Egypt. J. Plant Breed. 6 (1): 143-160 (2002).

FABA BEAN BREEDING IN EGYPT FOR TOLERANCE TO *Orobanche*: A REVIEW

M. M. F. Abdalla and D. S. Darwish
Agronomy Department, Faculty of Agriculture, Cairo University

ABSTRACT

In this review, the published work on breeding faba bean for *Orobanche* tolerance/resistance in Egypt has been summarized. Mention is made to the effects and parasitizm of broomrape. The variability of the host and the parasite, the breeding strategies and screening techniques are presented.

The genetics and nature of host tolerance are recorded. Finally the achievements and the needed cooperation on the national level are also outlined.

Key words: ***Faba bean, Orobanche crenata, Parasitizm, Variability, Breeding, Screening, Nature of tolerance.***

INTRODUCTION

Faba bean *(Vicia faba)* is the most important pulse crop in Egypt. The acreage's and seed yields vary from season and location to another. Therefore, one of the drawbacks affecting this crop is its yield instability. This is attributed to various biotic and abiotic limitations. These limitations include diseases, pests, *Orobanche,* less favourable environments...etc.

Broomrape (*Orobanche crenata*) is an annual plant obligatory parasitic on faba bean and other susceptible hosts in the Mediterranean area. It causes severe losses to the host and in severe cases may result in a crop failure. *Orobanche* species lack chlorophyll and thus unable to live independently. Losses of faba bean yield due to *Orobanche* parasitizm may reach 100 % (Darwish 1987 and Zaitoun 1990). The degree of yield losses vary according to host genotype, level of parasitizm, sowing date, soil moisture and many other factors (Nassib *et al* 1979 and 1982, Abdalla 1982, Darwish 1987, Zaitoun 1990, Darwish 1991 a, b and c, Abdalla and Fischbeck 1992b and Abdalla and Darwish 1996a and 1999). Therefore, the control of broomrape will help to improve the production and stability of faba bean yield.

Control of *Orobanche* is not easy due to its production of huge amounts of tiny, long-lived seeds which are dispersed by wind and other means. Also, the seeds remain alive for several years in soils until germinated by secreted stimulant/s of proper host/s. Different methods were suggested to control *Orobanche* and/or alleviate its effects. These include cultural practices such as hand pulling, deep ploughing or zero tillage, irrigation/flooding, crop rotation including trap or catch crops, delayed sowing, fertilizers, soil solarization, biological control, chemical control, soil fumigation, use of suicidal germination stimulants, using tolerant hosts and integrated control. Unfortunately, majority of these methods do not offer satisfactory results to control this parasitic weed and in some regions the problem tends to be catastrophic. Breeding resistant/tolerant genotypes may provide a reliable measure of protection against *Orobanche* (Nassib *et al* 1982, Abdalla 1982, Darwish 1987, Radwan *et al* 1988 a and b, Abdalla and Fischbeck 1992b, Abdalla and Darwish 1994, 1996b and 1999, Khalil *et al* 1994 and Saber *et al* 1999).

The improvement of faba bean yield and stability could be achieved by reducing cultivars susceptibility to various limiting stresses such as *Orobanche* parasite. This should be considered an important goal to faba bean breeders. This article reports the previous and current status of faba bean breeding to broomrape tolerance in Egypt.

