

BEHAVIOR OF SOME FABA BEAN GENOTYPES UNDER NATURALLY OROBANCHE INFESTED SOILS

Azza F. El-Sayed¹, Heba A.M.A. Saleh¹, S.A. Arab²
and M. M. H. Abd El-Wahab³

1. Food Legume Res. Dep., Field Crops Res. Inst., ARC, Giza, Egypt.
2. National Gene Bank, ARC, Giza, Egypt.
3. Agronomy dept., Fac. of Agri., Cairo Univ.

ABSTRACT

Two experiments were carried out to evaluate ten faba bean genotypes under naturally infested soils with broomrape (*Orobanche crenata* Forsk.), at Giza Agricultural Research Station, Agricultural Research Center, Egypt during 2023/24 and 2024/25 seasons. A Randomized Complete Block Design (RCBD) with three replications was used in this study and morphological identification was measured using the recommended scales reported by the international union for protection of new varieties, descriptors. Three new genotypes (L47, L41 and L86) produced highest seed yield plant⁻¹ and seed yield ardab fed⁻¹ in both seasons. These genotypes exceeded the tolerant cultivar (Misr 1) by 47.62%, 43.58% and 25.19%, respectively as mean yield of the two seasons. Two genotypes (L47 and L41) combined the superiority in seed yield and tolerance of *Orobanche* with a significant reduction in number and dry weight of *Orobanche*. The results of the heat map analysis also showed that genotype L47 had the best performance for most studied traits, suggesting that this genotype could be used as a new source in breeding programs for *Orobanche* tolerance. The most related traits to *Orobanche* tolerance were stem anthocyanin coloration, leaflet folding, flower length characters and seed yield in ardab fed⁻¹, so these morphological characters could be used in the faba bean breeding programs as selection markers for *Orobanche* tolerance.

Key words: *Vicia faba*, Genotypes, *Orobanche* tolerance, cluster analysis, seed yield

INTRODUCTION

Faba bean (*Vicia faba* L.) is an important pulse crop grown worldwide as a source of protein (ranging from 22% to 38%) for human food and animal feed (Abdalla *et al* 2017). The average cultivated area in 2023 was 118,556 fed., with an average production of 9.44 ardab/fed (Agricultural Statistics 2023). However, its cultivation area is strongly hampered in Mediterranean and Middle East farming systems by the parasitism of broomrape causing important yield losses (El-Dabaa *et al* 2021). Legumes are parasitized mainly by two different species of broomrapes, namely crenata broomrape (*Orobanche crenata* Forsk) and foetida broomrape (*Orobanche foetida* Poir) (El-Mergawi and El-Dabaa 2025).

Faba bean is facing different biotic stresses such as diseases, insects, and weeds. The parasitic weed broomrape (*Orobanche crenata* L.) is the most limiting factor for faba bean cultivation not only in Egypt but also worldwide. Moreover, faba bean crops in, Egypt, suffer significant yield losses, ranging from an average of 30-40% to as high as 80-95%, due to the parasitic weed *Orobanche crenata* (broomrape). This infestation leads to reduced plant height, fewer pods, and lower seed yield (Soliman *et al*

2023). Unfortunately, due to the severity of these losses, the cultivated area in Egypt has gradually decreased from 385,000 feddan in 1997/98 to about 62,790 feddan in 2019/2020 due to the increased *Orobanche* infested fields (FAOSTAT 2021), and the competition with others crops. Therefore, faba bean breeders have used various biometrical techniques to develop the most efficient breeding procedures to face biotic and abiotic stressors in addition to evaluating the genetic effects of genes controlling quantitative traits to maximize yield potentials across a large number of them (Ayshooa, *et al* 2020, Araújo *et al* 2021 and Abd El-Aty *et al* 2023)

The genetic nature of broomrape resistance/tolerance is not clear at now and requires more studies on Egyptian faba bean genotypes. However, several tolerant cultivars are known to farmers in Egypt under the commercial name ‘Giza 843’. An acceptable level of resistance was found in Vf1071, an inbred line selected from cv. Giza 402 in Southern Spain. This line has been used in breeding programs to develop the well-adapted, high yielding cv. Baraca (Gnanasambandam *et al* 2012).

