Progress on farmer training in parasitic weed management

L'état d'avancement de la formation des agriculteurs dans la gestion de mauvaises herbes parasites

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Preface

The damage caused by the parasites *Orobanche* on field and vegetable crops in Northern Africa and the Near East, and *Striga* on cereals in several countries of Africa South of the Sahara is significant. For instance, in Morocco, infestation of *Orobanche* crenata in food legumes (mainly faba bean) causes yield losses of 29 000 tonnes annually, which is equal to US$17 million. The complete devastation caused by *Orobanche* in many areas of North Africa and the Near East has to be reduced; otherwise farmers will abandon their fields or shift to other crops. The situation of the effect of *Striga* on crops such as sorghum, maize and millet is similar.

No single method has so far been found to successfully control the root parasitic weeds *Orobanche* and *Striga*. For this reason, an integrated control approach is required that should be feasible for small-scale farmers to implement.

Understanding the problem of these parasitic plants, the damage they cause to crops and to farmers' economies, FAO decided to implement two regional projects, where the main component was farmer training. The idea was to familiarize farmers with the biology of the weeds and allow them to propose or adapt control strategies.

Within the framework of the two regional projects, and according to the needs of farmers in parasitic weed management, specific training curricula were developed and implemented.

The participatory approach implemented in other projects/activities on Integrated Pest Management (IPM) was used. This methodology enabled farmers in field schools to study the cycle of the parasitic plants and to decide which control methods to use and when to implement them. Facilitators also contributed their knowledge and experiences to the discussions of farmers.

The process of generation and dissemination of agricultural innovations involves several players, among which the most important are farmers, assisted by extension workers and researchers. They together with the decision makers and the general public were the target groups for raising awareness and developing skills in *Orobanche* and *Striga* control in affected crops.

The present material is a compilation of various country reports generated within the framework of the project. It clearly shows the progress made by farmers in the process which empowered them to implement improved management strategies against *Orobanche* and *Striga* parasitic weeds.

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Farmer training on parasitic weed management

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Summary

The importance of farmer training on parasitic weed management is emphasized. A thorough understanding of parasitic weed biology, including detailed knowledge of the parasitism, is needed by farmers to develop the control methods. Knowledge of the factors affecting germination and haustorium formation and attachment to host plants, parasite growth and seed production is essential in this case. The IPM approach is the key to developing a comprehensive training programme for farmers on new technologies. The IPM process begins with the farmer (who takes the decisions in the field) and not the pest or weed. IPM has two core activities in the training and extension process: Training of Trainers (TOT) and Farmer Field Schools (FFS). In FFS farmers are able to conduct their own experiments, sharpen their observation and research skills and take the initiative, adapting the alternatives to local conditions. Parasitic weeds are good target pests to develop training of extension workers and farmers on integrated management.

La formation des agriculteurs dans la gestion des plantes parasites

Résumé

Il faut souligner l'importance de la formation des agriculteurs dans la gestion des mauvaises herbes parasites. Une compréhension complète de la biologie des plantes parasites, y compris la connaissance détaillée du parasitisme, est indispensable pour éduquer les agriculteurs à savoir développer des méthodes de gestion. La connaissance des facteurs affectant la germination, la formation et la fixation d'haustorium des plantes hôtes, la croissance des parasites et la production de graines fondamentaux pour éviter les mauvaises herbes parasites. L'approche de la Lutte Intégrée est la clef pour développer un programme de formation complet pour les agriculteurs, basé sur les nouvelles technologies de gestion. Le processus de Lutte Intégrée commence à partir de l'agriculteur, qui prend les décisions dans le domaine, et pas par le parasite ou la mauvaise herbe. La Lutte Intégrée a deux activités de base dans le processus de formation et de vulgarisation:

- La formation des formateurs (TOT) et
- la création des champs écoles paysans (FFS). Dans les FFS les agriculteurs peuvent mettre en pratique leurs propres expériences, améliorer la qualité de leurs observations et de leurs recherches mais aussi prendre l'initiative, adaptant les nouvelles solutions aux conditions locales.