1-*Orobanche* Parasitizm

The tiny seeds of *Orobanche* remain viable for a long time in the soil until germinated by stimulant(s) secreted by suitable host(s). The host secretes such stimulant just before its flowering stage (Kadry and Tewfic 1956a and Abou-Raya *et al* 1973). Germinating seed give rise to a small tube-like organ, which upon contact with the host partially penetrates the host root and develops into a primary haustoium. Meanwhile those parts of the tube remaining outside the host root enlarge to form a tubercle from which numerous rootlike organs arise. These roots are not adapted to a direct uptake of water from soil. Rather, they are able to attack other host roots and produce secondary haustoria (Kadry and Tewfic 1956 b). Nutritive materials are channeled from the host to the parasite through the haustoria. A few days after the onset of host plants flowering, "signs" of drought of host appear as an indication of the start of *Orobanche* parasitizm (Abdalla 1982, Darwish 1982 and Abdalla *et al* 1982). Leaves of the host become faintly greenish, plant development ceased and drooping of leaves may occur. A single stem apex develops from the parasite tubercle carries a terminal floral spike that emerges from the soil indicating the presence and function of the parasite. *Orobanche* becomes more developed and vigorous. Signs of depleted metabolites, poor vegetative growth, almost absence of generative organs growth, dryness and death of some host plants, nourishment of *Orobanche* are observed and more spikes are observed above soil surface.. A few weeks' later, all susceptible hosts will show total failure, die and the picture of the field will show poor developed (or dead) host plants and spread of weeds due to lost host plants and absence of competition. Flowering, seed formation and dryness of *Orobanche* plants culminate parasite growth (Abdalla 1982).

2-Variability of Host and Breeding Strategies

Many Egyptian scientists reported the variability among faba bean genotypes to *Orobanche crenata* parasitizm. They reported about host stocks that exhibit relatively more tolerance to broomrape with more or less normal development and pod set, associated with poor and late parasite development, in addition to very severe susceptible hosts and different intermediate reactions (similar to performance of reaction to quantitative characters).

Nassib *et al* (1979) selected *Orobanche* free and less infected plants for progeny test. Differences in *Orobanche* infection occurred within selected families. Selected tolerant lines in progenies reached 44.05 % compared to 21 % in non-selected entries. A stock (F-402) was reported to be highly tolerant to *Orobanche* and was afterwards commercially released as cultivar Giza 402.

Abdalla (1982 & 1992) and Abdalla and Fischbeck (1992b) evaluated 209 land races from 16 Governorates in the *Orobanche* nursery. They found wide variability among and within land races for tolerance to *Orobanche*. The authors suggested in the breeding programmes to avoid selecting *Orobanche*-free plants which may be escapes and strongly recommended selection criterion based on the concept of breeding for uniform resistance. In this respect selection favoured tolerant plants that were weakly parasitized by *Orobanche*, but maintained normal growth and development and carried pods containing seeds. Relative yields of hosts in the *Orobanche* field compared to those of free field were taken into consideration. Abdalla (1982) summarized data of more than 17.000 plants grown in *Orobanche* nursery, in Cairo University. Counting the appearing *Orobanche* spikes above soil surface on the fourth week of March showed differences between land races from same Governorate and from different ones. Samples collected from El-Faiyum Governorate had 3 times as many *Orobanche* as a sample from New Valley (190 against 65 spikes/ridge, respectively). Land races from Kualyubia had an average spikes of 163/ridge whereas average range of individual land races varied from 19-399 spikes/ridge. The percentages of surviving plants and their yields were also determined (Abdalla 1982). In all land races, tolerant and susceptible plants were found. Percentage of surviving plants till harvest varied from 18 % (New Valley Governorate) to 39 % (Sohag). Within Sohag Governorate land races, percentages varied from 15 to 42 %. Considering seed yield per plant in the *Orobanche* field relative to sister plants grown in uncontaminated plots, wide ranges were observed. Average Governorates indicated 85 % for New Valley and 13 % for El-Faiyum. The within Governorates data expressed wider variability. For instance Beni Suef Governorate has relative seed yield that ranges of 0 to 102 %. In conclusion, variability of land races with respect to *Orobanche* tolerance, was encouraging to use the local germplasm for breeding against the parasite. In addition, quantitative reaction of performance indicates possibility of quantitative inheritance of tolerance to *Orobanche*. A strategy to develop new varieties were recommended by Abdalla and Fischbeck (1992a). It is based on: a) selecting the best yielding local genotypes, b) blend is made from the best stocks experimented under different conditions, c) the blend of b is distributed to farmers and d) every farmer selects and multiplies his own seed stock year after year.

Ibrahim *et al* (1979) scoring for *Orobanche* attack, gave variety Giza 4 the score of 100, Rebaya 40 (55) and Family 402 (21). Both Giza 4 and Rebaya 40 are not *Orobanche* tolerant. The previous reports confirm the possibility of quantitative inheritance of tolerance to broomrape. It is therefore logic that Abdalla (1982) recommends selecting faba bean for tolerance and thereafter raising the level of tolerance through appropriate handling of the materials.