In addition to traditional genetic resistance, the host plant's morphological and physiological characteristics can also significantly influence tolerance to *Orobanche* infection. Stem anthocyanin pigmentation serves as an outward indicator of stress response and antioxidant capability, potentially enhancing the plant's resistance to the oxidative and nutritional imbalances brought on by broomrape parasitism (Louarn *et al* 2016). Foliage intensity, particularly the greenness of leaves, reflects chlorophyll content and overall photosynthetic capacity, which are critical for sustaining growth and yield when plants are challenged by *Orobanche* infestation. Greener foliage has been associated with higher chlorophyll levels, better light-use efficiency, and improved recovery from stress, thereby contributing to host tolerance against the strong assimilate drain caused by parasitic plants (Munns and Tester 2008). Under parasite stress, leaf folding or rolling often linked to drought adaptation can lower incident radiation and transpiration, conserving water and photosynthetic efficiency; when parasitized, these mechanisms may indirectly increase host vigor (Pérez-de-Luque *et al* 2007). Flower length and related floral traits may also influence tolerance, as they affect pollination efficiency and reproductive success

under stress, allowing infected plants to sustain seed production despite reduced assimilate supply (Rubiales and Pérez-de-Luque 2012). In parallel, the presence of wing melanin spots or other dark pigments can act as morphological indicators of stress adaptation, as melanin and related phenolic compounds are known to function in photoprotection, antioxidant defense, and pathogen resistance (Chalker-Scott 1999). These morphological characteristics represent adaptive features that, while not direct resistance mechanisms, can contribute to the overall tolerant phenotype and should be considered in breeding programs aiming to combine physiological tolerance with genetic resistance to *Orobanche*.

This study aimed to evaluate the behavior of ten faba bean genotypes under natural infested field with *Orobanche*.

MATERIALS AND METHODS

The present investigation was carried out at Giza Agricultural Research Station, ARC, Egypt during 2023/24 and 2024/25 seasons, to evaluate seven faba bean landraces compared with three commercial cultivars as checks. The check cultivars were Misr 1 (tolerant to *Orobanche crenata*) and Sakha1 and Giza716 (susceptible to *Orobanche crenata*); the origin and pedigree of the studied faba bean genotypes are listed in Table (1).

Table 1. The pedigree of faba bean genotypes under study.

No.	Genotype	Origin/Pedigree
1	L 47	Landrace collected from Behrira
2	L 41	Landrace collected from Ismailia
3	L 86	Landrace collected from Qena
4	L 94	Landrace collected from Asyut
5	L 14	Landrace collected from Asyut
6	L 35	Landrace collected from South Sinai
7	L 34	Landrace collected from New Valley
8	Misr 1	(G3 X 123A /45/76) X (62/1570/66 X G2) X Romi X Habashi
9	Sakha 1	Giza 716 X 620/283/85
10	Giza 716	461/842/83 X 503/453/83

Experiment procedures and experimental design

Faba bean genotypes were sown during the last week of October 2023/24 and 2024/25 growing seasons in a Randomized Complete Blocks Design (RCBD) with three replications. The experiment was conducted in a field naturally infested with programs. The experimental plot consisted of four ridges, each ridge 3 m length broomrape, which is commonly used in resistance screening breeding and 0.6 m width. Faba bean seeds were planted in single seeded hills, 20 cm apart on both sides of each ridge. All agricultural practices for producing faba bean were applied according to recommendations.

Data recorded

At harvest, ten guarded faba bean plants were taken at random from each plot to determine the agronomic traits: number of branches/plant, number of pods/plant, number of seeds/plant, seed yield/plant (g) and 100-seed weight (g). The two middle ridges of each plot were harvested to determine the seed yield in ardab/feddan (ardab =155 kg and feddan = 4200 m²).

Five morphological identification traits (present in Table 2) were measured and recoded using the recommended scales reported by International Union for Protection of New Varieties (UPOV 2003) descriptors. Furthermore, three studied traits were used as indicator for *Orobanche* tolerance (date of *Orobanche* emergence, number and dry weight of *Orobanche* spikes/m²).

Statistical Analysis

Obtained data were subjected to proper statistical analysis of variance according to the technique of analysis of variance (ANOVA) for the design, as published by Gomez and Gomez (1984). Least significant difference (LSD) was used to test the differences between treatment means at (5%) probability as described by Snedecor and Cochran (1980). The homogeneity test was done according to (Bartlett 1937). The test was not significant for most of traits under study, so, the two season's data were combined. The relationship between the germplasm was measured by calculating their Euclidean distance and paired group as phonogram using PAST Paleontological Statistics Version 3.08 (Dryden and Mardia 1998).

Table 2. A list of scored traits according to UPOV 2003.

Traits	Description
Stem anthocyanin coloration	Weak
	Medium
	Strong
Foliage intensity of green color	Light
	Medium
	Dark
Leaflet folding (along the main vein, terminal pair of leaflets)	Weak
	Medium
	Strong
Flower length	Short
	Medium
	Long
Wing: melanin spot	Absent
	Present