Les mauvaises herbes parasites sont un bon objet cible pour développer la formation des vulgarisateurs et des agriculteurs sur la gestion intégrée.

I. Problems posed by root parasitic weeds

The problem of parasitic weeds has been well described by various authors during the last three decades. The root parasites *Striga* (witchweed) and *Orobanche* (broomrape) are vicious pests in both tropical and sub-tropical areas (Joel, 2000). On a worldwide basis, parasitic weeds represent one of the most destructive and intractable problems to agricultural production in both developed and developing countries (Aly, 2007).

There are two main complexes of root parasitic weeds, *Striga* spp and *Orobanche* spp., both common in areas of low fertility soils and annual low rainfall.

Striga hemiparasitic weeds are obligate root parasites of cereals or legumes in Africa South of the Sahara and other dry hot climate sites in India and Yemen. *Striga hermonthica* tends to be the major problem in cereals in West, Central and East Africa, with *Striga asiatica* becoming more important in southern areas (SP-IPM, 2003). Cowpea is also affected by *Striga gesnerioides* and *Alectra vogelii*, the latter being important in eastern and southern parts of Africa. In Africa, *Striga* negatively affects the lives of over 100 million people, implying that these parasitic weeds are among the most important constraints to agricultural development in this region (Mboob, 1999).

Orobanche spp. are a problem in the Mediterranean area, including countries in Europe and North Africa and others in the Near East. These holoparasites affect several crops, such as vegetables, legumes, sunflower and tobacco among others. *Orobanche cernua* is one of the most aggressive species; it is widespread in sunflower grown in Eastern Europe and the Near East.

Orobanche ramose, which is also present in Cuba, Chile and Mexico, and *Orobanche aegyptiaca* attack a wide range of solanaceous crops such as tomatoes, potatoes, eggplant, pepper and tobacco, while *Orobanche crenata* is probably the main pest in various leguminous crops, including faba beans.

Both complexes of parasitic weeds cause huge crop yield losses annually, and in severe cases when the infestation is very high farmers have no other option than to abandon their fields. The situation is aggravated by the fact that pressure for land has increased at the same time as demographic growth in several countries affected by the parasitic weeds. In the past long fallow was practised largely for the control of *Striga* or *Orobanche* even alternating with itinerant agriculture, but nowadays this method of rotation is not possible due to the shortage of land - particularly non-infested - and the accelerated degradation and impoverishment of soils.

The author considers that if these problems were prioritized by officials of the Ministries of Agriculture or Rural Development, and support given to the extension and production of clean seeds, food production could be increased by 10-15 percent.

II. Methods for parasitic weed management

There is no single method available to control parasitic weeds. There is a new technology available for *Striga* control consisting of the use of low rates of herbicide and a safener for the crops seeds, reported as effective in maize (Kanampiu and Friessen, 2002), which are not

affordable by all small farmers in Africa though relatively cheap. In the case of *Orobanche* it is possible to use some herbicides, again at low rates, in limited crops. The most popular herbicide application here is glyphosate post-emergence in faba beans.

Although all these control measures have their merits, in the long term parasitic weeds should be managed through the implementation of an integrated approach, where containment is essential (Ransom, 1996).

Containment can be achieved through the use of crop seeds free of parasitic weed seeds, good quality amendments, clean farm implements and control of parasitic plants avoiding their flowering and seed setting in order to reduce build-up of the seed bank in soil.

Several cultural, chemical and physical control methods exist, but their implementation is not always feasible. A good example is crop rotation, which is as usually market driven. Other possibilities are intercropping cereals with legumes, increased use of organic manure and N fertilizers, spraying 2,4 D early in cereals grown alone or hand-pulling the parasites at this stage of the plant for combating *Striga*; for *Orobanche* some of these control strategies cannot be implemented. Crops affected by *Orobanche*, particularly vegetables and tobacco, may react adversely to increased application of N fertilizers and amendments; the limitation of crop rotation is also applicable here. There are not many herbicides other than glyphosate for *Orobanche* control in certain crops and they should be applied carefully following the correct rates.