Darwish (1982) and Abdalla *et al* (1982& 1983) tested 49 faba bean genotypes in the *Orobanche* nursery. They reported that some host stocks relatively tolerated broomrape than others and remained healthy with normal development and pod set and the poor developed parasite appeared later in season.

Darwish (1987) and Radwan *et al* (1988a) reported on effects of selection for *Orobanche* tolerance between land races (LR) or between and within LR or single-plant selection. The original 86 LR had wide variation expressed in the following ranges: 0.9-14.4 (*Orobanche* spikes/plant at 139 days), 0.0-71.5 % (dead plants), 3.6 – 79.2 % (green podless plants), 0.0 – 89.3 % (podded plants), 0.0 – 14.9 (pods/plant), 0.0 – 29.3 g (seed yield/plant) and a vigour score of 1.0 – 4.5 (score of *Orobanche* tolerance where scale 1- dead and 5 green strong plants). This refers to the quantitative variability and reaction of the host LR to parasitizm. They found that individual-plant selection and selection between and within lots are more efficient than selection only among lots. Inbreeding (obtaining seeds from caged-grown plants) was reported to improve tolerance as due to recessive genes controlling *Orobanche* tolerance. The authors recommended for breeding to *Orobanche* tolerance to: a) selection between and within host materials, b) intercrossing tolerant selections for 1-2 generations to increase recombinations, c) resultant populations from b are subjected to 1-2 generations of inbreeding, and d) practicing individual-plant selection for tolerance.

Darwish (1991c) found that inbreeding might contribute to variation for *Orobanche* tolerance in faba bean and host's defensive action increased due to homozygosity, whereas the performance was strengthened by heterozygosity. He suggested a strategy for developing tolerant cultivars by selecting among inbreds for lower expression of parasitism and then composing the highly combined ones.

Radwan and Darwish (1989 & 1991) analyzed the genetic potential of 10 lines for tolerance by polycross test. They found that the lines have wide differences in combining ability for tolerance. The genetic potential of lines for tolerance showed that lines posses intrinsic differences in tolerance that may or may not be transmitted to their cross progeny. They suggested the assessment of general combining ability of tolerant screened lines to detect the beneficial heterozygotic effects in order to build tolerant synthetics.

Darwish (1992) evaluated some well combined tested faba bean genotypes (6 stocks) and their composite (Syn-1) in *Orobanche* and free conditions to detect the effect of composing such parents on performance and stability. He found that Syn-1 yielded better than the mean of all parents in 15 environments. However, some parents outyielded the synthetic in some environments. The best parent was not always the same. Moreover, Syn-1 was the most stable compared to other parental stocks. The previous faba bean synthetic (Cairo 1 variety) was evaluated for later Syn generations relative to its parental genotypes under *Orobanche* - free and infested conditions (Darwish and Abdalla 1994), in addition to elucidating the stability performance using various parameters (Darwish 1996). The synthetic variety was the most stable stock and it showed better performance than its parents over environments.

Abdalla and Fischbeck (1992b) reported on early work done in the eighties on selection for tolerance to *Orobanche* in faba bean, which was practiced in parasitized host plants that relatively produced good yield. They found that the frequency of tolerant plants were higher in selfed progenies of land races. The authors proposed to upgrade tolerance and to combine different genes from local and exotic stocks that may be differing in genetic background in order to build up high level of uniform resistance.

Abdalla and Darwish (1994) found that the level of tolerance could be upgraded by selection in local material. They reported that low parasitism was generally accompanied by relatively better host growth, more percentage of podded plants and higher seed yield (see also Abdalla and Darwish 1996a).

Khalil *et al* (1994) evaluated a total of 408 families with other checks for *Orobanche* tolerance. They used the pedigree method for screening and evaluation within and between crosses. They found that four breeding lines were significantly less infested by *Orobanche* and gave higher yields than the susceptible checks.