RESULTS AND DISCUSSION

Mean performance

Highly significant mean squares due to genotypes were detected for all studied traits, except for 100 seed weight in both seasons and No. of branches in 1st season, indicating that the expected genetic gain from selection for these traits could be fast in these genetic materials. Data presented in Table (3) showed the behavior of ten faba bean genotypes that included 7 landraces and 3 cultivars. This result was in harmony with those found by Tantawy *et al* (2022). Four new land races (L47, L41, L86 and L94) showed good performance under high infestation with *Orobanche* and showed significant increase in the No. of branches, pods, seeds and seed yield plant⁻¹ as well as seed yield in ardab fed⁻¹ when comparing with the tolerant cultivar Misr 1. Specifically, the genotype L47 exhibited superiority to Misr 1 of 6.49% for No. of branches plant⁻¹, 66.20% for No. of pods plant⁻¹, 67.25% for No. of seeds plant⁻¹, 64.58% for seed yield plant⁻¹ and 47.51% for seed yield in ardab fed⁻¹ as an average of the two seasons. In the same time, genotype L41 ranked second with mean superiority of 3.92% for

No. of branches plant⁻¹, 53.86% for No. of pods plant⁻¹, 54.54% for No. of seeds plant⁻¹, 47.12% for seed yield plant⁻¹ and 43.49% for seed yield in ardab fed⁻¹. The genotype L86 also recorded superiority by 2.00% for No. of branches plant⁻¹, 49.49% for No. of pods plant⁻¹, 49.44% for No. of seeds plant⁻¹, 42.14% for seed yield plant⁻¹ and 25.15% for seed yield in ardab/fed. A high superiority was found in L94 genotype for No. of pods plant⁻¹ (37.65%), No. of seeds plant⁻¹ (35.10%), seed yield plant⁻¹ (26.46%) and 8.21% superiority for seed yield in ardab fed⁻¹. The tolerant cultivar Misr 1 recorded the highest mean value for 100-seed weight (g) in both seasons as comparing to all genotypes under study. In contrast, the land races L41, L35 and L34 showed lower value than the check cultivar (Misr 1).

From the previous data we can conclude that both landraces L47 and L41 superiority may be related to high ability to produce more branches, pods and number of seeds per plant which is reflected on the improved seed yield. These results are similar to those obtained by Abdalla and Darwish (1999); Abd El-Wahab (2007); Abbes *et al* (2007b); Ashrie *et al* (2010) and Soliman *et al* (2023).

Table 3. Effect of *Orobanche crenata* infestation on yield and yield components of faba bean genotypes at the seasons 2023/24 (1st), 2024/25 (2nd) and the mean of both seasons.

Genotypes	No. of branches plant ⁻¹			No. of pods plant ⁻¹			No. of seeds plant ⁻¹		
	1 st	2 nd	Mean	1 st	2 nd	Mean	1 st	2 nd	Mean
L 47	2.67	2.57	2.62	22.33	25.00	23.67	72.39	82.87	77.63
L 41	2.63	2.47	2.55	15.67	19.00	17.34	49.03	62.81	55.92
L 86	2.63	2.37	2.50	15.00	16.67	15.84	47.18	53.37	50.28
L 94	2.37	2.33	2.35	11.33	14.33	12.83	34.46	43.88	39.17
L 14	2.30	2.20	2.25	9.33	13.00	11.17	27.68	40.25	33.97
L 35	2.00	2.10	2.05	8.00	9.33	8.67	23.67	28.41	26.04
L 34	1.90	1.33	1.62	4.33	5.67	5.00	13.39	17.66	15.53
Misr 1	2.60	2.30	2.45	7.00	9.00	8.00	21.82	29.01	25.42
Sakha 1	2.30	2.20	2.25	5.67	7.33	6.50	17.52	23.83	20.68
Giza 716	1.90	1.67	1.79	3.67	4.33	4.00	11.14	13.79	12.47
L.S.D 0.05	N.S	0.47		2.11	3.70		9.63	7.14	
C.V%	16.66	12.69		12.16	17.56		17.64	10.51	

Table 3.Cont.

Genotypes	Seed yield plant ⁻¹ (g)			100-seed weight (g)			Seed yield ardab fed ⁻¹		
	1 st	2 nd	Mean	1 st	2 nd	Mean	1 st	2 nd	Mean
L 47	67.377	77.450	72.410	93.074	93.464	93.269	6.61	7.44	7.03
L 41	41.613	55.410	48.510	84.879	88.154	86.517	6.03	7.02	6.53
L 86	41.033	47.633	44.330	86.980	89.353	88.167	4.49	5.36	4.93
L 94	30.230	39.530	34.880	80.039	90.081	85.060	3.68	4.36	4.02
L 14	24.107	35.867	29.990	87.097	89.794	88.446	3.37	4.05	3.71
L 35	20.773	25.503	23.140	87.750	89.699	88.725	2.55	3.19	2.87
L 34	11.477	15.473	13.480	85.698	88.922	87.310	1.66	2.29	1.98
Misr 1	22.317	28.987	25.650	102.277	99.993	101.135	3.30	4.08	3.69
Sakha 1	15.783	22.827	19.310	90.088	95.639	92.864	1.74	2.36	2.05
Giza 716	9.983	12.767	11.380	89.590	92.543	91.067	1.58	2.09	1.84
L.S.D 0.05	6.90	6.12		N.S	N.S		1.22	1.56	
C.V%	14.14	9.87		17.64	8.80		20.25	21.46	

