0.950****	-0.018	**-0.923****	---	---

Ns, *and ** indicate insignificant, significant at 5% and at 1%, respectively.

The difference or accumulated GDD at each of days to onset flowering (OF) and to onset podding (OP) were correlated negatively significant with corresponding means of OF (r=-0.700*&-0.760*) and OP (r=-0.795**&-0.692*), respectively. This means that the onset of faba bean plant flowering and podding occurred earlier by increasing GDD after completing seedling emergence. However, seedling emergence seems to be affected by soil factors (temperature and moisture) rather than air temperature as translated as GDD. The higher thermal units accumulated at day 100 were negatively correlated with DE, OF and OP. The number of days to broomrape appearance (DOA) is positively correlated with GDD in spite of lacking significance. The rates of change as regression coefficients of phonological developments due to increasing GDD were in harmony with detected correlation coefficients with magnitudes that prove variable thermal requirements for faba bean phonological development. Confalone *et al.* (2011) and Mekkei and El-Haggan (2018) concluded the importance of thermal units in the growth and development of faba bean plants.

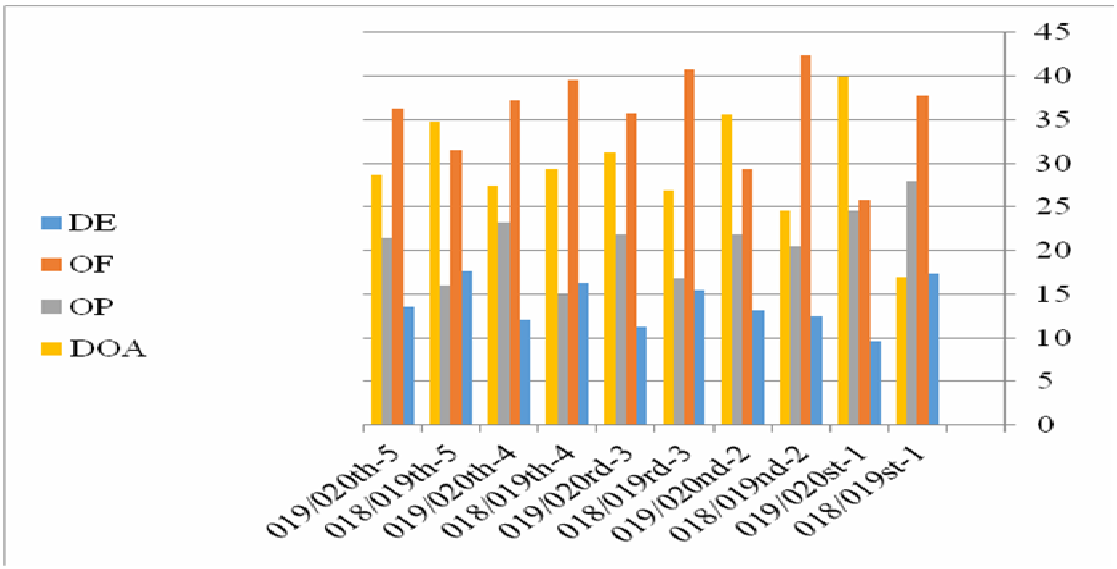

Fig. 2 : Relative GDD recorded during the phonological stages of faba bean to 100 days heat units of five sowing dates of 2018/2019 and 2019/2020 seasons.

Mean performance and variation among sowing dates

Across sowing dates in both seasons, the number of days till emergence (DE) was higher in 1st season with the highest CV% (13.5) as compared to 2nd season whose CV% at its peak is 7.5 % (Table 4). For days to onset flowering (OF), the duration of flowering among faba bean genotypes is statistically the same in 4th and 5th SD in 1st season whereas in 2nd season across all SDs, there was a significant difference in days to faba bean flowering.

