EFFECT OF SOWING DATE ON CHOCOLATE SPOT AND RUST FOLIAR DISEASES REACTION, YIELD COMPONENTS AND SEED QUALITY IN FABA BEAN (*VICIA FABA*)

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ABSTRACT: **In order to study the effect of early sowing date on plant characteristics, chocolate spot and rust foliar diseases reaction, and yield characters of twelve faba bean genotypes, an experiment was conducted at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 2018/2019 and 2019/2020 growing seasons. The early sowing date (1st October) caused high infection of foliar diseases infection (chocolate spot and rust), reduced flowering date, No. branches, No. pods, No. seeds plant^{-1}, 100 seed weight and seed yield compared with optimum sowing date (1st November). Electrical conductivity, crude protein % and total carbohydrate % were significantly increased under early sowing date compared to optimum one. Line 6 and Line 7 had the highest seed yield and stable performance across different sowing dates and showed high values for No. seeds per plant, and/or 100 seed weight. The cluster analysis classified the tested genotypes to two main different groups, the first group contained Line 3 and Line 4, which differed in origin and performance and had the heaviest 100-seed weight, but had low No. seeds plant^{-1}. The rest genotypes were found in the second main branch. Line 6 had the highest seed yield under early sowing date and recorded low percentage of decline in yield as a result of early sowing, so it is suitable to sown in the case of early sowing date.**

Key words: **Faba Bean, Sowing date, Chocolate Spot, Rust, Yield, Yield Components and Seed Quality.**

INTRODUCTION

Faba bean (*vicia faba* L.) is the fourth most important pulse crops in the world (Talal and Shalaldeh, 2006). It is one of the most important legume crops worldwide because it is nitrogen fixing leguminous plant, offering high quality protein, capable of returning atmospheric nitrogen to the soil (Amin, 1988). Faba bean is used as human food in developing countries and as animal feed, mainly for pigs, horses, poultry and pigeons in industrialized countries (Talal and Shalaldeh 2006).

The cultivated area was about 56,394 h with an average yield of 10 ardab fad^{-1}, in north parts of Egypt, representing about 85% of the total cultivated faba bean area. The total production in 2018/2019 season was about 135,345 tons, while the total consumption was estimated to be about 420,000 tons (FAO, 2020). The total local production of this crop is still insufficient to cover the local consumption, due to yearly decreased area and moderate productivity from the previously mentioned certainties. The low yield of faba bean have been attributed to poor soil fertility, low use of inputs, weed, depth of sowing, inadequate soil moisture, poor appropriate time of planting and plant density (Hebblethwaite *et al*., 1983, Asfaw *et al*., 1994 and Wakweya *et al*., 2016).

Planting date is crucial in faba bean, because early or late sowing expose the crop to drought, adverse temperature, pests and diseases attack. Several studies indicated that sowing date significantly influenced the seed yield and growing traits in faba bean and late sowing increased the severity of insect and disease attack and reduced days to flowering, green pod length, seeds per pod and seed yield (Yusufali *et al.,* 2007, Kawochar *et al.,* 2010 and Khalil *et al.,* 2010). In addition, sowing date significantly affects the timing and duration of vegetative and reproductive stages consequently seed yield, yield components and seed quality (Refay 2001 and Turk and Tawaha 2002).

Some farmers intended to plant faba bean crop in September and October, while the optimum sowing date for the commercial cultivars is the first half of November. Under this early sowing, the seed yield decreased significantly due to the high level of infection with foliar diseases i.e. chocolate spot (*Botrytis fabae*) and rust (*Uromysis fabae*), high infestation with insects and abnormal conditions (Amer *et al*., 1992 and Hussein *et al.,* 1994). El-Galaly *et al.* (2006) found that, sowing on 10th November gave the highest seed yield. Amer *et al.* (1997) found that, late sowing dates reduced the amount of diseases infection, while the highest seed yield was obtained from optimum sowing date.

In addition, genotypes may play an important role in increasing seed yield through their response to applied cultural practices and environmental conditions. Several studies reported significant variations among tested genotypes in vegetative and yield characters (Mohammed and EL-Abbas, 2005, Bakry *et al.*, 2011, K andil *et al*., 2011, Mulualem *et al*., 2012 and Abido and Seadh, 2014).

Therefore, this research aimed to study the effects of early sowing date and genotypes on chocolate spot and rust foliar diseases reaction, seed yield and its components and seed quality in faba bean.

MATERIALS AND METHODS

The present study was conducted at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 2018/2019 and 2019/2020 growing seasons. Soil analysis was showed in Table (1).

Twelve genotypes were selected from the faba bean research program at Sakha Station for their deceases reaction The names and pedigree of the studied genotypes were presented in Table (2). The studied genotypes included four local check cultivars (Sakha 1, Sakha 4 Sakha 3, and Giza 40) and eight promising lines. The studied genotypes were evaluated under two sowing dates i.e., 1st October (early) and 1st November (optimum). All other culture practices were done as recommended.

The meteorological data for the two winter growing seasons from Sakha meteorological station are given in Table (3).

Table 1: Soil analysis of the Experimental Field at Sakha Agricultural Research Station at 2018/2019 and 2019/2020 Seasons.

Determination	S and %	Silt %	Clay %	Texture	pH	E.C. (ds/m)
1st Season	13.94	24.81	61.45	Clay	7.9	2.1
2nd Season	15.23	23.75	61.02	Clay	8.2	2.2

Table 2: Name and pedigree of twelve faba bean genotypes.