It is true that there are some new methods such as soil solarization that may help to reduce parasitic weed infestation, but not all farmers can afford to purchase plastic transparent film and wait 4-6 weeks for solarization and then crop planting.

At this point, a thorough understanding of parasitic weed biology, including detailed knowledge of the specific mechanisms of parasitism, is needed in order to develop novel control methods (Joel, 2000). There is a need to know better the factors affecting germination and haustorium formation and attachment to host plants, parasite growth and seed production.

Conventional methods, both individually and in combination, have a limited impact on controlling parasitic weeds (Verkleij & Kuijper, 2000).

However, the fact is that thousands of farmers in developing countries do not know the biology of these plants: some even think that they reproduce by rhizomes and stolons, others have never seen tiny seeds produced by these parasites, ignore the existence of a subterranean growth phase, and other details. Not knowing their enemy makes it really difficult for farmers to design effective control strategies.

III. The importance of farmer training on parasitic weed management

IPM is a decision-making process that considers all possible control measures, such as cultural, mechanical, biological and chemical, selecting a control method to suit each individual situation. The IPM approach is the key to developing a comprehensive training programme for farmers on new technologies. The basis of this approach is the training of extension workers and other agents who work closely with farmers (Braga et al., 2001).

The IPM process begins with the farmer (who takes the decisions in the field) and not the pest or weed. IPM has two core activities in the training and extension process: Training of Trainers (TOT) and Farmer Field Schools (FFS). The first is an effective way to keep extension workers up-to-date on newly developed technologies. The knowledge gained will be useful for them later in organizing FFS for the farmers in their area.

FFS is an excellent opportunity for farmers to conduct their own experiments, sharpen their observation and research skills and take the initiative, adapting the alternatives to local conditions. All the methods developed previously by research will be better accepted by farmers when they themselves test, adapt and adopt them, taking into account local conditions specific to their areas. This participatory approach aims at ensuring informed decisions by farmers to solve location-specific problems, respond to opportunities and cope with rapid change.

Parasitic weeds are good target pests to develop training of extension workers and farmers on integrated management. The implementation of TOT will update the knowledge of the extension workers and other agents on biology and control of root parasitic weeds. Once this first step of training is finished, they can act as facilitators for organizing other FFS. Facilitators are not teachers; rather they will intelligently facilitate and guide the process of training for farmers without trying to teach them.

Farmers will make their own observations in the field and will learn about the growth-cycle of root parasitic weeds, about the factors stimulating seed germination of these plants, the existence of false hosts, and other elements to enable them to think and design new approaches for reducing the incidence of these weeds.

To this end, FAO assisted several countries during the cropping seasons of 2005 and 2006 in two regions of the world, implementing one project in West Africa with the participation of six francophone countries, where *Striga* is a very serious constraint to cereal production, and another in seven countries of North Africa, the Near East and of Sub-Saharan Africa, to combat *Orobanche* crenata in faba beans.

Among various activities included in the work plan of the projects these countries implemented TOT and various FFS in their territories. A total of 1 800 farmers were trained on integrated technologies for the control of root parasitic weeds, and the experiences described in this material are an example of what can be still done to reach farmers and to introduce available results into farming communities.

As is known, IPM was always considered a good practice for insect control - and later for disease control - but there was a doubt whether weeds could also be included in the curriculum of FFS. The experiences of 13 countries clearly show the advantages of including weeds in such training as well as some shortcomings still to be overcome in future training exercises with farmers.

References

Aly R. 2007. Conventional and biotechnological approaches for control of parasitic weeds. In Vitro Cellular and Developmental Biology – Plant 43 (4): 304-317.

Braga R., Labrada R., Fornasari L. and Fratini N. 2001. Manual for Training of Extension Workers and Farmers on Alternatives to Methyl Bromide for Soil Fumigation. FAO, Rome, 35 pp.