Regarding OP, days to Onset of podding was statistically insignificant in 2nd, 3rd and 5th SD in 1st season. Whereas, in 2nd season onset of podding was the same in 4th and 5th SDs. Lastly, for the DOA, FDwtR, FSYR, DWOR, Podded %, H.I, TISY varied significantly across all sowing date (SD) in both seasons.

Generally, it may be observed that early faba bean sowing during October and early of November resulted in early emergence of faba bean seedling (DE), flowering (OF), onset podding (OP) and appearance of broomrape (DOA) particularly under 2nd & 3rd sowing of second season compared to the early sowing in first half of Oct or second half of December. However, dry weight of faba bean plants per ridge (FDwtR) were significantly higher under second sowing dates of both season than other dates either earlier or later sowing dates. The seed yield per ridge (SYR) fluctuates greatly among sowing dates and seasons, which proved to be sensitive to environmental conditions and broomrape infestation than dry weight production.

The interrelationships between the broomrape infestations either number or dry weight with other host traits varied in signs and significance from season to another and also due to sowing dates. The estimates and significance of correlation coefficients among *Orobanche* numbers (NOR) and dry wt (DOR) and the studied host traits could be presented as follows:

***Orobanche*- traits**	**FDwtR**		**SYR**		**Podded%**	
	2018/2019	**2019/2020**	**2018/2019**	**2019/2020**	**2018/2019**	**2019/2020**
NOR	0.233ns	-0.617**	0.041ns	-0.316*	-0.689**	-0.892**
DOR	0.346*	-0.500**	0.084ns	-0.382*	-0.578**	-0.822**
***Orobanche*- traits**	**HI**		**TIDw**		**TI SY**	
	2018/2019	**2019/2020**	**2018/2019**	**2019/2020**	**2018/2019**	**2019/2020**
NOR	-0.18ns	0.056ns	0.252*	1.000**	0.079ns	1.000**
DOR	-0.212ns	-0.051ns	0.457**	-0.268*	0.150ns	0.108ns

Ns, * and ** indicate insignificant, significant r coefficient at 5% and 1% levels.

Faba bean dry weight (FDwtR) and seed yield per ridge (SYR) affected differently from season to another as indicated by the significance of correlation coefficients. Under the dominated climatic conditions of second season, both yields affected significantly negatively, whereas under 2018/2019 season NOR and DOR correlated positively in spite of lacking significance in some cases. However, the percentages of podded faba host interrelated negatively highly significant under the conditions of both seasons. The ratio of seed yield to dry matter as HI seemed to be independent of the effects of broomrape infestation. Tolerance indexes of faba bean dry wt affected positively significantly by NOR and DOR under both seasons except DOR in second season which recorded negative correlation. However, tolerance index of seed yield showed only strong positive correlation with NOR.

Correlation and regression coefficients between the mean performance of faba bean varieties within all sowing dates in both seasons and corresponding coefficients of variations% are presented in Table (5). Irrespective of the level of significance between the performance of studied traits and corresponding variation (measured by V%) among studied genotypes, all traits recorded positive correlation between both criteria except OF, DwOR and podded%. This means that the levels of most of studied traits by any way were in harmony with the extent of variation among the investigated genotypes, but the direction of dependence differed among traits as shown by the regression coefficients. DE, HI and TISY showed higher dependence of variation on means than this of mean on CV% (0.959 *vs*. 0.106, 1.012 *vs.* 0.577, and 0.307 *vs.* 0.001, respectively). Thus environmental conditions that resulted in late seedling emergence or higher percentages of seed yield to dry matter production and higher broomrape tolerance corresponded with higher magnitudes of variations. On the other hands, beared of higher magnitudes of variation in faba flowering, faba dry wt, *Orobanche* dry wt and podded host% will be resulted in early flowering dates, lower production of dry matter, lower broomrape infestation level and reduce pod bearing host, respectively. However, the conditions of enhanced late onset of podding and broomrape appearance as well as higher seed yield of hosts will be expected to broaden variations among genotypes.