Abdalla (1996) reported on screening and selection for *Orobanche* tolerance in land races which is based on the concept of breeding for uniform resistance. Quantitative host reaction was observed. Selection between and within entries and progeny and bulk selection was used to develop tolerant stocks.

Based on the concept of breeding for uniform resistance a blend of most tolerant land races was grown for intercrossing in the apiary for two seasons (Abdalla and Darwish 1996b and 1999). The resultant population was exposed to infestation and the most tolerant progenies were selected and their progenies were tested for *Orobanche* tolerance. The best 32 progeny rows of 5th selected generation were studied for their performance either in *Orobanche* infested nursery or in free field and their stability across both conditions. None of the progenies were significantly inferior in the traits than checks in the *Orobanche* field, whereas a great number of them exhibited significantly favourable performance which encouraged bulking them for composing a new variety named" Cairo 2".

The search for uniform resistance applies the use of stocks with different genetic backgrounds to "accumulate" direct or indirect genes (characters) conferring tolerance through polycrosses which induce needed heterogeneity (Abdalla and Darwish 1999). Selection between and within progenies resulted in better performance concerning parasitism level, podded hosts % and seed yield under *Orobanche* infestation. Another cycle of selection (1998/1999 season) for more than 200 individuals resulted in less parasitizm level accompanied by high yield. Reevaluation of such selections during 1999/2000 and 2000/2001 showed that 24 progenies had significantly higher yield than all checks (unpublished data). Moreover, two families, i.e. 18 Hyto and 24 Hyto recorded under infestation 2 folds of seed yield as much as produced by all checks. Further large scale evaluations under different conditions are needed.

Variation in the parasite populations, the environments and their interactions with the host genotypes may results in performance instability. Studying the performance of different host genotypes under *Orobanche* infestation over various environments may provide useful information for planning breeding programmes and detecting tolerant stable hosts. In this concern Attia (1998) and Abdalla *et al* (1998) evaluated in naturally heavily infested soils with *Orobanche*, at Giza, Faiyoum and Sids locations twelve faba bean genotypes (Giza 2, G. 3, G.402, G.429, G.674, Giza Blanca, Cairo 1, C.241, L.101, P.11, X- 843 and BPL536) compared to glyphosate application as a check treatment. Environments, genotypes and genotypes x environments interactions were highly significant sources of variation. The studied genotypes varied greatly for the stability of their characters. The highly podded host stocks or those having high parasite rates showed lower environmental variances. *Orobanche* tolerance expressed in high podded plants percentage may be reflected in stability performance of this trait.

Ahmed *et al* (2001) studied seven Assiut breeding lines. Days to appearance of *Orobanche* varied from 70 to 76 days after faba bean sowing and dense sowing (100 seeds/m^2) showed more numbers and taller *Orobanche* spikes than lower density (50 seeds/m^2). Broomrape infestation affected plant and yield characteristics to different degrees and the authors recommended forcasting losses of parasitized faba bean by percentages of dead and podless plants in different lines. Higher numbers of *Orobanche* wiped the host plants, intermediate numbers resulted in podless plants whereas lowest numbers of *Orobanche* gave plants carrying pods. It is therefore clear that quantitative effects control host-parasite interaction. The data presented by the authors indicated absence of significant differences between the different lines concerning interaction with *Orobanche*. It therefore seems that all genotypes were generally tolerant (susceptible) to the broomrape. There were no check genotypes grown in healthy plot for comparison with parasitized plants in order to quantify deterioration due to *Orobanche* parasitizm.

3- Variability of Parasite

Radwan *et al* (1988b) (see also Fischbeck *et al* 1986) reported on 3 pot experiments where 22 faba bean lines were used against 9 "accessions" of *Orobanche*, 8 of which were collected from 5 Governorates from Egypt and the ninth was obtained through ICARDA (Syria). Different host characteristics were investigated: plant height, tillers, leaves, flowering nodes, podded nodes, pods, seeds, seed yield, dry weight and harvest index in addition to *Orobanche* shoots per plant. Data were collected at one through 7 dates according to characters. Variation was found for host lines, parasite accessions and line x accession interactions. Numbers of *Orobanche* spikes (shoots) were affected by host line and/or parasite accession. Variation in the early count of the parasite was mainly determined by differences among accessions, whereas differences among host lines were mainly responsible for variation in later counts of the parasite. The authors reported clear differences in "aggressiveness" among parasite accessions on vegetative and reproductive growth of hosts. They found weak relationship between number of *Orobanche* spikes and parasite damage (from a particular accession) and consequently concluded that numbers alone are not satisfactory measure of aggressiveness or host tolerance. However, one has to keep in mind that host damage is not only confined to yield losses. In addition, *Orobanche* performance would not be completely and satisfactory measured when 4 host plants are grown in a pot.