Kanampiu, F. & Friesen, D. 2002. *Striga* weed control with herbicide-coated maize seed. International Maize and Wheat Improvement Center (CIMMYT). (available at Url:http://www.cimmyt.org/Research/Maize/results/*Striga*/control.pdf)

Mboob, 1989. A regional program for West and Central Africa. In: I.O. Robson and H.R. Broad, Editors, Proceedings, FAO/OAU All-Africa Government Consultation on *Striga* Control Proceedings, FAO/OAU All-Africa Government Consultation on *Striga* Control (1989), pp. 190–194, Maroua, Cameroon.

Ransom, J. K. 1996. Integrated management of *Striga* spp. in the agriculture of sub-Saharan Africa. Proc. of the Second Int. Weed Control Congress, Copenhagen,

25-28 June 1996: Vol. 1-4, pp: 623-628. Brown, H., Cussans, G. W., Devine, M.D., Duke, S.O., Fernandez-Quintanilla, C., Helweg, A., Labrada, R., Landes, M., Kudsk, P. & Streibig, J. C. eds.

SP-IPM (2003) Tackling the scourge of parasitic weeds in Africa. IPM Research Brief No.1. International Institute of Tropical Agriculture (IITA), Cotonou, Benin.

Verkleij J.A.C. & Kuijper E. 2000. Various Approaches to Controlling Root Parasitic Weeds. Biotechnology and Development Monitor, No. 41 http://www.biotech-monitor.nl/4105.htm

Taxonomy of Agronomically Important Striga and Orobanche Species

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Summary

The taxonomy of the two most important parasitic genera in agriculture, *Orobanche* (broomrapes) and *Striga* (witchweeds) is summarized. The paper focuses on the most serious species and species clusters in these two genera. For witchweeds, discussion will center on *Striga asiatica* (L.) Kuntze and the putatively related species cluster (*Striga hirsuta* Benth., *Striga lutea* Lour., and *Striga elegans* Benth.); and on *Striga hermonthica* and related species [*Striga aspera* (Willd.) Benth., and *Striga gracilima* H. Melchior]; and *Striga gesnerioides* (Willd.) Vatke. (Synonyms: *Buchnera gesnerioides* Willd., *B. orobanchoides* R. Br., *Striga orobanchoides* (R. Br.) Benth., *Striga orchidea* Hochst., *Striga gesnerioides* var. *minor* Santapau).

Discussion of *Orobanche* includes the species cluster of *Orobanche crenata* Forskal, *Orobanche cernua* Loefl., and *Orobanche cumana* Wallr. and the cluster of *Orobanche aegyptiaca* Pers., *Orobanche ramosa* L., *Orobanche nana* (Reut.) Beck and *Orobanche mutelii* F. Schultz. Because of morphological reduction, parasitic plants exhibit tremendous reduction in their vegetative traits resulting in considerable variation. This limits the number of available characters used in distinguishing species within each group and pose taxonomic problems in parasitic plants especially species of *Orobanche*.

The accurate identification of parasitic plants comprises the first step in developing meaningful control strategies. Although most *Striga* and *Orobanche* species are not difficult to identify, the clusters of *Striga asiatica*, *Striga hermonthica*, *Orobanche crenata*, and *Orobanche aegyptiaca,* discussed in this chapter, are among the most confused species. Therefore we recommend that researchers have access to and use field guides that clearly distinguish these closely related species. All samples used in molecular studies and in other taxonomic studies must have vouchers and photos for verification.

La taxonomie des espèces de Striga et Orobanche important de point de vue Agronomique

Resumé

Le rapport explique la taxonomie de l'*Orobanche* et du *Striga,* les deux genres plus importants des plantes parasites dans l'agriculture. Le rapport se concentre sur les espèces et les branches d'espèces les plus sérieuses dans ces deux genres. Pour Striga, on mettra en relief la discussion sur le *Striga asiatica* (L.) Kuntze et les espèces putatives proches de cette branche (*S. hirsuta* Benth., *Striga lutea* Lour., et *Striga elegans* Benth.); et sur *Striga hermonthica* et spèces proches [*Striga aspera* (Willd.) Benth., et *Striga gracilima* H.