Table 4 : Mean performance and the coefficients of variation of faba bean genotypes in each sowing date at both seasons for studied traits.

Trait	**Season**	**SD1**		**SD2**		**SD3**		**SD4**		**SD5**	
		Mean	CV%	**Mean**	**CV%**	**Mean**	**CV%**	**Mean**	CV%	**Mean**	CV%
DE	1st	10.1c	5.6	8.0e	0.0	9.1d	13.5	10.7b	7.7	11.9a	11.1
	2nd	7.0e	0.0	9.0b	0.0	7.4d	7.5	8.3c	8.0	11.0a	1.0
OF	1st	36.3d	6.4	39.3c	1.2	41.1b	3.4	47.1a	0.3	47.5a	2.0
	2nd	27.5e	1.9	30.9d	2.9	35.2c	0.5	41.4b	1.0	46.0a	0.2
OP	1st	62.1c	0.7	64.6a	1.2	65.4a	4.2	63.6b	1.1	65.1a	1.6
	2nd	51.5d	2.3	53.2c	0.4	58.8b	1.8	63.7a	2.8	64.6a	1.7

DOA	1st	90.2c	10.8	104.4a	7.8	99.1b	5.9	93.7c	4.6	103.0ab	10.1
	2nd	111.3a	8.0	98.6b	7.7	91.6c	0.6	88.6c	1.5	87.4c	6.3
FDwtR	1st	1838.5b	17.0	2274.0a	24.7	1053.4c	21.8	1096.7c	17.5	657.7d	19.8
	2nd	2098.7b	8.7	2437.8a	9.8	1355.1c	19.0	1165.6d	16.3	1357.7c	5.2
FSYR	1st	206.6c	30.1	416.1a	24.4	202.9c	28.7	287.6b	21.5	150.5d	22.7
	2nd	211.3a	17.6	70.2c	13.3	102.1b	7.7	77.3c	15.8	206.0a	10.2
DWOR	1st	247.3a	30.8	273.0a	44.2	189.4b	23.8	169.9b	24.9	112.6c	26.5
	2nd	135.1d	38.0	200.9c	21.4	466.7a	11.7	257.5b	8.5	215.3c	10.4
Podded%	1st	71.7d	25.6	89.7c	5.7	91.4bc	13.7	95.5ab	6.4	99.8a	0.5
	2nd	100.0a	0.0	95.8a	2.7	53.8c	33.1	74.7b	12.9	97.4a	2.2
H.I	1st	11.4c	21.3	20.6b	27.4	19.6b	24.7	29.0a	45.0	23.6ab	40.0
	2nd	9.6b	15.2	2.7d	17.1	8.1c	17.7	6.9c	23.9	15.4a	9.2
TISY	1st	0.852c	52.0	2.579a	31.6	1.130c	59.6	1.929b	44.8	0.776c	27.8
	2nd	1.088a	35.6	0.975a	24.4	1.155a	21.3	0.954a	35.8	1.107a	26.4

Means of sowing dates in the same season followed by the same letter/s are not statistically different at 5% level of probability.

Table 5 : Correlation and regression coefficients between the mean performance of faba bean varieties within all sowing dates in both seasons and corresponding coefficients of variations %.

Coefficient	**Dependency**	**DE**	**OF**	**OP**	**DOA**	**FDwR**
r		0.318	-0.332	0.264	0.450	-0.260
b	**X=mean, Y=CV%**	0.959	-0.093	0.058	0.192	-0.003
b	**X=CV%, Y=mean**	0.106	-1.190	1.205	1.054	-24.919
Coefficient	**Dependency**	**SYR**	**DWOR**	**Podded%**	**H.I**	**TISY**
r		0.491	-0.358	-0.947**	0.764**	0.014
b	X=mean, Y=CV%	0.036	-0.043	-0.695	1.012	0.307
b	X=CV%, Y=mean	6.770	-3.018	-1.291	0.577	0.001

