Is *Vicia faba* population affected by parasitism from *Orobanche crenata* more than by competition from non-parasitic weeds?

Má parazitismus *Orobanche crenata* větší vliv na sezónní vývoj *Vicia faba* než konkurence společenstva neparazitických plevelů?

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Three experimental treatments were used to compare the growth and production of broadbean (*Vicia faba* cv. Giza 2), i.e. (1) in pure culture, (2) infected with the Mediterranean broomrape *Orobanche crenata*, and, (3) under competition with spontaneously grown multispecies community of non-parasitic weeds. The experiment was carried out in a glasshouse from March to July (in Central Bohemia, Czech Republic). The results suggest that the competitive effect of non-parasitic weeds on the broadbean yield and other parameters measured was, under the given conditions, more pronounced than the effect of broomrape parasite.

Keywords: *Orobanche crenata, Vicia faba*, non-parasitic weeds, parasitism, competition, glasshouse experiment, Czech Republic, Egypt

Introduction

It has been known that the flowering parasitic species of *Orobanche* prefer open sunny habitats and are independent of mineral richness of soils (ter Borg 1986). This is the reason why, during the long history of human civilization, their massive spread was supported by extensive agriculture of the mediterranean regions. *Orobanche crenata* Forsk. belongs to the fast-dispersed species. It is a particularly harmful weed species, affecting legume crops in Egypt and other countries surrounding the Mediterranean Sea.

Under heavy infection, the yield losses in susceptible crop species can reach as much as 100 % (López-Granados et García-Torres 1993a). When the ratio between *Orobanche crenata* and *Vicia faba* individuals is 4:1, the yield of the crop plant may be reduced by 50 % (Jain et Foy 1989). There is a body of literature on the host/parasite (crop/broomrape) relationships. Experiments of different type investigated the effect of seed density on the degree of broomrape infection (Pieters et Aalders 1986), mechanisms of crop plant resistance to the broomrape infection (Aalders et Pieters 1987), different responses of the broadbean to varying intensity of the broomrape infection (Radwan et al. 1988), relationships concerning the seed vitality and the seed bank (López-Granados et García-Torrés 1993b), and other aspects. Recently, quantitative evaluations of available data appeared more frequently (Jacobson et Marcus 1988) but are still urgently needed.

A simple question has been addressed in majority of studies on the interference between crops and weeds, i.e. is it parasitism or competition what influences more the crop plant? However, this problem is very rarely touched experimentally. In this glasshouse study, the parasite (*Orobanche crenata*) effects on the crop species (broadbean, *Vicia faba*) are compared with the competitive effects of a community of common non-parasitic weed species. The study also addresses further questions: Is there a direct relationship between the biomass of broadbean and that of broomrape, as manifested in the latter's stem biomass? How does the shoot number depend on either the presence of the parasite, or the interspecific competition?

Material and methods

The experiment was carried out in a glasshouse. Plants were grown in commonly used, homogenized garden mixture of soil and compost, equally spread over the experimental bed. *Vicia faba* L. cv. Giza 2 was used as a crop plant, *Orobanche crenata* Forsk. as a parasite; both were of Egyptian origin (used for experiments in National Research Centre, Dokki-Cairo). The crop plant was cultivated in the same pattern as often found in fields in the river Nile delta: the individual broadbean seeds were inserted into soil in 0.3 × 0.3 m span. The aim of the experiment was to compare (1) culture of *Vicia faba* free of the influence of other plants (= control), (2) culture of *V. faba* infected only with the parasite *Orobanche crenata*, and (3) culture of *V. faba* not infected by *O. crenata*, but affected by non-parasitic weeds.

Handling the extraordinary small and light seeds of *Orobanche crenata* during inoculation of the broadbean brings about a high risk of contamination of the neighbouring plots designed for non-recipient plants. For that reason, randomized block design was not used, but rather the uninfected (treatment no. 1) and infected (no. 2) broadbean plots were kept strictly separated. In the treatment with the parasite *Orobanche crenata* (no. 2), small amount of its seeds was added to a particular broadbean seed before it was covered with soil. Both this treatment (no. 2) and the control (no. 1) were regularly hand-weeded to eliminate the non-parasitic weeds. Treatment no. 3 was the broadbean culture without the broomrape but with a spontaneously developed multispecies community of non-parasitic weeds (the total cover of the crop plant and weeds at harvest time was 100 %). The species composition of the weed community was: *Fumaria officinalis* L., *Chenopodium album* L., *Ch. ficifolium* Smith, *Ch. viride* L., *Capsella bursa-pastoris* (L.) Medic., *Galinsoga parviflora* Cav., *G. ciliata* (Rafin.) Blake, *Sonchus oleraceus* L., *S. asper* (L.) Hill, *Convolvulus arvensis* L., *Taraxacum officinale* Weber in Wiggers, *Portulaca oleracea* L., *Stellaria media* (L.) Vill., *Euphorbia peplus* L., *Lamium purpureum* L., *Echinochloa crus-galli* (L.) Beauv., *Poa annua* L.