N.S = Non significant

Tolerance parameters of *Orobanche crenata* in this study were shown in Table (4), indicated that there was a different response to biotic stress (*Orobanche* parasite) in all genotypes under study; moreover, there were a highly genetic diversity that may be useful in determining the superiority of these genotypes to tolerate *Orobanche* and reduce the damage caused by this dangerous parasite. With regard to date of *Orobanche* emergence character, the tolerant cultivar Misr 1 delayed about two weeks in both seasons as comparing to the susceptible cultivar Giza 716. Also, both values of number of spikes/m² and *Orobanche* dry weight (g/m²) were lower in cultivar Misr 1 than Giza 716. It was clear that both landraces L47

and L41 delayed in the emergence of the parasite *Orobanche* as comparing to Misr 1 cultivar in both seasons. In contrast, the other tested genotypes were early in the emergence of the parasite *Orobanche* as comparing to Misr 1 cultivar.

Table 4. Effect of faba bean genotypes on parameters of *Orobanche crenata* tolerance at the seasons 2023/24 (1st), 2024/25 (2nd) and the mean of both seasons.

Genotypes	Date of <i>Orobanche</i> emergence			No of <i>Orobanche</i> spikes /m ²			<i>Orobanche</i> dry weight (g/m ²)		
	1 st	2 nd	Mean	1 st	2 nd	Mean	1 st	2 nd	Mean
L 47	107.33	107.67	107.50	38.00	36.33	37.17	105.00	105.00	105.00
L 41	105.33	106.67	106.00	47.33	45.67	46.50	389.33	363.33	376.33
L 86	97.67	96.67	97.17	50.33	48.67	49.50	424.00	414.33	419.17
L 94	101.33	100.33	100.83	57.77	56.33	57.05	442.00	427.67	434.84
L 14	97.33	97.67	97.50	58.33	57.67	58.00	507.33	438.67	473.00
L 35	91.33	89.67	90.50	64.33	61.67	63.00	540.00	506.33	523.17
L 34	93.33	91.67	92.50	77.00	73.67	75.34	646.33	617.67	632.00
Misr 1	103.67	105.67	104.67	72.17	67.00	69.59	266.67	234.67	250.67
Sakha 1	100.33	101.33	100.83	81.33	74.67	78.00	578.67	500.00	539.34
Giza 716	91.33	90.33	90.83	98.67	96.67	97.67	666.00	652.67	659.34
L.S.D 0.05	N.S	N.S		15.30	10.71		90.34	145.88	
C.V%	9.88	11.02		13.76	10.10		11.56	19.81	

N.S = Non significant

Moreover, according to the second parameter of tolerance (No. of spikes/m²), it was found that L47 ranked the first in this parameter because it showed a decrease in No. of spikes/m² of about 46.59%. The same trend was found in L41 landrace it exhibited a decrease of about 33.18%. The third parameter of tolerance (dry weight of spikes g/m²) indicated that L47 had high decrease in dry weight of spikes g/m² (58.11%). Moreover, it was clearly noticed that there was a positive relationship between yield characters and tolerance criteria, especially days to first spike, spikes number and spike dry weight. These results are in harmony with those confirmed by Abbes *et al* (2007a, b); Abbes *et al* (2011) and Trabelsi *et al* (2015).

On the other hand, the other tested lines in this study had increased in both No. of spikes/m² and dry weight of spikes (g/m²) in both seasons as comparing to tolerant cultivar Misr 1.

From the data presented in Tables 3 and 4 we can conclude that the lines L47 followed by L41 from Behrira and Ismailia governorates, respectively, produced had higher seed yield as well as lower number and dry weight of *Orobanche* spikes /m² than the commercial cultivar (Misr 1). These landraces are considered as new genetic resources that may be used in breeding programs for *Orobanche* tolerance in faba bean.

Characterization

The Morphological traits for faba bean genotypes under study are presented in Table (5). Intensity of stem anthocyanin coloration was strong in the two tolerant genotypes, Misr 1 and L47 and weak in the two genotypes Giza 716 and L34; the other six genotypes were medium. Anthocyanin is a red–purple flavonoid pigment that accumulates in stems, petioles, and sometimes leaves. Their intensity varies by genotype and can be influenced by stress. It is important in tolerance to *Orobanche* because it provides antioxidant defense, photoprotection, osmotic stability, and links to defensive metabolism. This helps the host remain physiologically vigorous even under heavy parasite pressure, reducing yield loss (Louarn *et al* 2016). Foliage intensity of green color was light in all faba bean genotypes. Leaflet folding refers to the degree of closure or curling of leaflets along the midrib or margins.

Table 5. Morphological traits of studied faba bean genotypes.