Radwan *et al* (1988b) elaborated the relative parasitizm index (RPI) where *Orobanche* numbers were adjusted to host vigor grown in plots free of *Orobanche* (RPI = numbers of *Orobanche* spikes per parasitized plant for each 100 g unit of dry weight of host grown in plots free of the parasite). Using RPI, extent of seed yield depression and the most aggressive *Orobanche* accession No. 10 (from Faiyum Governorate), the authors distinguished 4 patterns of host-parasite reactions, three tolerant and one susceptible. Although this is a simplification of reaction, but the authors did not rule out possibility of quantitative differences.

Abdalla and Fischbeck (1992b) reported on studies that were carried out during 1979-1981 on local Egyptian land races of faba beans and their interaction with *Orobanche*. Numbers of *Orobanche* spikes per ridge (studies on 18 land races from 12 Governorates) varied from 17 to 364. Investigated four plants lifted at random from each land race indicated that *Orobanche* was not evenly distributed on host plants. Some land races (No. 241, 289 and 342) maintained *Orobanche* with single spikes whereas others were parasitized by multispiked broomrape. It is interesting to report here that Land Race 241 was-after different studies-propagated as variety Cairo 241.

Variation in fresh and dry weight of *Orobanche* per host plant was also reported by Abdalla and Fischbeck (1992b). *Orobanche* parasitizing a faba bean plant had a fresh weight that ranged from 13-114 g and a dry weight from 2-14 g. Variation in colour and growth of *Orobanche* was also observed. About 70 % of host plants were lost due to parasitizm. Surviving plants varied from less than 10 % to more than 60 % in different land races and relative yield of host plants grown in *Orobanche* infested plots to plants grown in healthy plots varied from 1 % (12 % land races) to more than 75 %. (0.6 % land races). Inbreeding (one generation) improved the last category to nine folds. Variation of host and parasite and their interaction was reported.

Zeid (1997) and Nawar *et al* (1999) studied the parasitic ability of three broomrape accessions collected from El-Behera Governorate for their effects on growth and yield of Giza 3 and G.429 faba bean cultivars. Accessions varied significantly in total and living *Orobanche* spikes and dry weight/plant at pod set (at day 70) and pre-ripening (at day 95) and in the number of spikes/plant at the second stage only. Accessions varied in their effects on seed yield of the reported resistant cultivar (G.429), whereas they severely reduced the seed yield of susceptible Giza 3. However, Zeid (1997) did not find variation among the three *Orobanche* accessions regarding seed viability and chemotaxonomical approaches (SDS-polyacrylamide gel and RAPD of DNA analysis).

4-Screening Techniques

Host reaction to the parasite may be classified into the following broad classes:

a) parasitized plants that become dry and eventually die (wiped plants).
b) parasitized plants that remain unhealthy greenish and yellowish and severely suffer from wiped generative organs (flowers and pods) (podless plants).
c) parasitized plants that carry one or a few pods.
d) relatively and poorly parasitized plants that carry more pods than (c) and appear normally, and
e) non-parasitized plants that grow normally with good pod set.

The last category might be immune or escape plants.