** indicates significant correlation coefficients at 5% level of probability.

Genetic parameters and expected gains from selection

Heritability estimates give a foresight into the extent of genetic variation to phenotypic variations and the influence of environmental fluctuations on performance and expected gains from selections. The magnitudes of genetic variation under first season are much higher under first season than those recorded in the second one for all studied traits except HI (Table 6). Also the genetic variation was lacking in the 2019/2020 season for DOA, FDwtR and TISY. The calculated heritability varied greatly in magnitude among seasons and traits, but in general the higher estimates may be considered medium percentages. These results specify that there is significant genetic variation present in these traits to guarantee selection for better performance. These traits can therefore be given special consideration for selections aimed at faba bean improvement.

The genotypic coefficient of variation (GCV) provides a measure of genetic variability that exists among the studied genotypes. High GCV reveals the presence of exploitable genetic variability for the traits, which can enhance selection. The obtained GCV was higher in all studied traits with the exception of DOA, FDwtR, H.I, and TISY in 2nd season.

Across both seasons, the phenotypic coefficient of variation (PCV) obtained for all traits was higher in 1st season and lower in 2nd season with TISY having the highest PCV (30.4) and OF bearing the lowest PCV (0.9). High PCV reveals the occurrence of a greater scope of selection for the trait being considered, which depends on the amount of variability present. Thus a greater potential is expected in selecting for traits particularly TISY, H.I, FSYR, FDwtR, Podded % in 1st season among the faba bean genotypes. However, there is a narrow scope of selection for OF, DE and OP in 2nd season due to low variability.

Table 6 : Genetic variance (δ^2g), heritability (h^2), genotypic (GCV%) and phenotypic (PCV%) coefficients variation, expected genetic advance (GA) and relative advance(RGA) of selecting the best 10% of faba bean genotypes in each season for studied traits.

Trait	**Season**	**δ^2g**	**h^2**	**GCV%**	**PCV%**	**GA**	**RGA**
DE	1st	0.11	0.172	3.310	7.991	0.099	0.997
	2nd	0.01	0.144	1.259	3.316	0.027	0.318
OF	1st	0.29	0.238	1.283	2.628	0.227	0.537
	2nd	0.04	0.407	0.546	0.860	0.141	0.389
OP	1st	0.66	0.505	1.269	1.786	0.721	1.124
	2nd	0.14	0.252	0.636	1.267	0.164	0.282
DOA	1st	20.98	0.542	4.671	6.344	4.358	4.444
	2nd	0.00	0.000	0.000	2.993	0.000	0.000
FDwtR	1st	20057.99	0.392	10.233	16.336	97.524	7.046
	2nd	0.00	0.000	0.000	5.642	0.000	0.000
FSYR	1st	1236.01	0.386	13.909	22.396	23.800	9.416
	2nd	28.34	0.204	3.991	8.831	1.908	1.430

DWOR	1st	1090.28	0.379	16.640	27.020	21.978	11.076
	2nd	115.42	0.232	4.211	8.749	4.368	1.712
Podded%	1st	32.87	0.403	6.396	10.077	4.053	4.522
	2nd	4.30	0.152	2.459	6.303	0.554	0.657
H.I	1st	0.00	0.000	0.000	27.784	0.000	0.000
	2nd	0.28	0.439	6.228	9.402	0.410	4.795
TISY	1st	0.09	0.456	20.560	30.439	0.239	16.461
	2nd	0.00	0.000	0.000	14.048	0.000	0.000

Conclusions

The results indicated that, faba bean genotypes varied differently from one season to another due to the dominated climatic conditions. Also, heat accumulation (GDD) was highest in earliest sowing date and decreases in late sowing of faba bean. Generally, faba bean seed yield were varied greatly due to fluctuations in the environmental conditions and broomrape infestations. Also, the relationship between broomrape (*Orobanche crenata*) traits varied significantly with the studied traits across both seasons.

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