Genotypes	Stem anthocyanin coloration	Foliage intensity of green color	Leaflet folding	Flower length	Wing melanin spot
L 47	Strong	Light	Medium	Short	Present
L 41	Medium	Light	Medium	Long	Present
L 86	Medium	Light	Medium	Long	Present
L 94	Medium	Light	Medium	Long	Present
L 14	Medium	Light	Medium	Long	Present
L 35	Medium	Light	Medium	Long	Present
L 34	Weak	Light	Weak	Short	Present
Misir 1	Strong	Light	Medium	Short	Present
Sakha 1	Medium	Light	Medium	Long	Present
Giza 716	Weak	Light	Weak	Short	Present

Leaflet folding is important in tolerance to *Orobanche* infection because it improves water-use efficiency, regulates canopy microclimate, and helps the host maintain photosynthetic activity and yield under parasitic stress (Thebti *et al* 2024). It does not directly prevent attachment of *Orobanche* but contributes to the plant's ability to cope with the infection (Pérez-de-Luque *et al* 2007). Leaflet folding was weak in the highly susceptible genotypes (Giza 716 and L34), while the other genotypes were medium. Flower length is important in tolerance to *Orobanche* because it reflects the host's ability to sustain reproduction under stress, maintain assimilate allocation to flowers, and ensure seed set. It does not reduce parasite attachment (so not resistance), but it supports yield tolerance—

allowing the plant to produce seeds even under infection (Fernández-Aparicio *et al* 2016). Length of flower was short in the four genotypes Misr 1, Giza 716, L47 and L34, while the other six genotypes had long flower. Melanin spot of wing was present in all faba bean genotypes. These data prove that there was diversity among faba bean genotypes collected from different regions of Egypt in this study. These results are in agreement with those found by Arab *et al* (2013), Arab *et al* (2018) and El-Shal and Azza (2019). To sum up, the tolerant genotypes Misr 1 and L47 were characterized by strong stem anthocyanin coloration and medium Leaflet folding.

Heat map Analysis

Breeding new lines are critically important in faba bean breeding under *Orobanche*-infested soil because they offer a sustainable, integrated approach to control the parasitic weed and improve crop yield. By breeding for *Orobanche* tolerance or resistance, new lines reduce reliance on less effective cultural or chemical methods, leading to higher seed yields, better nutritional profiles, and increased profitability for farmers. Evaluating these new lines under infested conditions is crucial to identify those that can perform well despite competition for water, nutrients, and carbohydrates from the parasite (Soliman *et al* 2023).

The combined data of all pervious traits were used to construct two-way hierarchical cluster analysis using Ward's method in order to monitor the relationship among all genotypes under study depending upon yield, yield components, parameters of *Orobanche crenata* tolerance and morphological traits as well as if there are any traits related to each other. According to this analysis, the genotypes under study were distributed into three groups (fig. 1). The first group includes the tolerant genotypes L47 and Misr 1 classified the highest number of branches per plant, number of pods per plant, number of seeds per plant, seed yield per plant, 100-seed weight (g) and seed yield in ardab fed⁻¹. The second group includes the highly susceptible genotypes (L34 and Giza 716) classified the lowest number of branches per plant, number of pods per plant, number of seeds per plant seed yield in ardab fed⁻¹, and the highest number of *Orobanche* spikes per m² and *Orobanche* dry weight.