The selection criteria of faba bean to tolerate/resist *Orobanche* vary from one institute to another. Several scientists consider the numbers of broomrape parasitizing a plant (spikes appearing above soil surface) as index of host reaction (Nassib *et al* 1979 and El-Hosary and Sedhom 1990) where more numbers indicates host susceptibility. On the other hand Radwan *et al* (1988b) reporting on pot experiments found weak association between number of *Orobanche* spikes (from a particular *Orobanche* accession) and host damage. Therefore, they concluded that numbers alone are not satisfactory measure of parasite aggressiveness or host tolerance. Pertinent to this, Abdalla (1982) observed that when few *Orobanche* spikes were present on a susceptible host plant, they were generally taller, thicker and heavier than when many spikes were present. Moreover, the experience is that very susceptible hosts support few *Orobanche* spikes because they dry and die early in season. In addition, tolerant plants are generally slightly parasitized and *Orobanche* spikes appear later in season almost by the end of the generative growth. Such tolerant plants were selected by (Abdalla 1982) and the relative yield of infected-compared to yield of free plants are considered in final selection. The end result is that selection of these tolerant plants will be analogous to selection for uniform resistance (Abdalla and Hermsen 1971).

Attia (1998) and Abdalla *et al* (1998) used recommended glyphosate herbicide as check treatment in twelve faba bean genotypes at three locations. However, the tested genotypes responded differently to the glyphosate application in different locations and season. They also responded differently when tested in the *Orobanche* field without glyphosate application. The variation of faba bean land races to glyphostae doses was previously reported by Darwish (1982) and Abdalla *et al* (1983).

Nassib *et al* (1979 and 1982) used the number and dry weight of *Orobanche* stems as well as the percentage of *Orobanche* infected or free host plants as measures of *Orobanche* resistance.

Abdalla (1982), Darwish (1982), Darwish (1987) and Radwan *et al* (1988a) used both the number of *Orobanche* spikes and the percentage of yield reduction of infested plants compared to free ones as measures of tolerance.

Darwish (1991b) studied the validity of 9 measurements for tolerance: dry weight and seed yield of infested host plant, percent of podded plants, number and dry weight of broomrape shoots per host and per ridge, percent depression due to *Orobanche* for plant dry weight and seed yield and relative parasitism index (RPI). He recommended the use of percent plant dry weight and seed yield depression. This requires that genotypes be simultaneously grown in the broomrape nursery and in parasite free condition. The percent of podded plants proved a reliable measure of tolerance and reflects host genotypic differences. The allocation of field resources in screening faba beans for broomrape tolerance was studied also. The author analyzed the variance of tolerance measurements carried out on one or more rows per plot assuming seven-plot types. He found that using of two border rows/plot was best for detecting of differences. The estimated minimum number of replications ranged from 6-37 according to the tolerance measurement for estimating the magnitude of true differences between genotypes. The author concluded that plot size and number of replications that economize on resources would be satisfactory, if interest is in ranking a group of lines rather than estimation of true differences.

Nassib *et al* (1979) described a screening technique to host resistance. It involves inoculating the root mass of a 25-day old plant in a soil core of 5-cm diameter with sufficient *Orobanche* seed and then growing the plant in 25-cm pot under irrigation.

Darwish (1991a) studied the influence of various methods and rates of broomrape infection on faba beans. Broomrape seeds were either mixed with soil or placed in layers one-third or two-thirds down the soil profile at rates of 0.0, 125, 250 and 500 mg seeds/pot. The infection method did not significantly affect host performance. The differences due to host stocks and infection rates were significant, but the among host stocks were less obvious by increasing the rate of infestation.

Fadel (1994) studied the validity of five screening procedures of faba beans for *Orobanche* tolerance. The performance of selected populations fluctuated among seasons. Therefore, the selection of infested podded plants in insect- proof cages and the continuity of progeny tests for tolerance may be reflected in accumulation of favourable genes as confirmed by Abdalla and Darwish (1996a), however, depression due to inbreeding effects has to be circumvented.

5-Genetics of Host Resistance/Tolerance

Abdalla (1982) reported that tolerance (or resistance) to *Orobanche* seems to be a quantitative trait controlled by a complex genetic system.

Darwish (1987), Radwan *et al* (1988b) and Radwan and Darwish (1991) concluded that host parents have different sets of genes conditioning different tolerance expressions and that different genes govern different patterns of host/parasite reactions.