Genotype	Pedigree
Line 1	Nubaria 1 x Determinate
Line 2	Giza 40 x Ohishima-Zaira
Line 3	Santamora
Line 4	Otona x (Giza 716 x Otona)
Line 5	Giza 716 x Sakha 1
Line 6	Sakha 1 x Ohishima-Zaira
Line 7	Sakha 2 x Otona
Line 8	Sakha 1 x Sakha 2
Sakha 1	Giza 716 x 620/283/85
Sakha 4	Sakha 1x Giza 3
Sakha 3	Individual selection from Giza 716
Giza 40	Selected from Rebai 40

Table 3: Maximum, minimum, average temperature and rainfall during the growing seasons at Sakha Agricultural Research Station, (ARC), Egypt.

Month	Temperature (C)						Rainfall (mm)	
	2018/2019			2019/2020				
	Max.	Min.	Avg.	Max.	Min.	Avg.	2018/2019	2019/2020
Oct.	29	20	26	31	20	27	-	5.78
Nov.	25	17	22	27	19	24	3.01	0.25
Dec.	20	13	17	21	13	17	2.35	4.65
Jan.	19	10	19	17	9	14	2.25	8.48
Feb.	20	10	16	19	10	16	4.1	4.38
Mar.	22	12	18	23	12	12	6.7	3.43
Apr.	26	14	22	26	14	22	2.13	0.58

Reaction to foliar diseases was recorded on mid- February and mid - March for chocolate spot and rust, respectively, according to Bernier *et al.* (1984) disease scale. The studied characters measured on ten plants of each plot and contained flowering date, plant height, No. of branches plant^{-1}, No. of pods plant^{-1}, No. of seeds plant^{-1} and 100-seed weight. Seed yield was estimated from the two central ridges of each plot to remove of the marginal effect.

Seed quality was carried out at Sakha Seed Technology Research. Leached from four replicates of 50 seeds was weighed and soaked in 250 ml of distilled water for 24 h to measure in mmhos cm^{-1} using the electrical conductivity (EC) per gram of seed weight for each sub sample and calculated as follows: E.C = Conductivity for each flask / Weight of seed sample (g). Tested seeds were ground to a fine powder to pass through 2 mm mesh and used to determine the crude protein and total carbohydrate percentage according to methods of A.O.A.C (2006).

A randomized complete block design (RCBD) in three replications was used for each sowing date. Each plot consisted of four ridges, 3 m long and 20 cm apart.

The combined analysis across sowing dates in the two seasons were performed when the assumption of errors homogeneity cannot be rejected (Levene, 1960) according to Gomez and Gomez (1984). The means of the studied genotypes were used to perform the genotype and genotype by environment interaction GGE biplot according to Yan *et al*. (2001) using GenStat 18 (Payne *et al*., 2017). Hierarchical clustering procedure using Ward's minimum variance method was applied as described by Anderberg (1973) and developed by Hair *et al.* (1987). The dendrogram are performed using GenStat 18 (Payne *et al*., 2017).

RESULTS AND DISCUSSION

Analysis of variance

Mean squares of the studied characters under the two sowing dates in both seasons are illustrated in Table (4). The genotypes showed highly significant (0.01 probability) variances for all characters in all conditions. Homogeneity test showed that the error variances were heterogeneous across the two seasons and homogeneous for the two sowing dates in the two seasons for all characters. Therefore, the combined analyses were performed for the two sowing dates.

Table 4: The combined analyses of variance across sowing dates and genotypes for all studied characters.

SOV	df	Chocolate spot		Rust		Flowering date	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Sowing date	1	11.68**	4.01**	16.06**	2.00**	312.50*	401.39*
Rep/Sowing date = (Ea)	4	0.01	0.18	0.01	0.07	16.32	6.60
Genotypes	11	8.35**	7.23**	6.37**	5.80**	327.15**	367.68**
Genotypes * Sowing date	11	0.32**	0.17**	0.09**	0.30**	7.95**	2.90**
Pooled Error = (Eb)	44	0.20	0.14	0.10	0.15	4.96	3.57
	df	Plant height		No. branches plant^{-1}		No. pods plant^{-1}	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Sowing date	1	1369.39*	800.00*	0.03ns	2.06*	1697.02**	1834.56**
Rep/Sowing date = (Ea)	4	70.19	52.78	0.12	0.09	1.19	0.41
Genotypes	11	218.91**	143.06**	0.98**	1.14**	11.29ns	7.51**
Genotypes * Sowing date	11	13.93**	23.48**	0.09**	0.13**	1.49ns	0.26**
Pooled Error = (Eb)	44	16.56	8.46	0.08	0.12	5.86	0.94
	df	No. seeds plant^{-1}		100 seed weight		Seed yield	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Sowing date	1	15856.94**	17503.79**	372.13**	249.06**	190.98**	148.74**
Rep/Sowing date = (Ea)	4	73.54	3.79	1.65	0.24	0.06	0.17
Genotypes	11	265.71**	253.53**	389.45**	325.68**	11.80**	9.75**
Genotypes * Sowing date	11	21.14**	19.83**	15.37**	13.27**	1.12**	1.13**
Pooled Error = (Eb)	44	58.36	28.58	3.00	5.44	0.26	0.24
	df	EC		Crude protein %		Total carbohydrate %	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Sowing date	1	1.25ns	1.98ns	2.58*	1.40*	4.51ns	4.52ns
Rep/Sowing date = (Ea)	4	0.18	0.36	0.16	0.15	0.78	1.18
Genotypes	11	320.78**	317.91**	59.42**	57.50**	84.82**	82.29**
Genotypes * Sowing date	11	0.03**	0.11**	0.10**	0.09**	0.19**	0.26**
Pooled Error = (Eb)	44	0.43	0.29	0.51	0.26	0.66	1.00

(*) and (**) significant at 0.05 and 0.01 levels probability, respectively.