Melchior]; et *Striga gesnerioides* (Willd.) Vatke. (Synonymes: *Buchnera gesnerioides* Willd., *B. orobanchoides* R. Br., *Striga orobanchoides* (R. Br.) Benth., *Striga orchidea* Hochst., *Striga gesnerioides* var. *minor* Santapau).

La discussion sur l'*Orobanche* inclut les espèces *Orobanche crenata* Forskal, *Orobanche cernua* Loefl., et *Orobanche cumana* Wallr., mais aussi la branche de *Orobanche aegyptiaca* Pers., *Orobanche ramosa* L., *Orobanche nana* (Reut.) Beck et *Orobanche mutelii* F. Schultz. À cause d'une réduction morphologique, les plantes parasites montrent une énorme réduction dans les caractères végétatives ayant pour résultat une variation considérable.

Ceci limite le nombre de caractères disponibles utilisés dans des espèces pour leur différentiation dans chaque groupe et pose des problèmes taxonomiques des plantes parasites particulièrement d'Orobanche.

L'identification précise des plantes parasites est le premier pas pour développer des stratégies significatives de gestion. Bien que la plupart des espèces *Striga* et *Orobanche* ne soient pas difficile à identifier, les branches de *Striga asiatica*, *Striga hermonthica*, *Orobanche crenata*, et *Orobanche aegyptiaca,* discutés dans le présent rapport, sont souvent les espèces les plus faciles à confondre. Pour cette raison, nous recommandons que les chercheurs aient accès à l'utilisation des guides des champs qui montrent clairement la différence entre les espèces proches. Les échantillons utilisés dans les études moléculaires et dans les autres études taxonomiques devront avoir des bons et des photos pour la vérification.

I. *Striga* species

The genus *Striga* is predominantly African in origin and distribution. Of approximately 40 described *Striga* species, about 30 are endemic to Africa (Mohamed *et al.* 2001). Based on molecular evidence, Olmstead *et al.* (2001) placed the hemiparasitic genera traditionally included in the Scrophulariaceae including *Striga*, into the Orobanchaceae with the result that both of these genera--*Striga* and *Orobanche*-- are now in the same family.

Striga species are distinguished from other root parasites by unilocular anthers and bilabiate (two-lipped) corollas with a pronounced bend in the corolla tube. In some species the corolla is bent within the calyx teeth as in *Striga hermonthica*, in others it is bent above the calyx as in *Striga asiatica*. Other features used in distinguishing agronomically important species include indumentum types [pubescence, hirsute, and whether hairs are ascending or retrorse (pointing backward)]; stem shape (round, obtusely square, and square in cross section); leaf lobing and dentation (whether leaf margins are lobed, serrate or smooth); inflorescence types (spike, raceme, and the length of the inflorescence relative to the vegetative stem); number of ribs on the calyx tubes and length of calyx teeth relatives to tubes; and corolla color and type of indumentum on corolla.

The *Striga asiatica* cluster includes *Striga asiatica*, *Striga hirsuta*, *Striga lutea*, and *Striga elegans.* The fourth species in this cluster is morphologically unique and will be discussed later. It is important to emphasize that the Southeast Asian forms of *Striga asiatica* are not included in this analysis since their relationship to the African species complex is not known.

The name *Striga asiatica* is used to describe the noxious red-flowered *Striga* species which overwhelms sorghum, maize, and other cereal crops in Africa. Unlike *Striga hirsuta* and

Striga lutea, the *Striga asiatica* plants are profusely branched with leaves up to five cm long, longer than the plant internodes. Also, the bract in *Striga asiatica* is longer than the calyx. The number of the calyx teeth is five but in *Striga asiatica* it can be up to eight with teeth of unequal length. Overall, *Striga asiatica* is more scabrous (rough to the touch) than either of *Striga hirsuta* and *Striga lutea*.