Each of the three parallel beds for particular treatments covered 3 × 1.80 m and hosted 45 individuals of the crop plant. The control plot was located in the middle, with the treatments no. 2 and 3 situated alongside, sharing the longer border. From each treatment, 10 sampling patches with the crop plant were randomly selected. The size of the patch was 0.3 × 0.3 m, corresponding to the area occupied by the shoots of a single broadbean plant. To compare the seed biomass as well, the extremely suppressed broadbean plants (unfertile, without seeds) from the treatment no. 3 were excluded: the treatment with non-parasitic weeds was thus restricted to 5 samples. For each subplot sampled, the total

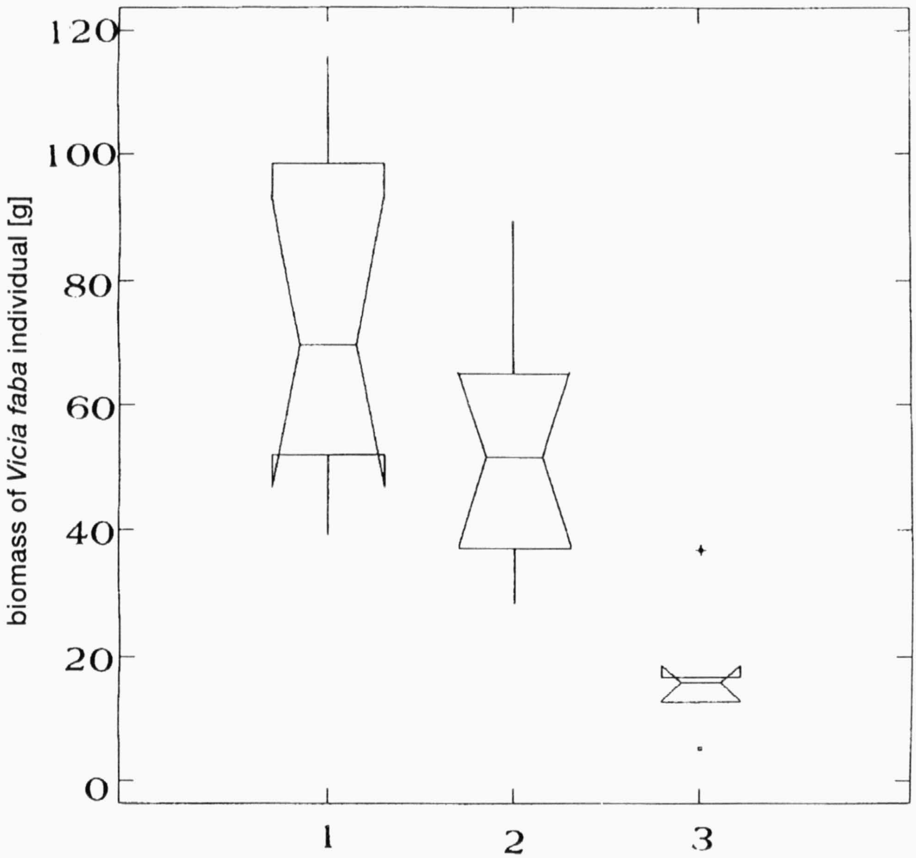

Fig. 1: Notched box and whisker plot for biomass of *Vicia faba* individuals in different stands: (1) without weeds, (2) with *Orobanche crenata*, and (3) with the mixture of non-parasitic weeds. The box encloses the middle 50 % of data (i.e. between the upper and the lower quartile), with the median in the middle. The length of the notch represents approximate 95 % confidence interval for the median. Whiskers extend to the extreme points within 1.5 interquartile ranges from the quartile. Data points beyond this range are plotted individually.

above-ground biomass, seed biomass and shoot number per one broadbean plant were assessed. In the treatment no. 2, stem numbers of *Orobanche crenata* and their total (both above-ground and below-ground) biomass per each broadbean plant (i.e. in a subplot) were measured. In the treatment no. 3, the total above-ground weed biomass was evaluated. The biomass was dried at 60 °C. The experiment was conducted from 22 March to 7 July 1989, when the above-ground biomass was harvested. Temperature fluctuated between 20 and 40 °C.

Results and discussion

The yield of *Vicia faba* shoot biomass decreased significantly in the treatment with non-parasitic weeds (Fig. 1, Table 1). All the parameters studied were reduced in the

Table 1. – Mean and standard deviation (in the brackets) for the assessed parameters of the crop plant (*Vicia faba*). Values represent means for the subplot area sampled.

Treatment	Number of shoots		Above-ground dry mass (g)		Seed dry mass (g)		Number of samples
1	4.50	(1.71)	72.67	(28.52)	22.65	(20.24)	10
2	4.10	(1.19)	52.62	(19.11)	16.79	(12.09)	10
3	1.80	(0.44)	17.52	(11.66)	7.70	(5.68)	5

Table 2. – Mean and standard deviation (in the brackets) for the parameters of the parasite (*Orobanche crenata*) and non-parasitic weeds assessed. Values represent means for the subplot area sampled.