Significant and high significant variations were detected due to sowing date, genotypes and interactions between genotypes and sowing dates for all studied characters in both seasons (Table 4), except for sowing date for No. branches plant^{-1} in the first season, EC and total carbohydrate % in both seasons, which were insignificant. The genotypes and interaction between genotypes and sowing dates were insignificant for No. pods plant^{-1}. These results indicated that faba bean genotypes responded differently to the different environmental conditions suggesting the importance of assessment of genotypes under different environments in order to identify the best genotype make up for a particular environment. Similar results were obtained by Ibrahim (2016) and Sharifi (2018), which reported that all studied vegetative and yield characters were significantly affected by the first order interaction i.e., sowing date x cultivars. Hence, the value recorded for characters will be influenced by the combined effect of both studied factors.

Means performance

Effect of sowing date

The overall mean effect of sowing dates was first assessed by evaluating all genotypes across years. Effect of sowing date on all studied traits is presented in Table (5). The environmental factors (temperature, humidity and day length) were distinct at the time of sowing and during crop growth under different natural photothermal environments. The observed variation in the studied characters of the genotypes between optimum and early sowing date can be considered as combination effect of sowing date and weather differences.

Foliar diseases infection (chocolate spot and rust) showed high values in the early sowing date. Early sowing date caused high infection compared with the optimum sowing date. Also, Early sowing date reduced flowering date. The chemical analysis significantly differed among the tow sowing dates as a shown in Table (4). The early sowing date (1st October) produced the highest values of EC, crude protein % and carbohydrate % across the two growing seasons. These results agree with Hegab *et al.* (2014) who obtained that (1st of November) surpassed the others sowing dates in carbohydrate and protein percent.

Early sowing date (1st October) produced the highest values of plant height caused shading on lower parts of the canopy. Smith (1982) and Manning *et al*. (2020), found that shading increased flower abscission in faba bean. This effect may partly explain the reduced No. pods and yield associated with excessive vegetative growth because lower parts of the canopy receive less light in such circumstances.

It was noticed that optimum sowing date (1st November) caused significant increases in No. branches, No. pods, No. seeds plant^{-1}, 100 seed weight and seed yield compared with early sowing date (1st October). On the contrary, EC, crude protein % and carbohydrate % were significantly increased compared to optimum sowing date.

The superiority of seed yield observed with the optimum sowing date might be attributed to the increase in No. pods, No. branches and 100 seed weight. These findings confirm the results obtained by Alazaki and Al Shebani (2012), Abdou *et al.* (2013), Badr *et al.* (2013), Ibrahim (2016) and Megawer *et al.* (2017), they obtained that optimum sowing date gave the highest mean values for No. branches, No. pods, 100 seed weight and seed yield. As well as, Shaban *et al.* (2013) confirmed that 25th November gave the highest value of protein percentage.

Table 5: Effect of sowing dates on faba bean characters in both growing seasons.

Treatment	Chocolate spot		Rust		Flowering date (day)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Early	3.72	3.72	3.53	3.61	46.94	46.25
Optimum	2.92	3.25	2.58	3.28	51.11	50.97
$LSD_{0.05}$	0.21	0.74	0.21	0.46	7.03	4.47
Treatment	Plant height (cm)		No. branches plant^{-1}		No. pods plant^{-1}	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Early	141.53	142.64	2.79	2.54	11.83	12.07
Optimum	132.81	135.97	2.78	2.88	21.54	22.17
$LSD_{0.05}$	14.59	12.65	0.59	0.53	1.90	1.11
LSD0.01	25.63	22.23	1.04	0.93	3.34	1.96
Treatment	No. seeds plant^{-1}		100 seed weight (g)		Seed yield (ardab fad^{-1}.)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Early	36.11	37.5	93.40	92.46	11.49	11.54
Optimum	65.79	68.68	97.95	96.18	14.74	14.42
$LSD_{0.05}$	14.93	3.39	2.24	0.85	0.43	0.71
Treatment	EC mmhos cm^{-1}		Crude protein %		Total carbohydrate %	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Early	24.86	25.19	29.19	29.26	45.10	45.49
Optimum	24.60	24.86	28.82	28.98	44.6	44.99
$LSD_{0.05}$	0.74	1.05	0.70	0.68	1.54	1.89

Sowing date is an important factor which significantly affects the duration of vegetative and reproductive stages consequently yield its components and seed quality (Refay, 2001 and Turk and Tawaha, 2002). Since, environmental factors i.e., temperature and light differ due to sowing dates. Many studies indicated that sowing date had significant yield limiting factor on faba bean. Thus, Talal and Ghalib (2006) reported that planting on November resulted in a significant yield advantage (157%), more shoot and root growth, more number of nodules and higher nodule dry weight. They concluded that much of this advantage resulted from the extended period of vegetative growth which resulted in the improvement of several agronomical characters. Similarly, ElMetwally *et al.* (2013) showed that sowing date at the end of October recorded the highest values of growth characters.

Effect of genotypes

Significant genotypes differences were showed in all characters studied as presented in Table (6). All genotypes showed a resistance reaction for foliar diseases infection (chocolate spot and rust), except for Giza 40 which was the most affected by diseases (susceptible) in early cultivation compared to optimum sowing date. Line 4 and Sakha 1 improved achieved the superiority on flowering date (42.50 and 41.67 day in first season, 41.67 and 41.67 in second season, respectively), it could be used as sources of earliness in breeding program, while Line 6 and Sakha 3 were the latest genotypes (61.67 and 61.67 day in first season, 61.67 and 62.50 in second season, respectively).