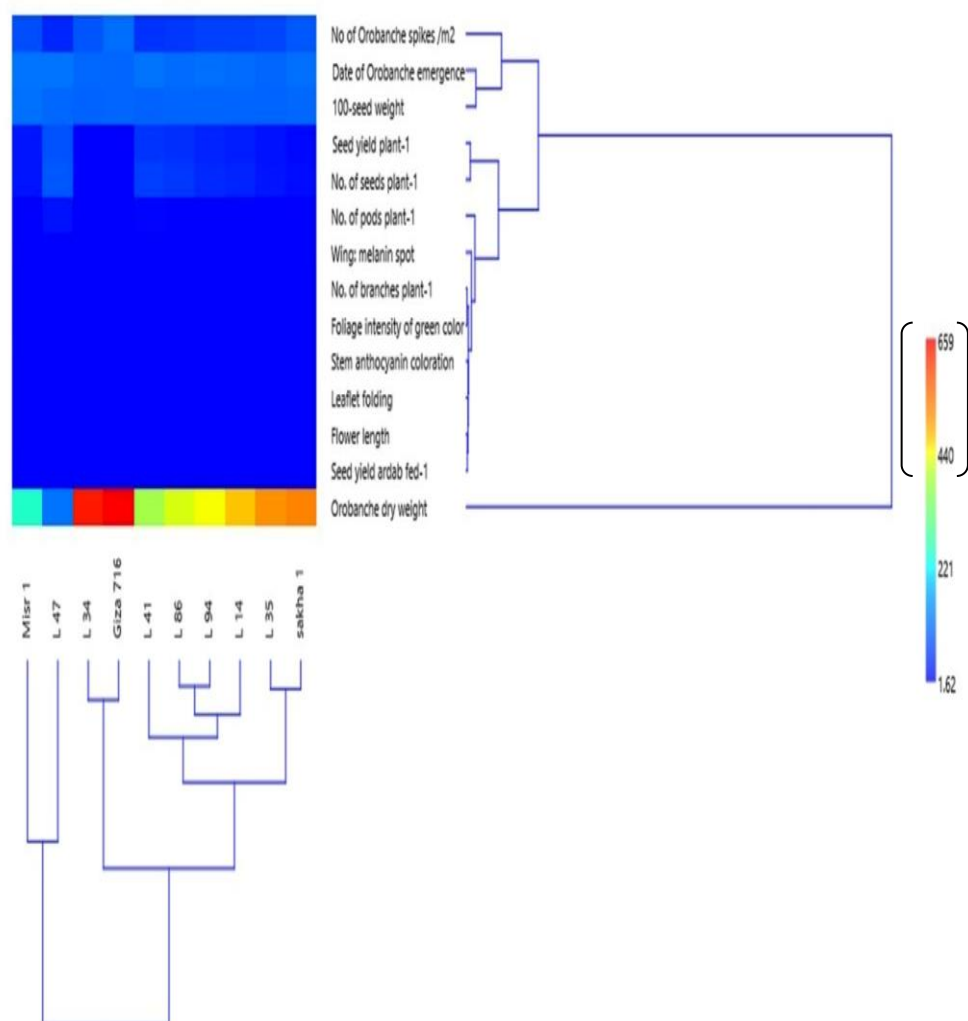


Fig 1. Phonogram showing the relationships between ten genotypes of faba bean using Distance metric of Euclidean correlation coefficient and average linkage method.

The third group includes other genotypes that have moderate values for most traits. This means that the genetic background played significant role in the inheritance of all traits under study and there is a significant genetic diversity among genotypes in relation to the recorded traits in this study. This result is in agreement with that reported by El-Blasy *et al* (2024), who found enrich genetic diversity in faba bean genotypes in relation to chocolate spot disease tolerance traits.

In the second way of clustering, the studied traits were distributed into three groups; the first group included the three traits number of *Orobanche* spikes per m², date of *Orobanche* emergence and 100- seed weight. The second group includes the five traits seed yield / plant, number of seeds/plant, number of pods per plant, number of branches per plant and seed yield ardab fed⁻¹ as well as morphological traits (stem anthocyanin coloration, foliage intensity of green color, leaflet folding, flower length and wing melanin spot). The third group included *Orobanche* dry weight (Figure 1). The most related to each other traits were number of branches per plant, morphological traits and seed yield in ardab fed⁻¹.

A popular graphical method for visualizing the relationship between several variables in biological, environmental, and agricultural research is the heat map. Heat maps make it simple for researchers to find both positive and negative associations between characteristics or parameters in big datasets by using a gradient of colors to indicate correlation coefficients (Friendly 2002; Wilkinson and Friendly 2009). This visual method improves the interpretability of correlation matrices and streamlines intricate statistical relationships, particularly when working with a large number of interconnected variables. For example, heat maps have been used in plant science to show how morphological, physiological, and biochemical traits relate to one another under various stressors (Szymańska *et al* 2017). Such visualizations enhance the selection of potential genotypes in breeding programs in addition to aiding in the detection of critical features that contribute to stress tolerance. Thus, employing a heat map as a correlation analysis design provides an effective, user-friendly, and data-driven way to condense large-scale correlation structures.

