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ASSESMENT OF DIFFERENT NON-HOST CROPS AS TRAP CROP FOR REDUCING *OROBANCHE AEGYPTIACA* PERS. SEED BANK

Bipana Devi Acharya
Department of Botany
Amrit Science Campus, Tribhuvan University, Kathmandu, Nepal
E-mail: bipanaacharya@gmail.com

ABSTRACT

Experiments were performed in pot and field conditions to evaluate effects of non-host crops on *Orobanche* seed bank. The two sites chosen for the study were located in highly *Orobanche* infested areas of Nawalparasi district, an inner Terai region of central Nepal. Pot and field experiments were conducted in the soil naturally infested with *Orobanche* seeds. Altogether, 21 different non-host crop species were tested in the study. *Orobanche* seed density in soil samples collected from pot/plot before planting and after harvest of each crop species was recorded. Data of pre-plant and post-harvest were compared in order to assess the effects of the test crops on *Orobanche* seed density. On the basis of degree of effects on the *Orobanche* seed bank, the investigated crop species could be classified in to three categories: (a) non-potential trap crop: garlic, chilli, coriander, carrot, buckwheat, sunflower, french bean, pea, egg plant, potato, fenugreek, wheat and faba bean; (b) moderately potential trap crop: barley, onion, chickpea and maize; and (c) highly potential trap crops: radish, lentil, linseed, fennel and cumin.

Key words: *Orobanche aegyptiaca,* trap crop, seed bank, germination.

INTRODUCTION

Orobanche is a serious root holoparasite of many economically important dicotyledonous plants. It is a threat to about 16 million hectares of arable land in the mediterranean region and west Asia (Sauerborn 1991). They are very difficult to control due to their high seed production up to 500000 seeds/plant in *O. crenata* (Cubero and Moreno 1979). The seeds are very small (0.25-0.35 mm) and can remain viable possibly up to 20 years in soil in absence of suitable host (Cubero and Moreno 1979, Puzzilli 1983, Kadry and Tewfic 1956). The fruit is a capsule containing 1200-1500 small, dark grey seeds. This serves as a source of infestation for the crops in the following years. This results in building of persistent seed bank of Orobanche making its eradication difficult (Foy *et al.* 1989). In Nepal, it has been a constraint in the production of two important cash crops namely, tori (*Brassica campestris* var. *toria*) and tobacco (*Nicotiana tabaccum*) crops (Rao *et al.* 1988, Jacobsohn *et al.* 1989).

Many non-host plants can stimulate the germination of *Orobanche* seeds (Brown *et al*. 1951, Krishnamurthy *et al.* 1977, Abbes *et al.* 2008). Root exudates from flax (*Linum* *usitatissimum* L.), and corn (*Zea mays* L.), which are not host of *O. minor* can stimulate the seed germination more than that of clover (*Trifolium repens* L.), which is a normal host (Brown *et al.* *1*952). The use of trap crops and catch crops is one of the best methods currently available to control agricultural root parasites (Sauerborn 1991). It is hypothesized that trap crops or non- host plants stimulate the germination of the parasite seed but cannot be infected and thus reduces seeds in the soil due to suicidal germination. In the present study, an attempt has been made to find out the effects of different non-host crops on the seed bank of the *O. aegyptiaca* in naturally infested soil.

MATERIALS AND METHODS

Experiments were conducted in pots and two fields at site A (Vedabari) and site B (Beldia) in the Nawalparasi District, an Inner Terai region of Nepal, where infection of the *Orobanche* sp. was fairly high. The district is situated at about 153 Km. South-West to Kathmandu Valley. Both sites are farmer's fields hired for tori growing season.

Pot experiments were carried out at Site-A to study the effect of different non-host crops on seed bank of *O. aegyptiaca*. Altogether, 22 winter crops were tested (Table 1). Pot mixture included: a) soil collected from naturally infested field by *Orobanche* seeds, b) Fertilizers (N–0.8g/kg, P 1.2g/kg and K 0.6g/kg of soil) and, c) compost. The earthen pots of size 9 inches diameter were first moistened with water and then filled with soil mixture. About 3/4th of pots were buried into the soil to avoid rapid fluctuation of soil temperature and moisture.