The number of rows of hairs on the lower surface of the leaves and bracts is a unique and dependable feature that distinguishes *Striga hirsuta* from *Striga lutea*. *Striga hirsuta* has a single row of stiff hairs running along the margins and the mid rib of its leaves and bracts. *Striga lutea* has two rows of hispid hairs along the margin and mid rib of its leaves and bracts. *Striga lutea* plants are characteristically tall (up to 40 cm) and usually are unbranched or rarely with two branches. *Striga hirsuta*, on the other hand, is typically branched and the plants are the shortest (10 cm) in this cluster. Flower color can be of various shades of red and yellow and is not a reliable guide for species determination. *Striga asiatica* flowers are typically red with yellow throat. Flowers of *Striga lutea* are usually yellow, those of *Striga hirsuta* typically red but any of these species may occasionally have flowers of various shades of red, sometimes on the same plant. This is not unusual as the corolla color is controlled by few genes.

There are also distinct differences in the range of these species, though this may change overtime as in the following example of *Striga asiatica*. Until the late eighties and early nineties *Striga asiatica* was very largely confined to south and central Africa, normally south of the equator (*Striga asiatica* was also introduced into southeastern USA). In these areas *Striga asiatica* is usually restricted to agronomic hosts. Then it was reported from Kenya in the late 80's and Togo in West Africa in the early 90's. Our *Striga* surveys in West Africa and Sudan in the 80's and in Ethiopia as recent as 2007 show that *Striga asiatica* is not established as serious a problem north of the equator as it is in southern Africa, though it does occur sporadically on crops in several countries in West and East Africa. In November 2007 we surveyed *Striga* in Ethiopia. We reached as far south as Caves Omar and Megalo southeast of the Bale Region (6° 30'N, 41° 00'E), North to Mekele just south of the Eritrean boarder (13° 50'N, 39° 40'E), and east to Dire Dawa Region close to the Somali borders (9° 50'N, 42° 20'E). We encountered *Striga asiatica* once (and only two plants) in a demonstration farm. However, in 1985/1986 Chris Parker collected small forms of *Striga asiatica* with bright scarlet flowers widespread in Ethiopia attacking grasses without harming crops. In the south and east, however, *Striga asiatica* with various corolla colors ranging from brown, red, orange, and yellow were sporadically attacking sorghum and maize. Similar forms of *Striga asiatica* with various corolla colors were found attacking sorghum and maize in Ethiopia but with the scarlet forms attacking only native grasses (Sherif et al. 1987). *Striga asiatica* was not previously reported as a problem in Ethiopia until recently (Parker 1988). It was also known from a few collections in the Nile Delta in Egypt. This clearly suggests that the presence of *Striga asiatica* north of the equator is relatively recent compared to its establishment in southern Africa. As suggested by Berner and his team (1994), contaminated crop grains are the main source of *Striga* spread in Africa. *Striga hirsuta* and *Striga lutea* are distributed through much of Africa but common in west and central parts of the continent, especially the savannah grassland from Senegal to Ethiopia (Mohamed et al. 2001). While *Striga asiatica* is predominantly confined to crop fields, *Striga hirsuta* and *Striga lutea* are rarely problems on crops and are confined to natural grasslands.

Striga elegans is the fourth species in this cluster. However it is rarely confused with any of the other related species. It has brilliant scarlet flowers with yellow throats and dense

compact inflorescences. Limited to south and east Africa, it reaches its northern range in Kenya and has not been reported from crops. Our research (Mohamed 1994, Mohamed et al. 1996) showed that it is more closely related to *Striga asiatica* than other species in the cluster. No molecular study has yet been done to determine the phylogenetic relationships of the *Striga asiatica* species group but it is more likely that *Striga elegans* is the wild relative of *Striga asiatica*, they are sympatric in southern Africa. A group of researchers from Old Dominion University, University of Georgia, and State University of New York-Oswego are studying the systematics of the genus *Striga* and its various cluster groups.