Abdalla and Darwish (1994) pointed out that the genetics of faba bean host tolerance to *Orobanche* and the parasitizm against the host may not be a simple one. Tolerant plants were selected from both "tolerant" and "susceptible" stocks. Both segregated into tolerant and "susceptible" plants (with different frequencies) upon reaction to *Orobanche*.

Abd El-Halim (1994) studied the inheritance of faba bean resistance/tolerance to *Orobanche crenata* by means of six-population method of two crosses. Rebaya 40 × Giza 2 (susceptible × susceptible) and

Rebaya 40 × Giza 402 (susceptible × tolerant). The data fitted the additive - dominance model of quantitative characters and the additive effect was highly significant. The number of factors affecting the resistance was reported to be 10.8 pairs of genes in the cross R 40 × G. 402 and 23.6 pairs of genes (or gene groups) in the other cross. Surprising is the fact that the other cross is a reaction of susceptible x susceptible parents.

Attia (1998) and Darwish *et al* (1999) used eight faba bean genotypes (Giza 429, Giza 674, X-843, Cairo 241, BPL 536, Giza Blanca, Giza 461 and Giza 3) as parents for diallel mating design. The eight parental genotypes and the 28 F_2's were evaluated. Results indicated that the parents could be classified into two groups: tolerant (G. 429, G. 674, X-843, C. 241 and BPL536) and susceptible (G.B, G.461 and G. 3). None of the F_2 crosses involving the three tolerant genotypes (Giza 429, Giza 674 and X-843) exceeded their respective parents in the mean seed yield. All F_2 crosses having the three susceptible genotypes as common parents recorded higher mean seed yield than their parents except two crosses. Mean squares for GCA were highly significant for all studied traits except number and dry weight of *Orobanche* heads per host plant. However, mean squares for SCA was only significant for plant height, number of branches and seeds per host plant. Results pointed out that the inheritance of parasitizm was not simple. Recessive quantitative genes conferring resistance/tolerance may be present in both tolerant and susceptible combinations. They may contribute directly or indirectly to the expression of the tolerance/ resistance.

Zayed (1995) crossed 4 faba bean parents. Number of broomrapes per host parent varied from 1.6 to 5.8 and average of F_1 was 1.5 (from 0.6 to 3.0). The author reported that additive, dominance, over dominance, major gene and polygenes are operating in determining number of broomrapes per host plant.

6-Nature of Host Resistance/Tolerance

Nassib *et al* (1979) ascribed the resistance of F 402 compared to susceptible stocks, to less production of the germination stimulant, establishment of mechanical and physiological barriers, slowing root tap growth, less production of lateral roots and more compact root mass.

Darwish (1987) pointed out that the host may interfere with the development of the parasite at three different stages of its life cycle viz., germination, tube penetration of host root and after the parasite has established itself in the host. During germination, host resistance would be displayed by lack or reduced excretion of the germination stimulant. Difficulty in the penetration of the haustorium may be partly mechanical or by inhibiting enzymatic processes by which the parasite establishes itself in the host root tissues. Once the parasite has established itself, the host may arrest or hamper further development of the tubercle.

Radwan *et al* (1988b) distinguished four different patterns of reaction based on the level of parasitism and the extent of seed yield depression. The host ability to reduce the number of established parasite shoots were reactions 1 & 2. The host defensive counteractions against established parasites were manifested in reactions 1 and 3. The fourth pattern of reaction, i.e. susceptibility was the host's inability either to reduce establishment or hamper the development of the established parasite.

Zaitoun (1990) found that, irrespective of the severity of infections, the earlier infection increased the susceptibility of the host plant.

The resistance mechanism in "G. 402" was thought to be a mechanical hindrance preventing the penetration of the parasite (Zaitoun *et al* 1991). Zaitoun and ter Borg (1994) found 3 levels of resistance mechanism of faba bean to *Orobanche crenata* infection: necrosis of host cells prevented broomrape intrusion before or after penetration or after the development of a small tubercle. The authors reported that the reactions of faba bean were hypersensitivity at the flowering stage and partial resistance at ripening. Attia (1992) reported an active secondary growth and early rupture of the endodermis in susceptible Giza 2, whereas the endodermis remained intact with thick cell walls in other tolerant genotypes, due to reduced secondary growth.