Seeds or seedlings of test crops were collected from the local market. Crop seeds were sown 3-4 cm deep in the soil. Tubers of potato, bulb-lets of garlic and, seedlings of onion, egg plants and that of chili were planted in the pots. The number of the seeds sown for the pot experiments and the final number of plants that were maintained for the experiment are given in Table 1. To avoid dehydration of the germinating seeds, pots were covered with thin layer of straw and regular watering was done. The straw cover was removed when seedlings were shown up. There were three replications for each treatment, including control pots. Soil samples for quantitative estimation of *Orobanche* seeds were collected from each pot at the time of crop sowing and after harvest.

Field experiments were conducted in the rain-fed fields at Site A and Site B, with maize and tori as summer and winter crops, respectively. The field had homogenous nutrient and moisture regimes. The soil type in field A was sandy-loam with 71% sand, 22% silt, 7% clay and 2.01% total organic matters. Soil nitrogen was 0.151%, phosphorus 189 kg/ha, potassium 516 kg/ha, and the soil pH was 6.2. Manuring was done with animal dung. Unlike the Field-A, the soil type in Field-B was loam with 49% sand, 30% silt, 21% clay and 2.28% total organic matters. Nitrogen was 0.132%, Potassium 724 kg/ha, and Phosphorous 161 kg/ha. The soil pH was 6.7. The mean soil temperature of experimental areas varied from 12°C to 23°C in the morning (at 6 am) and from 15°C to 25°C in the afternoon (at 1 pm) during the study period.

The fields were ploughed twice with tractor supported with disc harrow two weeks before final preparation, i.e., at the second week of September. The field has randomized complete block design with 22 treatments including control. The plot area in Field-A was 2.4 × 2.6 m and it was 2.4 × 3.6 m in Field-B. There were three replications for each treatment.

The seeds/seedlings/bulblets/tubers of 22 test crops obtained from local market were planted after the final preparation of the field in first week of October. Plots were irrigated a day before sowing. Later irrigation was done as required. Soil was sampled two times from each plot: first before sowing and, the second after harvest. The sampling

Table 1. List of winter crop plants, their number sown/pot and number maintained/pot, for screening their efficiency in reducing *O. aegyptiaca* seed bank in soil.

Crops tested (Botanical name)	Common name	Seeds sown/pot	Plants maintained/pot
Allium cepa L.**	Onion	3	1
Allium sativum L.***	Garlic	3	2
Capsicum frutescens L.**	Chilli	3	1
Cicer arietinum L.*	Chickpea	5	3
Coriandrum sativum L.*	Coriander	10	5
Cuminum cyminum L.*	Cumin^{+}	10	5
Daucas carrota L.*	Carrot	10	3
Fagopyrum esculentum Moench*	Buckwheat	5	2
Foeniculum vulgare Mill.*	Fennel	10	5
Helianthus annus L.*	Sunflower	3	1
Hordeum vulgare L.*	Barley	7	3
Lens culinaris Medic.*	Lentil	7	3
Linum usitatissimum L.*	Linseed	7	3
Phaseolus vulgaris L.*	French bean	3	1
Pisum sativum L.*	Pea	5	3
Raphanus sativus L.*	Radish	5	2
Solanum melongena L.**	Egg plant	2	1
Solanum tuberosum L.***	Potato	3	1
Trigonella foenum graecum L.*	Fenugreek	10	5
Triticum aestivum L.*	Wheat	7	3
Vicia faba L.*	Faba bean	5	3
Zea mays L.*	Maize	3	1

*Seed, **Seedling, *** Bulb-let, **** Tuber, + Tested in pot only

spots were located between plant rows and there were three equally spaced spots between rows. Soil was sampled using auger reaching up to 15 cm deep. One Kg of Soil was sampled from different spots of a plot using composite soil sampling technique for laboratory estimation of *Orobanche* seeds. The percentage reductions of *Orobanche* seeds were determined from the difference of initial *Orobanche* seed count before sowing and final *Orobanche* seed count after harvest. The number of the Orobanche seeds in the soil was estimated with method of Ashworth (1976) with some modification (Acharya 2002, Acharya et al. 2003).

RESULTS

Comparison of seed bank in soil before sowing and after harvest of different test crops showed that the number of *Orobanche* seeds reduced in all cases, even in fallow pots or plots (controls).

Pot experiment

The number of *Orobanche* seeds/100 g soil before sowing and after harvest of different test crops including control pots is presented in Fig. 1 which shows that there is a reduction in number of *Orobanche* seeds in most of the test crops. The percentage of *Orobanche* seed in the study reduced from 11.64±0.84 to 54.27±8.63 with an average of 24.43±11.17% (Table 2).