REFERENCES

- Abbes, Z., M. Kharrat, P. Delavault, P. Simier and W. Chaibi (2007a).** Field evaluation of the resistance of some faba bean (*Vicia faba* L.) genotypes to the parasitic weed *Orobanche foetida* Poir. Crop Protection 26: 1777-1784.
- Abbes, Z., M. Kharrat, P. Simier and W. Chaibi (2007b).** Characterization of resistance to crenate broomrape (*Orobanche crenata*) in a new small-seeded line of Tunisian Faba Beans. Phytoprotection 88: 83-92.
- Abbes, Z., F. Sellami, M. Amri and M. Kharrat (2011).** Variation in the resistance of some faba bean genotypes to *Orobanche crenata*. Pakistan Journal of Botany 43(4): 2017-2021.
- Abd El-Aty, M. S., M. A. El-Hity, Th. M. Abo Sen, I.A.E. Abd El-Rahaman, O. M. Ibrahim, A. Al-Farga and Amira M. El-Tahan. (2023).** Generation mean analysis, heterosis, and genetic diversity in five Egyptian faba beans and their hybrids. Sustainability 15, 12313.
- Abd El-Wahab, M. M. H. (2007).** Selection for *Orobanche* tolerance in segregating generations of faba bean. M.Sc. Thesis. Faculty of Agricultural, Cairo University, Egypt.
- Abdalla, M. M. F., and D. S. Darwish (1999).** Breeding faba bean for *Orobanche* tolerance using the concept of breeding for uniform resistance. In J. Kroschel, M. Abderabihi, & H. Betz (Eds.), Advances in parasitic weeds control at on-farm level (Vol. II, pp. 205-213).
- Abdalla, M. M. F., M. Shafik, S. Attia and H. Ghannam (2017).** Heterosis, GCA and SCA effects of diallel-cross among six faba bean (*Vicia faba* L.) Genotypes. Asian Res. J. Agric. 4: 1–10.
- Agricultural Statistics (2023) "Winter Crops".** Agriculture Statistics and Economic Sector, Ministry of Agriculture and Land Reclamation, Egypt.
- Arab, S. A., Abeer Elhalwagi and M. H. El Shal (2013).** Morphological and chemical characterization of thirty seven faba bean genotypes. Egypt J. Plant Breed. 17 (5): 97-105.
- Arab, S. A., Azza F. El-Sayed and Marwa Kh. A. Mohamed (2018).** Genetic diversity in some faba bean landraces using morphological characters and yield components. Plant Production, Mansoura Univ. 90 (12): 975 – 980.
- Araújo, M., S. dos Santos, W. Aragão, K. Damasceno-Silva and M. Rocha (2021).** Selection of superior cowpea lines for multi-traits and adaptabilities to the Piauí semi-arid using genotype by yield trait biplot analysis. Ciência Agrotecnol. 45, e011921.
- Ashrie, A. M., E. A. I. Mohamed, A. Helal, Y. M. Abdel-Tawab and E. H. EL-Harty (2010).** Performance of six faba bean genotypes under free and *Orobanche* soils. Egyptian Journal of Plant Breeding 14(2): 189- 205.

- Ayshooa, L., O. Aljubouri and S. Aljubouri (2020).** Effect of Nano H.A Nitrogen and urea fertilizer on growth and yield of two varieties of Broad Bean *Vicia faba* L. Int. J. Agric. Syst. 12: 202–227.
- Bartlett, M. S. (1937).** Properties of sufficiency and sratistical tests. Proceeding of the Royal Statistical Society, Series A160: 268-282.
- Chalker-Scott, L. (1999).** Environmental significance of anthocyanins in plant stress responses. Photochemistry and Photobiology 70(1): 1-9.
- Dryden, I. L. and K. V. Mardia (1998).** Statistical Shape Analysis. Wiley.
- El-Blasy, S. A. S, Azza F. El-Sayed and Doha M. Kandeel (2024).** Evaluation of some faba bean genotypes under infection by chocolate spot disease. Egypt. J. Plant Breed. 28(1):85– 115.
- El-Dabaa, M. A. T., K. H. E. Haggag, and R. A. El Mergawi (2021).** Application of *Trichoderma* Spp. in controlling *Orobanche ramosa* parasitism in chamomile. Middle East Journal of Applied Sciences 11(1): 360-367.
- El-Mergawi, R. and M. El-Dabaa (2025).** *Orobanche crenata* control in three faba bean varieties by soaking seeds in acetylsalicylate solutions. J. Crop Prot. 14 (1): 29-43.
- El-Shal M.H. and Azza F. El-Sayed (2019).** Assessment of some agro-morphological traits in genotypes of Egyptian faba bean (*Vicia faba* L.). AUJAS, Ain Shams Univ., Cairo, Egypt, Special Issue, 27 (1).
- FAOSTAT (2021).** FAOSTAT Data. Retrieved from <http://faostat3.fao.org/browse/FB/CC/E>
- Fernández-Aparicio, M., F. Flores and D. Rubiales (2016).** The effect of *Orobanche crenata* infection severity in faba bean, field pea, and grass pea productivity. Frontiers in Plant Science 7: Article 1409.
- Friendly, M. (2002).** Corrgrams: Exploratory displays for correlation matrices. The American Statistician 56(4): 316–324.
- Gnanasambandam, A., J. Paull, A. Torres, S. K., T. Leonforte, H. Li, X. Zong, T. Yang and M. Materne (2012).** Impact of molecular technologies on faba bean (*Vicia faba* L.) breeding strategies. Agronomy 2: 132-166.
- Gomez, K.A., and, A. A. Gomez (1984).** Statistical Procedures for Agricultural Research. 2nd, (ed). John Wiley and Sons, U.S.A.
- Louarn, J., M. C. Boniface, N. Pouilly, L. Velasco, B. Pérez-Vich, P. Vincourt and S. Muñoz (2016).** Sunflower resistance to broomrape (*Orobanche cumana*) is controlled by specific QTLs for different parasitism stages. Frontiers in Plant Science 7: Article 590.
- Munns, R. and M. Tester (2008).** Mechanisms of salinity tolerance. Annual Review of Plant Biology 59: 651–681.
- Pérez-de-Luque A., M. D. Lozano, M. T. Moreno, P. S. Testillano and D. Rubiales (2007).** Resistance to broomrape (*Orobanche crenata*) in faba bean (*Vicia faba*): cell wall changes associated with prehaustorial defensive mechanisms. Annals of Applied Biology 151(1): 89-98.