With respect to plant height, the results showed that the tallest genotype in first season was Line 7 (149.17 cm), while Sakha 4 was the shortest one (127.50 cm), while in second season the tallest genotype was Line 2 (145.83 cm), while Sakha 1 was the shortest one (131.67 cm). For No. branches Sakha 3 gave the highest values (3.59 in first season and 3.68 in second season). Sakha 1 and Sakha 4 showed the highest values in No. pods per plant (17.97 and 18.81, respectively) in first season, while Line 5 and Sakha 1 were the highest in second season (18.41 and 18.12, respectively). Line 6 and Line 8 showed the highest values for No. seeds per plant, while Line 3 was showed the lowest values in both growing seasons. For 100 seed weight Line 3, Line 4 and Line 7 showed the highest values, while Line 2 was showed the lowest values. v6 showed the superiority in seed yield in both growing seasons (14.86 and 14.97 ardab fed.$^{-1}$), while the susceptible variety Giza 40 was the lowest seed yield.

Table 6: Mean performance of the studied genotypes for the studied characters in both growing seasons across the two sowing dates.

Genotypes	Chocolate spot		Rust		Flowering date (day)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Line 1	3.83	3.83	2.50	3.17	44.17	44.17
Line 2	3.67	3.67	3.50	3.83	58.33	59.17
Line 3	3.00	3.00	2.50	3.00	44.17	44.17
Line 4	2.33	3.67	3.17	4.00	42.50	41.67
Line 5	2.67	2.67	2.17	2.83	45.83	46.67
Line 6	3.50	3.00	4.33	3.83	61.67	61.67
Line 7	2.50	3.00	1.83	3.17	47.50	47.50
Line 8	3.17	3.00	2.50	2.50	44.17	44.17
Sakha 1	3.83	3.83	3.50	3.33	41.67	41.67
Sakha 4	3.00	3.00	2.50	2.83	45.83	42.50
Sakha 3	1.83	2.50	2.67	2.67	61.67	62.50
Giza 40	6.50	6.67	5.50	6.17	50.83	47.50
$LSD_{0.05}$	0.21	0.74	0.21	0.46	7.03	4.47
Genotypes	Plant height (cm)		No. branches plant^{-1}		No. pods plant^{-1}	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Line 1	139.33	145.00	2.39	2.36	16.19	17.62
Line 2	139.17	145.83	2.95	2.99	16.91	17.90
Line 3	134.17	135.00	3.06	3.05	13.40	14.13
Line 4	135.00	134.17	2.47	2.27	15.39	16.72
Line 5	135.00	138.33	2.48	2.38	17.63	18.41
Line 6	140.00	140.83	2.69	2.38	16.53	16.90
Line 7	149.17	143.33	2.46	2.39	16.36	17.22
Line 8	143.33	144.17	3.36	2.91	16.52	16.99
Sakha 1	128.33	131.67	2.78	2.61	17.97	18.12
Sakha 4	127.50	135.00	2.89	3.11	18.81	16.31
Sakha 3	135.00	135.83	3.59	3.68	17.39	17.55
Giza 40	140.00	142.50	2.29	2.36	17.18	17.61
$LSD_{0.05}$	14.59	12.65	0.59	0.53	-	1.11

Table 6: cont.

Genotypes	No. seeds plant^{-1}		100 seed weight (g)		Seed yield (ardab fad^{-1}.)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Line 1	48.55	52.75	94.86	91.15	13.80	13.29
Line 2	53.89	56.27	83.58	83.71	14.14	14.34
Line 3	36.29	38.38	105.19	102.37	14.31	13.04
Line 4	41.32	44.70	111.83	106.31	13.96	14.12
Line 5	51.35	53.52	95.69	92.28	13.72	13.81
Line 6	57.75	59.08	95.39	94.70	14.86	14.97
Line 7	54.12	57.00	100.24	103.60	14.56	13.82
Line 8	59.66	61.35	95.69	95.16	11.19	11.82
Sakha 1	54.39	54.71	94.04	95.13	11.34	11.88
Sakha 4	54.49	58.14	85.80	85.69	11.20	11.25
Sakha 3	48.09	48.67	99.49	97.02	12.35	12.18
Giza 40	51.52	52.50	86.60	84.71	10.20	10.75
$LSD_{0.05}$	14.93	3.39	2.24	0.85	0.43	0.71
Genotypes	EC mmhos cm^{-1}		Crude protein %		Total carbohydrate %	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Line 1	23.73	24.34	26.62	27.09	47.17	48.20
Line 2	31.45	31.80	24.61	24.91	51.01	51.51
Line 3	25.95	26.13	31.16	31.33	42.25	42.73
Line 4	41.28	41.40	30.27	30.58	42.96	43.83
Line 5	31.94	32.06	28.03	28.21	46.73	46.53
Line 6	26.95	27.58	32.89	32.55	40.72	40.94
Line 7	16.04	16.42	33.68	33.55	37.76	38.29
Line 8	18.64	18.97	32.02	32.21	44.27	44.31
Sakha 1	21.10	21.30	30.05	30.14	43.22	43.72
Sakha 4	22.91	23.05	25.67	25.59	46.28	46.54
Sakha 3	18.00	18.28	24.75	24.52	49.80	49.60
Giza 40	18.80	18.95	28.31	28.77	46.04	46.66
$LSD_{0.05}$	0.74	1.05	0.70	0.68	1.54	1.89

For EC, the lowest values obtained from in Line 7 (16.04 and 16.42), while the highest values (41.28 and 41.4) obtained from Line 4 in first and second seasons, respectively. For crude protein % Line 6 and Line 7 showed the highest values in both seasons. For total carbohydrate %, Line 2 was the best. Similar variations, among genotypes, were reported by Attia *et al.* (2009), Osman *et al.* (2010) and Ibrahim (2016), they reported significant differences among faba bean genotypes in vegetative growth, seed yield and yield components characters.