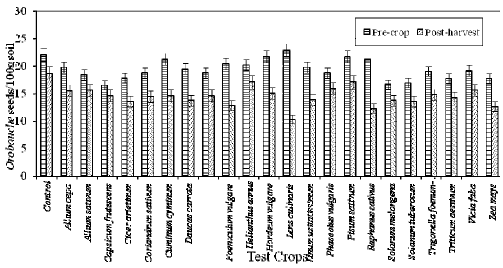

Fig. 1. Number of *Orobanche* seeds/100 g soil at the time of pre and post harvest of different test crops in pot experiments.

Of the 22 crops investigated (Fig. 1), the reduction of *Orobanche* seed bank was found to be significant (P=0.05) compared to control pots in cumin, carrot, fennel, barley, lentil, linseed, radish and maize (Table 2). The reduction was highest in lentil (54.27±8.63).

Test crops like onion, chickpea, coriander, buckwheat, pea, brinjal, potato, fenugreek, wheat, and faba bean reduced *Orobanche* seed density from 17.68±10.95 to 23.64±2.99%. Furthermore, the reduction of seed density of the parasite was fairly low in crops like garlic, chili, sunflower and french bean, which ranged from 11.64 to 15.15%. The values of reduction were statistically insignificant compared to the reduction in control pots.

Field A

Number of *Orobanche* seeds/m^2 of plots before and after harvest of different test crops of the Field-A is given in Fig. 2. Out of 21 test crops investigated, seed bank was reduced significantly (P=0.05) in onion, chickpea, radish, fennel, lentil and linseed than in control plots. Plots with coriander, carrot, buckwheat, sunflower, barley, pea, egg plant, potato, fenugreek, wheat, and maize (Fig. 2) showed reduction in *Orobanche* seed density but insignificantly at P=0.05 when compared with control plots. The percentage reduction of *Orobanche* seeds in test crops like garlic, chili, french bean and faba mean were more or less same as in control plots, hence showed same groupings in Duncan's multiple range tests followed after ANOVA (Table 2).

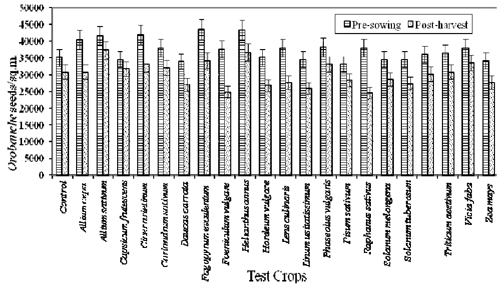

Fig. 2. Number of *Orobanche* seeds/sq m at the time of pre and post harvest of different test crops in Field A (Vedabari).

Field B

Number of *Orobanche* seeds/m^2 at pre-plant and post harvest of different test crops in the field are shown in Fig. 3. The mean reduction in *Orobanche* seed bank in this field was found to be 19.24±7.62% and the reduction was highest in lentil (35.39±1.83%.) and lowest in chili (6.41±5.28%). Out of 21 crops investigated, *Orobanche* seed bank was reduced significantly (P=0.05) in fennel, lentil, linseed, radish and barley compared to control plots (Table 2).

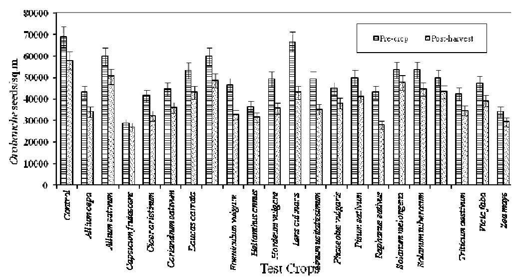

Fig. 3. Number of *Orobanche* seeds/sq m at the time of pre and post harvest of different test crops in Field B (Beldia).

Table 2. Reduction (%) of seed density of *O. agyptiaca* in different test crops grown in pots, Field A and Field B. Same letters followed after the mean ± standard deviation in a column do not differ significantly at P=0.05 according to Duncan's Multiple range tests followed after ANOVA.