Striga hermonthica is the largest, among the agronomically important species, and the most destructive of all *Striga* species. It is common in Sahelian Africa from Senegal to Ethiopia reaching its southern limits in Congo and Tanzania and causes more damage in sorghum, maize, and millet than any other crop pest. Also it is sporadic as an invasive in the Nile Delta and Yemen (where it may be native). *Striga hermonthica* has great within-species variation which is expected as it is an obligate out-breeder (Aigbokhan et al. 1998, 2000). Also *Striga hermonthica* collected from different geographical regions exhibits variability (Mohamed 1994). This species has developed strains specific to sorghum and millet. These are morphologically similar but have consistent floral variations. The millet-strain has smaller dull pink corollas and the sorghum-strain has a larger pink corolla. Floral variations may discourage cross pollinations between these strains and further enhance the differentiation of populations in *Striga hermonthica* as evidenced in recent molecular studies in which populations of *Striga hermonthica* collected from sorghum, millet, and maize showed genetic differences, the maize strains were more closely related to the sorghum-strain than to the millet-strain (K. I. Mohamed, unpublished).

Striga aspera is also an out-crosser and frequently hybridize with *Striga hermonthica* (Aigbokhan et al. 1998, 2000). It attacks maize in Ethiopia; maize, rice, and sugarcane in West Africa (Mohamed et al. 2001). Some of the damage attributed to *Striga hermonthica* in West Africa may in fact be due to *Striga aspera* with expansion of agriculture into natural grasslands exposing crops to parasitism. It is reported only from the savannah north of the equator both as a native and weedy species especially in West Africa.

Striga hermonthica, *Striga aspera*, and *Striga gracilima* are morphologically similar forming a species cluster. *Striga gracillima,* known only from southern Tanzania, Malawi, and northern Zambia, does not attack crops and is rarely sympatric with the other two species. *Striga gracillima* is determined by its short corolla tube (6-8 mm), bent proximally and covered with dense stiff hairs but never glandular-pubescent. It has the smallest corolla lobes (upper lip 4mm long, lower lip 1-3mm long). *Striga aspera* is exceptional in having a glandular pubescent corolla which is bent distally above the calyx teeth, longer calyx teeth (3-5 mm) which are about the same length as the calyx tube, and narrow leaves (≤ 2 mm). *Striga hermonthica* also lacks glandular-pubescent hairs on the corolla with hairs less dense than in *Striga gracillima*; corollas are much larger than in the other two species. *Striga hermonthica* is the tallest and most robust of all these witchweeds.

Striga gesnerioides is the only species attacking broad-leaf hosts. In addition to host preference, *Striga gesnerioides* tends toward holoparasitism reminiscent of *Orobanche*. *Striga gesnerioides* plants appear achlorophyllous (colorless) though they may have chlorophyll masked with other pigments. As a result, plants are white, shades of purple, and red --similar to *Orobanche* species. In addition, plants of S*triga. gesnerioides* have leaves reduced to scales-- a feature common to all *Orobanche* species.

Because of these characteristics, in addition to succulence, and tuftedness habit, *Striga gesnerioides* was never confused with other witchweeds. This species is the most widely distributed of all witchweeds. Its range includes Africa, Arabia, Asia, and the United States of America (where it has been introduced). *Striga gesnerioides* has developed host specific strains, the most important attack cowpea especially in West Africa and tobacco in Zimbabwe. Other reported host-specific strains includes *Indigofera* and *Tephrosia* in the Fabaceae Family, *Merremia*, *Ipomoea*, and *Jaquemontia* in the Convolvulaceae; and *Euphorbia* in the Euphorbiaceae. These host-specific strains do not damage crops but have the potential of becoming weedy, and agriculturalists should become aware of them. Some of these strains have unique distribution and known only in certain regions such *Merremia* strain reported only from southern Al Jazera Province in Sudan.