Interaction between sowing dates and genotypes

Data in Table (7) showed a highly significant interaction between sowing dates × genotypes for all studied characters in both seasons, except for No. pods plant^{-1} in first season was insignificant, indicating that genotypes differently responded to sowing date. Since flowering date and yield characters showed reduced values, with early sowing date. Also, foliar diseases infection (chocolate spot and rust) showed a high reaction values in early sowing date. The interaction effect might be in the magnitude of difference in each genotype, with early sowing. For example, in chocolate spot disease Line 3 didn't show difference with early sowing from 1st October to 1st November, while Giza 40 the reaction values increased in early sowing date compared with those obtained in optimum sowing date. Line 2 showed high reduction for flowering date due to early sowing date, while Line 4, Line 6 and Sakha 1 showed low difference. On the other h and, a great reduction in yield and yield characters was observed. Line 3 showed a low reduction compared with the other genotypes. Similar significant first order interaction, i.e., sowing date x genotypes, were reported by Sharaan *et al*. (2004), Attia *et al.* (2009), Osman *et al.* (2010), Bakry *et al.* (2011), Abd- El Hafez et al., (2012), Alazaki and Al –Shebani (2012), Attia et al. (2013), Hegab *et al.* (2014), Ibrahim (2016) and Megawer *et al.* (2017).

Table 7: Mean performance of the studied faba bean genotypes across the two sowing dates for studied characters in both growing seasons.

Genotypes	Chocolate spot				Rust			
	Season 1		Season 2		Season 1		Season 2	
	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2
Line 1	4.33	3.33	4.00	3.67	3.00	2.00	3.33	3.00
Line 2	4.00	3.33	4.00	3.33	4.00	3.00	4.00	3.67
Line 3	3.00	3.00	3.00	3.00	3.00	2.00	3.00	3.00
Line 4	2.67	2.00	4.00	3.33	3.33	3.00	4.00	4.00
Line 5	3.00	2.33	3.00	2.33	2.67	1.67	3.00	2.67
Line 6	4.00	3.00	3.00	3.00	4.67	4.00	4.00	3.67
Line 7	3.00	2.00	3.33	2.67	2.33	1.33	3.33	3.00
Line 8	3.67	2.67	3.33	2.67	3.00	2.00	3.00	2.00
Sakha 1	4.33	3.33	4.00	3.67	4.00	3.00	3.33	3.33
Sakha 4	3.00	3.00	3.00	3.00	3.00	2.00	3.00	2.67
Sakha 3	2.33	1.33	3.00	2.00	3.33	2.00	3.33	2.00
Giza 40	7.33	5.67	7.00	6.33	6.00	5.00	6.00	6.33
$LSD_{0.05}$	0.61		0.50		0.44		0.52	
Genotypes	Flowering date (day)				Plant height cm)			
	Season 1		Season 2		Season 1		Season 2	
	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2
Line 1	41.67	46.67	41.67	46.67	146.67	132.00	151.67	138.33
Line 2	53.33	63.33	55.00	63.33	141.67	136.67	150.00	141.67
Line 3	41.67	46.67	41.67	46.67	140.00	128.33	140.00	130.00
Line 4	41.67	43.33	40.00	43.33	138.33	131.67	138.33	130.00
Line 5	43.33	48.33	45.00	48.33	140.00	130.00	143.33	133.33
Line 6	60.00	63.33	60.00	63.33	145.00	135.00	141.67	140.00
Line 7	45.00	50.00	45.00	50.00	151.67	146.67	145.00	141.67
Line 8	41.67	46.67	41.67	46.67	146.67	140.00	146.67	141.67
Sakha 1	40.00	43.33	40.00	43.33	133.33	123.33	136.67	126.67
Sakha 4	45.00	46.67	40.00	45.00	130.00	125.00	138.33	131.67
Sakha 3	60.00	63.33	60.00	65.00	140.00	130.00	136.67	135.00
Giza 40	50.00	51.67	45.00	50.00	145.00	135.00	143.33	141.67
$LSD_{0.05}$	3.05		2.58		5.57		3.98	
Genotypes	No. branches plant^{-1}				No. pods plant^{-1}			
	Season 1		Season 2		Season 1		Season 2	
	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2
Line 1	2.32	2.47	2.10	2.63	11.23	21.14	12.59	22.65
Line 2	2.90	2.99	2.61	3.36	13.60	20.21	13.02	22.77
Line 3	3.10	3.02	3.02	3.08	8.42	18.38	9.62	18.65
Line 4	2.60	2.33	2.02	2.51	10.17	20.60	11.34	22.09
Line 5	2.50	2.47	2.29	2.47	12.50	22.77	13.20	23.63
Line 6	2.65	2.72	2.07	2.68	11.53	21.52	11.83	21.96
Line 7	2.53	2.40	2.25	2.54	11.27	21.45	12.05	22.40
Line 8	3.36	3.37	2.48	3.34	11.60	21.44	11.92	22.07
Sakha 1	2.92	2.64	2.60	2.61	13.07	22.88	13.04	23.20
Sakha 4	2.86	2.92	3.04	3.18	13.83	23.78	11.30	21.31
Sakha 3	3.29	3.88	3.68	3.68	12.45	22.33	12.44	22.65
Giza 40	2.46	2.12	2.29	2.43	12.32	22.03	12.54	22.67
$LSD_{0.05}$	0.38		0.47		-		1.33	

Table 7: cont.