Tested Crops	Common name	Reduction (%) in seed density (Mean ± Sd)		
		Pot expt	Field A	Field B
Allium cepa L.	Onion	22.00 ± 3.78 ABCD	23.73 ± 3.00 CDEFGH	17.33 ± 9.99 ABCD
Allium sativum L.	Garlic	15.15 ± 5.08 A	10.47 ± 1.51 AB	13.47 ± 6.80 AB
Capsicum frutescens L.	Chili	11.64 ± 0.84 A	8.20 ± 3.16 A	6.41 ± 5.28 A
Cicer arietinum L.	Chickpea	23.64 ± 2.99 ABCD	20.72 ± 5,15 BCDEFG	22.40 ± 5.81 BCDE
Coriandrum sativum L.	Coriander	22.41 ±3.69 ABCD	17.25 ± 7.84 ABCDEF	19.73 ± 4.96 ABCD
Cuminum cyminum L	Cumin	31.29 ± 8.98 DE	—	—
Daucas carrota L.	Carrot	29.53 ± 5.47 BCDE	19.44 ± 5.85 ABCDEF	18.98 ± 9.91 ABCD
Fagopyrum esculentum Moench	Buckwheat	21.86 ± 8.64 ABCD	19.17 ± 3.63 ABCDEF	19.89 ± 7.84 ABCD
Foeniculum vulgare Mill.	Fennel	37.33 ± 5.91 EF	31.01 ± 9.58 GH	28.83 ± 9.56 DEF
Helianthus annus L.	Sunflower	14.62 ± 9.16 A	14.22 ± 7.64 ABCDE	14.09 ± 7.68 AB
Hordeum vulgare L.	Barley	31.33 ± 8.58 DE	24.22 ± 6.24 DEFGH	27.89 ± 9.62 CDEF
Lens culinaris Medic.	Lentil	54.27 ± 8.63 G	26.93 ± 6.34 FGH	35.39 ± 1.83 F
Linum usitatissimum L.	Linseed	30.05 ± 2.84 CDE	25.36 ± 7.51 EFGH	29.26 ± 4.64 DEF
Phaseolus vulgaris L.	French bean	14.49 ± 5.33 A	12.59 ± 6.20 ABCD	15.08 ± 3.28 ABC
Pisum sativum L.	Pea	20.56 ± 3.38 ABCD	15.08 ± 2.37 ABCDEF	17.45 ± 8.26 ABCD
Raphanus sativus L.	Radish	42.28 ± 5.29 F	34.69 ± 9.09 H	34.96 ± 5.00 EF
Solanum melongena L.	Egg plant	17.68 ± 10.95 AB	16.49 ± 6.73 ABCDEF	11.31 ± 4.60 AB
Solanum tuberosum L.	Potato	19.34 ± 6.08 ABCD	20.73 ± 3.15 BCDEFG	15.13 ± 8.04 ABC
Trigonella foenum-graecum L.	Fenugreek	22.51 ± 0.69 ABCD	16.11 ± 7.17 ABCDEF	12.08 ± 9.16 AB
Triticum aestivum L.	Wheat	18.79 ± 5.47 ABC	15.20 ± 4.21 ABCDEF	16.98 ± 9.01 ABCD
Vicia faba L.	Faba bean	18.04 ± 5.67 AB	11.82 ± 7.85 ABC	17.64 ± 1.19 ABCD
Zea mays L.	Maize	28.05 ± 6.70 BCDE	18.99 ± 8.00 ABCDEF	13.66 ± 4.89 AB
Control		15.09 ± 3.47 A	12.39 ± 1.54 ABCD	15.40 ± 3.02 ABC

DISCUSSION

In the present study, it was interesting to note that there was some reduction in *Orobanche* seed bank in fallow (control) pots and plots. The reason (s) behind the reduction might be that the weed seed density is not only affected by the host stimulants but also by many other environmental factors, like rainfall, wind, tillage practices, kind of manure used, activities of soil animals (rodents and insects) and more importantly soil microorganisms (Lopez-Granados and Garcia-Torres 1993). In present study, the mass of isolated *Orobanche* seeds from infested soil samples contained a fair number of damaged seeds. Some of the damaged seeds were found infested with fungus (i), some empty (without embryo) and some broken (possibly devoured by soil insects). On the basis of the results obtained from seed bank study, the tested crops have been categorized into three groups: Non-potential, moderately potential, and highly potential trap crops, which are discussed below.

Non potential trap crops: Among the tested crops, Garlic, Chilli, Coriander, Carrot, Buckwheat, Sunflower, French bean, Pea,Egg plant, Potato, Fenugreek, Wheat and Faba bean showed insignificant reduction in *Orobanche* seed bank. Though many of these crops like Garlic, French bean, Potato, egg plant, carrot, sunflower. faba beans has been described as trap crop for *O. aegyptiaca* (Foy *et al* 1989, Sauerborn 1991, Jacobshon *et al* 1980), but in present study it was unable to reduce its seed bank. The possible reason for this may be due to presence of different physiological races in *O. aegyptiaca*, which was also suspected by Jacobshon (personal communication).