- Rubiales, D. and A. Pérez-de-Luque (2012).** Resistance against broomrapes (*Orobanch* spp.) in faba bean (*Vicia faba*) based in low induction of broomrape seed germination. *Euphytica* 186:897–905
- Snedecor, G. W. and W. G. Cochran (1980).** Statistical Methods. (7th ed.) Iowa State University, Iowa, U.S.A.
- Soliman, A. A., M. A. Ibrahim, Salwa M. Mostafa, Amany M. Mohamed and Shymaa F. A. Kalboush (2023).** Evaluation of fifteen faba bean (*Vicia faba* L.) genotypes for *Orobanch crenata* tolerance and foliar diseases resistance. *Egypt. J. Agric. Res.* 101 (3): 997-1006.
- Szymańska, R., I. Ślesak, A. Orzechowska and J. Kruk (2017).** Physiological and biochemical responses to high light and temperature stress in plants. *Environmental and Experimental Botany* 139:165–177.
- Tantawy, A. A. A., S. Sh. Abdullah, Y. A. M. Hefny and A. R. M. Ridwan (2022).** The integrated management of broomrape weed in faba bean under naturally infested soil conditions. *Journal of Sohag Agric. Science (JSAS)* 7(2):154-170.
- Thebti, S., A. Bouallegue, T. Rzigui, Y. En-Nahli, F. Horchani, T. Hosni, M. Kharrat, M. Amri and Z. Abbes (2024)** Potential physiological tolerance mechanisms in faba bean to *Orobanch* spp. parasitism. *Front. Plant Sci.* 15:1497303.
- Trabelsi, I., Z. Abbes, M. Amri and M. Kharrat (2015).** Performance of faba bean genotypes with *Orobanch foetida* Poir. and *Orobanch crenata* Forsk. infestation in Tunisia. *Chilean Journal of Agricultural Research* 75(1), January-March.
- UPOV (2003).** The international union for the protection of new plant varieties, Descriptor for Broad bean. TG/206/1.
- Wilkinson, L. and M. Friendly (2009).** The history of the cluster heat map. *The American Statistician* 63(2), 179–184.

سلوك بعض التراكيب الوراثية من الفول البلدى

تحت ظروف العدوى الطبيعية بالهالوك

عزه فتحى السيد^١، هبه أمين محمد على صالح^١، سليمان عبد المعبود عرب^٢

و مصطفى محمد حسن عبدالوهاب^٣

١. قسم بحوث المحاصيل البقولية - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر.

٢. البنك القومى للجينات - مركز البحوث الزراعية - الجيزة - مصر.

٣. قسم المحاصيل - كلية الزراعة - جامعة القاهرة.

أجريت تجربتان حقليتان فى أرض موبوءة طبيعيا بالهالوك بمحطة بحوث الجيزة، مركز البحوث الزراعية، مصر خلال موسمى ٢٣/٢٠٢٤، ٢٤/٢٠٢٤ لتقييم سبعة تراكيب وراثية من الفول البلدى (L47, L41, L86, L94, L14, L35, L34) بالإضافة الى ثلاثة أصناف محلية (مصر ١، سخا ١ و جيزة ٧١٦). واستخدم تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات فى هذه الدراسة. تم تقدير الصفات المورفولوجية باستخدام المقاييس الموصى بها التي وضعها الاتحاد الدولي لحماية الأصناف الجديدة. أظهرت النتائج أن التراكيب الوراثية L47, L41, L86 حققت زيادة فى صفات المحصول ومكوناته وكذلك نقص فى عدد شماريخ الهالوك/م^٢، وزن الهالوك الجاف جرام/م^٢. كما أظهرت نتائج التحليل العنقودي أن التركيب الوراثي L47 كان أفضل تركيب وراثي لمعظم صفات المحصول ومكوناته لذلك يمكن استخدامه في برامج تربية تحمل الهالوك فى الفول البلدى. كانت الصفات الأكثر ارتباطا ببعضها البعض هي درجة تلوين الأنتوسيانين في الساق، التفاف الأوراق، طول الزهرة، إنتاجية البذور (أردب فدان^{-١})، وبالتالي يمكن استخدام هذه الصفات المورفولوجية في برامج التربية في الفول البلدى كعلامات للاختيار بين التراكيب الوراثية للتحمل للهالوك.

المجلة المصرية لتربية النبات ٢٩ (٢): ٢٠٣-٢١٩ (٢٠٢٥)