Genotypes	No. seeds plant^{-1}				100 seed weight (g)			
	Season 1		Season 2		Season 1		Season 2	
	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2
Line 1	33.67	63.44	37.69	67.81	92.31	97.40	86.63	95.66
Line 2	42.80	64.97	41.06	71.47	81.66	85.50	81.93	85.50
Line 3	22.81	49.77	26.05	50.71	100.71	109.66	98.48	106.27
Line 4	27.30	55.34	30.34	59.06	107.03	116.63	102.26	110.37
Line 5	36.37	66.34	38.34	68.70	95.72	95.67	90.27	94.30
Line 6	40.29	75.22	41.36	76.80	94.94	95.84	93.56	95.84
Line 7	37.27	70.98	39.87	74.14	97.7	102.77	102.85	104.35
Line 8	41.86	77.45	42.92	79.78	94.00	97.39	93.48	96.85
Sakha 1	39.63	69.14	39.39	70.03	91.97	96.12	94.42	95.84
Sakha 4	39.30	69.68	40.32	75.97	84.56	87.05	85.4	85.98
Sakha 3	34.29	61.9	34.43	62.91	94.72	104.25	96.57	97.46
Giza 40	37.77	65.27	38.21	66.79	75.46	77.73	73.69	75.74
$LSD_{0.05}$	10.45		7.32		2.37		3.19	
Genotypes	Seed yield (ardab fad^{-1})				EC mmhos cm^{-1}			
	Season 1		Season 2		Season 1		Season 2	
	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2
Line 1	11.77	15.83	12.11	14.48	23.91	23.55	24.43	24.26
Line 2	12.04	16.23	13.28	15.39	31.61	31.28	31.88	31.72
Line 3	12.34	16.28	12.12	13.97	26.11	25.78	26.22	26.04
Line 4	12.01	15.92	12.38	15.87	41.44	41.13	41.46	41.34
Line 5	11.91	15.53	11.82	15.81	32.12	31.76	32.58	31.53
Line 6	13.81	15.91	14.11	15.84	27.10	26.80	27.88	27.28
Line 7	12.94	16.18	12.53	15.12	16.18	15.89	16.55	16.28
Line 8	9.49	12.90	10.31	13.32	18.87	18.41	19.16	18.78
Sakha 1	9.69	12.99	10. 00	13.77	21.25	20.95	21.49	21.10
Sakha 4	9.50	12.90	9.38	13.11	22.92	22.91	23.19	22.90
Sakha 3	11.70	12.99	10.34	14.02	18.03	17.96	18.36	18.20
Giza 40	9.13	11.27	9.16	12.33	18.82	18.78	19.05	18.84
$LSD_{0.05}$	0.70		0.66		0.90		0.73	
Genotypes	Crude protein %				Total carbohydrate %			
	Season 1		Season 2		Season 1		Season 2	
	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2	SD-1	SD-2
Line 1	26.77	26.47	27.25	26.93	47.55	46.79	48.34	48.06
Line 2	24.92	24.30	24.96	24.87	51.30	50.71	51.62	51.41
Line 3	31.21	31.11	31.41	31.25	42.92	41.58	42.85	42.60
Line 4	30.37	30.17	30.58	30.57	43.38	42.54	43.90	43.75
Line 5	28.23	27.83	28.42	28.00	46.82	46.63	46.57	46.49
Line 6	32.94	32.84	32.98	32.13	40.88	40.55	41.22	40.65
Line 7	33.88	33.47	33.63	33.47	37.94	37.58	38.61	37.97
Line 8	32.20	31.83	32.42	32.00	44.54	44.00	44.50	44.11
Sakha 1	30.41	29.68	30.26	30.02	43.24	43.20	44.16	43.27
Sakha 4	25.71	25.63	25.60	25.58	46.55	46.00	47.03	46.05
Sakha 3	24.91	24.58	24.77	24.28	49.94	49.67	49.67	49.53
Giza 40	28.78	27.85	28.87	28.68	46.13	45.95	47.37	45.95
$LSD_{0.05}$	0.98		0.70		1.11		1.37	

Genotype main effect plus genotype × environment interaction (GGE) biplot for grain yield

GGE analysis has tremendous potential value to plant breeders, agronomists, pathologists, physiologists, nutritionists, and anyone working in an applied science field. It is currently being used to evaluate overall agronomic merit, quality, genotype environment interaction for numerous traits, genotype × trait interactions, and trait × environment interactions in breeding lines being advanced through the testing system, to select parents and parental combinations for crossing, to evaluate relationships among traits (especially quality), to identify determinants of yield and quality factors in the populations, and to assess the discriminating value and stability of various testing locations (Yan and Kang, 2003).

Figure (1) presented a scatter plot for PC1 and PC2 with 91.31 and 3.92 sum of square of G × E interaction, respectively. This biplot explain genotypes in PC1 scores > 0 were identified as adaptable and higher yielding and those that had PC1 scores < 0 were identified as non-adaptable and lower yielding. PC2 identified stable genotype when it's near the center of biplot (0). In this case the group of stable genotypes was Line 7 and Line 6. These results are logical, since Line 6 and Line 7 are breeding genotypes that were selected in the same environment, and have similar agronomic performance. But Giza 40 were unstable. Yan and Kang (2003) pointed out, 1) E is large but irrelevant to genotype evaluation, and therefore it should be removed from the data, 2) only G and GE are relevant to meaningful genotype evaluation, and they must be considered simultaneously in making selection decisions. The concept can be represented by the formula (P – E = G + GE). The term GGE is the contraction of G + GE. Its refers to genotype main effect (G) plus genotype-by-environment interaction (GE).