7-Achievements and Future Prospects

At present ARC has 14 improved varieties under distribution (Giza 2, G. 3 improved, G. 461, G. 714, G. 716, G. 717, G. 643, G. 402, G. 429, G. 674, G. 843, Nubaria 1, Sakha 1 and Misr 1). Five of them are reported to be *Orobanche* tolerant (G. 402, G. 429, G. 674, G. 843 and Misr 1). The rest except G. 2 are recorded as foliar disease resistant. Agronomy Department of Cairo University developed 4 varieties (Cairo 1, C. 375, C. 241 and C. 2). Three of them except (C. 375) are *Orobanche* tolerant. Ten promising varieties are known in Assuit University, five of which are *Orobanche* tolerant.

Irrespective of achievements, progress is still unfortunately slow. This is a warning and a challenge to the breeders. The host, the parasite and the environment are variables. Much information is still lacking concerning this triangle interaction, the factors behind tolerance, the factors behind aggressiveness/virulence and the different screening and selection methodologies. As both the faba bean host and the *Orobanche* parasite are variable, national cooperation is badly needed in the field of host-parasite investigation in particular to the followings, which are quoted from Abdalla and Darwish (1999):

1. study the *Orobanche* "factors" of parasitism: presence of races or biotypes, their virulence and aggressiveness, their distribution and development, genetics of the parasitism, etc.;
2. elucidate the host-parasite interaction and the role of the environmental factors affecting host, parasite and their interaction;
3. develop selection criteria for tolerance or resistance.;
4. breed tolerant or resistant stocks.

Hence the cooperation and coordination are necessary among all interested institutes to develop a "breakthrough" high yielding varieties of faba bean particularly under *Orobanche* infestation and other stresses.

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تربية الفول البلدى فى مصر لتحمل الهالوك: استعراض للبحوث

مظهر محمد فوزى عبد الله-درويش صالح درويش
قسم المحاصيل-كلية الزراعة-جامعة القاهرة

تم فى هذه المقالة حصر البحوث المتعلقة بتربية الفول البلدى فى مصر بالنسبة لتحمل/مقاومة الهالوك. وفى هذا الشأن وضحت خطورة الهالوك وقدرة بذوره على البقاء حيه فى التربة فترات طويلة ثم كيفية تطفله على نبات الفول والتباينات التى تم دراستها فى العائل، واظهرت الدراسات أن السلالات المحلية من الفول البلدى تتباين فى تأثرها بالهالوك كما أنها يمكن أن ينتخب منها اصولا تتحمل الهالوك.

كما تم استعراض استراتيجيات تربية الأصناف المتحملة للهالوك والتى تعتمد على الانتخاب مع اختبارات النسل اللازمة ثم خلط تلك الانسال المتحملة معا بحيث يخلط فقط الانسال ذات المحصول المرتفع ويفضل أن تكون ذات قدرة عالية على التالف ما أمكن ذلك.

وعلى الرغم انه يوجد فى هذا الشان عدد من الأصناف المقاومة للهالوك التى استنبطت بواسطة مركز البحوث الزراعية وكلية الزراعة جامعة القاهرة وكلية الزراعة جامعة أسيوط إلا أن الإنجازات فى هذا الصدد ما زالت دون المستوى المطلوب مما يستدعى التعاون والتنسيق بين كافة المعاهد البحثية على المستوى القومى فى هذا المجال.

كذلك تم الإشارة الى التباينات فى الطفيل والطرق المختلفة المستخدمة فى تقدير المقاومة او التحمل للهالوك وظهر ان الطفيل يتباين وراثيا فى قدرته التطفلية على العائل كما ان طرق اختبار وتقدير المقاومة تختلف من مكان الى آخر وبالنسبة لطبيعة واختبار المقاومة فمازالت تستدعى التوسع والتعمق البحثى للوصول الى توحيد الطرق ما أمكن وتأكيد العوامل المؤثرة فى طبيعة المقاومة للهالوك.

المجلة المصرية لتربية النبات ٦ (١): ١٤٣-١٦٠ (٢٠٠٢).