Pea coriander, chilli and faba beans are described as trap crop for different species of *Orobanche* like *O. cernua, O. mutely, O. crenata, O. minor* (Krishnamurty *et al* 1977,Foy *et al* 1989, Sauerborn 1991), hence was tested in the present study. But in the present study, insignificant reduction in the *Orobanche* seed bank proved these crops to be non-potential trap crops.

Fenugreek was used as a trap crop for controlling *O. crenata* in *Vicia faba* fields in a pilot experiment of crop rotation in Northwest locality of Nile delta, Egypt (Al-Menoufi 1991). Cultivation of Fenugreek with *Vicia faba* reduced emergence of *O. crenata* by 89.8%, but in the present study, there was insignificant reduction in *Orobanche* seed bank in both fields after cultivation of fenugreek in comparison to fallow, indicating that it could not be a suitable trap crop.

Lins *et al.* (2006) have described *Triticum aestivum* L. (wheat) as a false host of *O. minor* and reported 20-70% seed germination in growth chamber experiments. But in the present study, the percentage reduction in *O. aegyptiaca* seeds in soil after cultivation of wheat was insignificantly different than reduction in control. Results obtained from pot experiment and field experiment in the present study support the view of Abu Irmaileh (1994) that there is no possibility of using wheat in rotation as a trap crop for *O. aegyptiaca*.

Moderately potential trap crops: On the basis of seed bank study in pots and fields, *Hordeum vulgare* L. (Barley), *Allium cepa* L. (Onion) *Cicer arietinum* L. (Chickpea) and *Zea may* L. (Maize) have been identified as moderately potential trap crops. Three crops *Allium cepa* L., *Cicer arietinum* L. and *Zea may* L. showed inconsistent results in pot and field experiments. But *Hordeum vulgare* showed consistent results in all experiments. Hence, out of 4 crops *Hordeum vulgare* can be considered the best moderate potential trap crop.

Hordeum vulgare L. (Barley) was found to be an occasional host of *O. aegyptiaca* while studying host range of different *Orobanche* species in Nepal (Khattri *et al 1*991). Results obtained in pot and field studies were encouraging as there was a significant increase in reduction (P=0.05) of *Orobanche* seed density, and not a single plant was found to be parasitized. Therefore, role of barley in crop rotation as trap crop for *Orobanche* seed bank reduction shows good promises because this is one of the traditional winter crops in *Orobanche* infested areas in Nepal.

Highly potential trap crops: On the basis of seed bank study, the crops like Radish, Fennel, Lentil Linseed and Cumin have been identified as highly potential trap crops. Radish, Fennel, Lentil, Linseed showed significant reduction in O*robanche* seed density (both in pots and plots), and only a couple of radish were found associated with adult parasite. Khattri (1997) described lentil as a rare host of *O. aegyptiaca* in Nepal. This study supports the finding of many workers like Acharya (2002), Sauerborn (1991), Krishnamurty *et al.* (1977), Kleifeld *et al.* (1994), Schnell *et al.* (1994), Al-Menoufi (1991). It becomes evident from the above findings that these crops are highly effective to induce seed germination of *O. aegyptiaca* but is not, usually parasitized showing a true character to be an ideal trap crop.

Cumin was able to reduce 21.7% seed bank of *O. crenata* in pot experiment (Schnell *et al.* 1994) but there is no information available regarding the testing of the crop plants with *O. aegyptiaca*. In the present study cumin was only tested in pot experiment in which seed bank reduced significantly (P=0.05) than that of control (fallow). As cumin was not tested in the field experiments, hence it needs further investigation.

CONCLUSIONS

Pot and field investigations for trap crop have clearly indicated that crops like radish (*Raphanus sativus*), lentil (*Lens culinaris*), linseed (*Linum usitatissimum)* and fennel (*Foeniculum vulgare*) ranked highest among the crops which reduce *Orobanche* seed bank significantly. Except the fennel, other three crops could successfully be incorporated as trap crops in the crop rotation in our agronomic conditions.

On the basis of results obtained from *Orobanche* seed bank study in pot and field conditions, the investigated crop species could be listed in one of the following three categories: (i) Non-potential trap crop: Garlic, chilli, coriander, carrot, buckwheat, sunflower, french bean, pea, egg plant, potato, fenugreek, wheat and faba bean. (ii) Moderately potential trap crop: Barley, onion, chickpea and maize. (iii) Highly potential trap crops: Radish, lentil, linseed, fennel and cumin (tested in pots only)

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