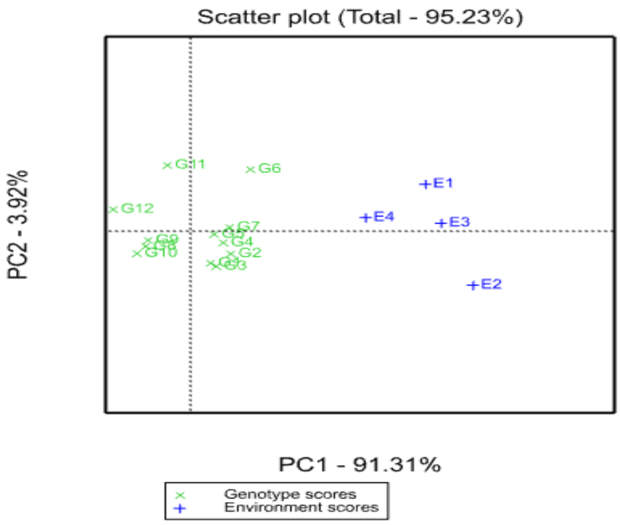

Figure 1: GGE biplot for seed yield of 12 genotypes across 4 environments. E1 = early sowing date season 1, E2 = optimum sowing date season 1, E3 = early sowing date season 2, E4 = optimum sowing date season 2, G1 = Line 1, G2 = Line 2, G3 = Line 3, G4 = Line 4, G5 = Line 5, G6 = Line 6, G7 = Line 7, G8 = Line 8, G9 = Sakha 1, G10 = Sakha 4, G11 = Sakha 3 and G12 = Giza 40.

Figure (2) visualizing of multi-environment yield trail (MEYTs) data is important for studying the possible existence of different genotypes in mega-environment (ME) in a region (Guch and Zobel, 1997) and Yan *et al.* (2000). The figure showed that a polegon of which-won-where pattern and three groups of environments (ME). The genotype Line 6 and Line 7 were won in environments E1, E3 and E4.

An ideal genotype should have the highest mean performance and be absolutely stable (i.e. perform the best in all environments). Such an ideal genotype is defined by having the greatest vector length of the high yielding genotypes and with zero GEI, as represented by an arrow pointing to it (Figure 3). Figure (3) showed that Line 7, which fell into the center of concentric circles, were ideal genotypes in terms of higher yielding ability and stability, compared with the rest of the genotypes. In addition, Line 2, Line 4, Line 5 and Line 6 located on the next concentric circles may be regarded as desirable genotypes.

Cluster analysis based on environments mean for all studied characters performance during 2018/2019 and 2019/2020 seasons were performed (Figure 4). The cluster analysis was used as an efficient procedure to emerge the structural relationships among tested genotypes and provides a hierarchical classification of them. In this analysis two main branches were appeared. The first main branch contained Line 3 and Line 4, both of this genotype very close to each other and differed in origin from all reaming studied genotypes as showed in Table (1) and performance, which they were the heaviest in 100 seed weight but have low No. seeds plant^{-1}. The rest genotypes were found in the second main branch. Giza 40 and Line 2 were found together in the same sub-sub-cluster, which Giza 40 a parent of Line 2. Line 8, Sakha 1 and Sakha 4 were found together in the same sub sub-cluster, which Line 8 and Sakha 4 sharing in Sakha 1 as a parent of both. Line 6 and Sakha 3 were found in the same sub sub-cluster, which they have similar performance. Cluster analysis has been used for description of the diversity based on similar characteristics Abdel-Rahman *et al*. (2019).

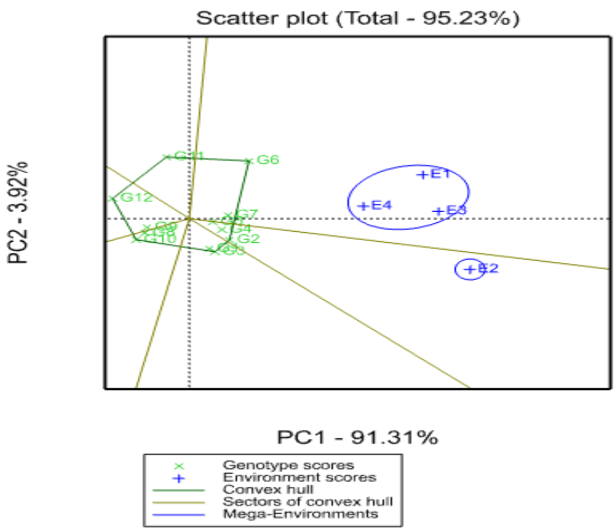

Figure 2: Mega-environment for seed yield of 12 genotypes across environments. E1 = early sowing date season 1, E2 = optimum sowing date season 1, E3 = early sowing date season 2, E4 = optimum sowing date season 2, G1 = Line 1, G2 = Line 2, G3 = Line 3, G4 = Line 4, G5 = Line 5, G6 = Line 6, G7 = Line 7, G8 = Line 8, G9 = Sakha 1, G10 = Sakha 4, G11 = Sakha 3 and G12 = Giza 40.