Orobanche crenata (Treatment no. 2)				Non-parasitic weeds (Treatment no. 3)	
Number of stems		Total dry mass (g)		Above-ground dry mass (g)	
4.70	(3.09)	9.15	(5.91)	286.58	(103.55)

following order of treatments: 1, 2, 3. The treatment no. 3 with non-parasitic weeds exhibited rapid differentiation. Several times the sprouting broadbean plant was suppressed by weeds to such a degree that it was prevented from flower and/or seed production, suggesting that there is a critical phase of sprouting and establishment of seedling when they are strongly influenced by weed competition (Frantík et al. 1990). If the crop plant has a faster start than weeds it becomes, under asymetric competition, a regulator of weed growth (Kovář et al. 1988).

The differences in the seed biomass produced per a broadbean individual are much less distinct than those in the total above-ground biomass. The values are highly variable, overlapping strongly (Table 1). In the present study, the broomrape effect was different from that reported by Mesa-Garcia et Garcia-Torres (1984) who indicated that *Orobanche* parasitism mostly affected the reproductive phase. The active phase of parasitism occurs when the bean vegetative development is almost at its end; the seeds of *Orobanche crenata* germinate 10–15 days before the host attains its flowering stage (Abou-Raya et al. 1973). However, negative relationship was found between the above-ground biomass of broadbean individuals and that of parasitising broomrape, the latter being closely related to the *Orobanche* stem number (Fig. 2). The number of *Orobanche* stems, however, does not reflect the actual parasitic influence on the productivity of the host (Radwan et al. 1988). Apparently, the bean shoot number is most influenced by the weed competition. Quantitative parameters for both parasitic (treatment no. 2) and non-parasitic (no. 3) weeds are shown in Table 2. The mere amount of dry mass (only above-ground) of non-parasitic weeds, being by an order of magnitude higher than that of broomrape dry mass, suggests that their effect on the crop plant was clearly different under the given conditions. Despite that the impact of the weed competition was distinctly higher than that of the broomrape parasitism, it is necessary to keep in mind that the results obtained for different levels of broadbean infection (e.g. Hassan et Zain El-Deen 1987) may largely differ. Also the "marked effects" of the plant neighbour and the pattern of infestation on parasite attack could be calculated in the case of combination of host crop species (Bouhatous et Jacquard 1994).

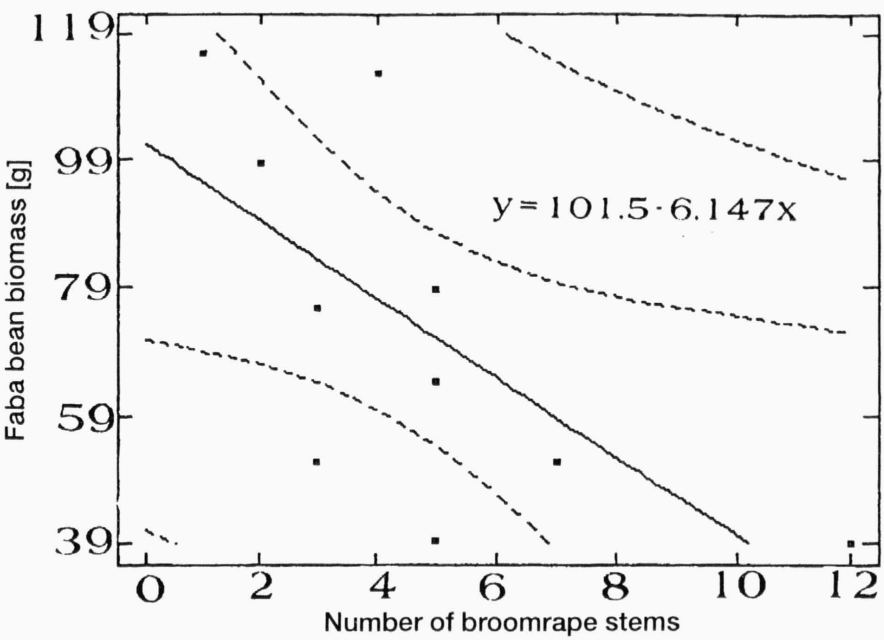

Fig. 2: Relationship between the number of stems of *Orobanche crenata* parasitising on one individual of *Vicia faba* and the above-ground biomass of the host plant.

Although this experiment aimed to simulate, at least as far as the plant spatial pattern is concerned, the situations met by practice, its results are valid only within the given arrangements. It included neither a combined treatment with both parasitic and non-parasitic weeds influencing the crop plant, nor different densities of plants.

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Souhrn

Skleníkový pokus porovnávající růstové a produkční parametry egyptské plodiny, bobu obecného (*Vicia faba* L. cv. Giza 2) v čisté kultuře, s infekcí mediteránní zárazy vroubené (*Orobanche crenata* Forsk.) a ve vícedruhové směsi neparazitických plevelů ukázal, že v daných podmínkách a kvantitativních proporcích porostních komponent mají zelené plevele zřetelně větší vliv na snížení počtu výhonů a nadzemní biomasy bobu.

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