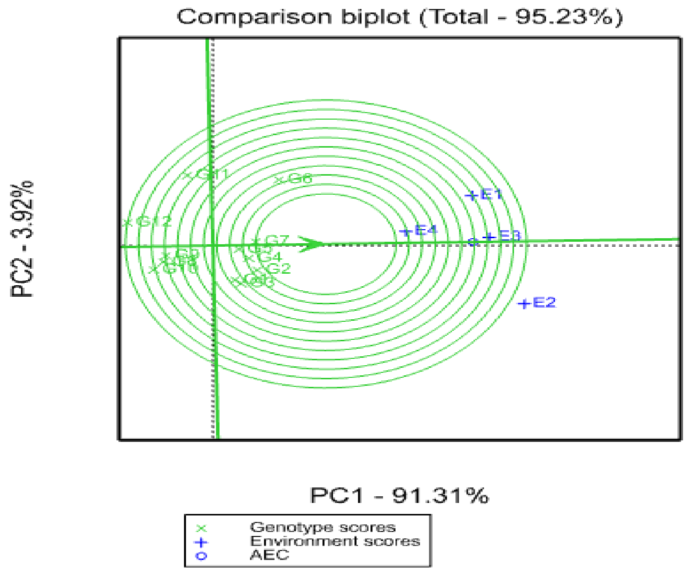

Figure 3: Ideal genotypes for seed yield of 12 genotypes across environments. E1 = early sowing date season 1, E2 = optimum sowing date season 1, E3 = early sowing date season 2, E4 = optimum sowing date season 2, G1 = Line 1, G2 = Line 2, G3 = Line 3, G4 = Line 4, G5 = Line 5, G6 = Line 6, G7 = Line 7, G8 = Line 8, G9 = Sakha 1, G10 = Sakha 4, G11 = Sakha 3 and G12 = Giza 40.

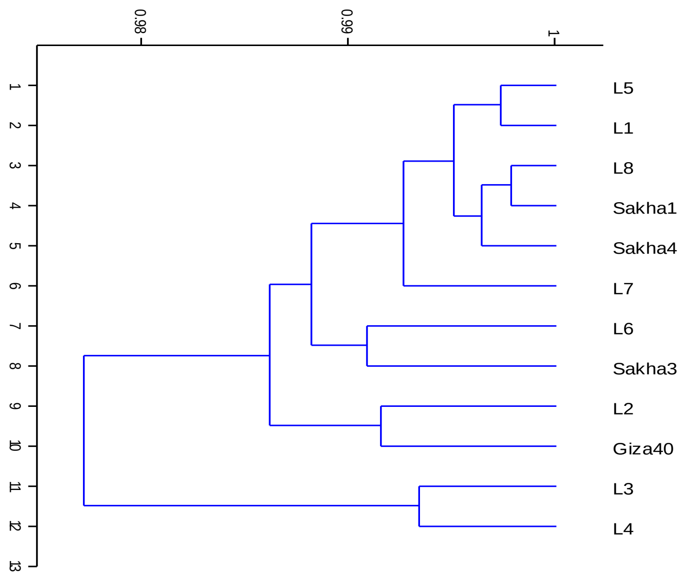

Figure 4: Dendrogram of 12 faba bean genotypes based on all studied characters.

CONCLUSION

It could be suggested according to this study that Line 2, Line 3, Line 4, Line 5, Line 6 and Line 7 could be reevaluated on the national level to confirm these results. The eight promising lines could be used in breeding program to improve foliar diseases infection (chocolate spot and rust). Also, Line 6 was appropriate genotypes to be cultivated under early sowing date.

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تأثير ميعاد الزراعة على مرضى التبقع الشيكولاتي والصدأ والمحصول ومكوناته وجودة البذور فى الفول البلدى

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[٢] قسم تكنولوجيا البذور– معهد بحوث المحاصيل الحقلية مركز البحوث الزراعية.

الملخص العربى

لدراسة تأثير ميعاد الزراعة المبكر على خصائص النبات المختلفة ومرضي التبقع الشيكولاتي والصدأ والمحصول ومكوناته لاثني عشر تركيب وراثي من الفول البلدى، تم تنفيذ التجربة بالمزرعة البحثية بمحطة البحوث الزراعية بسخا بمحافظة كفر الشيخ خلال موسمي ٢٠١٨/٢٠١٩ و٢٠١٩/٢٠٢٠. تسبب تاريخ الزراعة المبكر (١ أكتوبر) في ارتفاع معدل الإصابة بأمراض الأوراق الورقية (التبقع الشيكولاتي والصدأ)، والتبكير فى ميعاد التزهير وانخفاض عدد الفروع وعدد القرون وعدد بذور النبات ومحصول البذور مقارنة بميعاد الزراعة الأمثل (١ نوفمبر). ونتج عن ميعاد الزراعة المبكر زيادة في كل من معامل التوصيل الكهربى والبروتين الخام والمحتوى الكلى للكربوهيدرات مقارنة بميعاد الزراعة الأمثل. أظهرت السلالتان ٦ و٧ تفوقاً فى محصول البذور وثبات الأداء حيث أظهرا قيما عالية لعدد البذور للنبات و/ أو وزن ١٠٠ بذرة. قسم التحليل العنقودي التركيب الوراثية الى مجموعتين رئيسيتين مختلفتين، حيث احتوت المجموعة الأولى على السلالتين ٣ و٤ حيث اختلفتا في المنشأ والأداء عن باقي التركيب الوراثية، وأظهرتا أعلى القيم من وزن ١٠٠ بذرة ولكن مع عدد بذور قليل. كما كانت باقى التراكيب الوراثية فى المجموعة الثانية. وكانت السلالة ٦ الأفضل فى المحصول تحت ظروف ميعاد الزراعة المبكر مع انخفاض نسبة الفقد فى المحصول نتيجة التبكير فى ميعاد الزراعة، لذا فهي مناسبة للزراعة تحت ميعاد الزراعة المبكر.

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