II. *Orobanche* species

Broomrapes are native to the Mediterranean region (North Africa, the Middle East, and southern Europe) and western Asia. Their range extends to similar climates in Asia, Africa, Australia, and North and South America where they also cause significant crop damage. Broomrapes are holoparasitic with more than 100 species (up to 170 spp according to Uhlich et al. 1995) but only a few of them are considered weedy. Important broomrape species include *Orobanche crenata* Forskal which is common on garden pea (*Pisum sativum* L.), lentil (*Lens culinaris* Medik), faba bean (*Vicia faba* L.), and garden vetch (*V. sativa* L.) and other hosts in the Mediterranean basin; *Orobanche cernua* Loefl. reported on carrot (*Daucus carota* L.), tomato (*Lycopersicum esculentum* Mill.), and tobacco (*Nicotiana tabacum* L.) in the Mediterranean basin extending eastward into Europe and Asia; *Orobanche cumana* Wallr. which is primarily a serious pest of sunflower (*Helianthus annuus* L.) in the sunflower-growing countries in the Mediterranean basin, Eastern Europe, and countries of the former Soviet Union; *Orobanche ramosa* L. is common on oil seed rape (*Brassica napus* L.) and many hosts in the Solanaceae including eggplant (*Solanum melongena* L.), tomato, tobacco, and potato in the Mediterranean region, Asia, Africa, Chile, and the United States; also reported on hemp and rape in western Europe; *Orobanche aegyptiaca* which has similar host range as *Orobanche ramosa* in Mediterranean region; *Orobanche mutelii* on tobacco in the Mediterranean region and Europe, Asteraceae in south Spain, Oxalidaceae in Crete and Lebanon; and *Orobanche nana* on Asteraceae, Solanaceae and Fabaceae in the Middle East (see also Parker 1991).

The holoparasitic life style of *Orobache* has resulted in dramatic reduction in morphological characters useful in field identification. Broomrape species have reduced leaves, almost uniform inflorescences, microscopic and uniform seeds, and very little variation in corolla color and shape, and often similar hosts. Taxonomists agree that the morphological features used in the classification of *Orobanche* are poorly defined. This paucity of characters to delimit species makes the development of meaningful keys difficult. Also because of the succulent nature of *Orobanche*, specimens deteriorate fast and preserve poorly.

Traditionally, the genus is divided into four sections of which Orobanche and Trionychon contain the noxious weedy species. Section Trionychon includes economically important species such as *Orobanche aegyptiaca, Orobanche ramosa*, *Orobanche nana,* and *Orobanche mutelii* while Section Orobanche contains *Orobanche crenata*, *Orobanche cernua*, and *Orobanche cumana*. These sections are mainly identified by the structure of the calyx and the presence or absence of bracteoles. Both Orobanche and Trionychon have

zygomorphic calyces, but only Trionychon has bracteoles. Additional important distinguishing characteristics of the Section Trionychon are branched stems, an entire and campanulated (bell shaped) calyx, a blue or purple corolla, white anthers, and usually white stigmas. The Section Orobanche has a single stem; a calyx with two lateral segments; a white, yellow, brown, amethyst or red corolla; yellow, brown-grey or grey anthers; and yellow, orange, red, or purple stigmas (Pujadas-Salvà 2002, Plaza et al. 2004). Other features may include types of bracts, placentation, inflorescence types, cytology (chromosome number), host, and distribution. A combination of morphological characters rather than a single character are useful in identifying *Orobanche* species. Recent micromorophological (Andary 1994, Plaza et al. 2004), chemotaxonomical (Velasco et al. 2000), and molecular studies (Román et al. 2003, Manen et al. 2004) confirmed the integrity of these sections, some authors recognize them as separate genera.

Orobanche aegyptiaca, *Orobanche ramosa*, *Orobanche nana,* and *Orobanche mutelii* have similar morphologies and host ranges; these constitute a species cluster within the Section Trionychon. *Orobanche nana* and *Orobanche mutelii* were treated by some authors as infraspecific variants of *Orobanche ramosa. Orobanche aegyptiaca* can be identified by its relatively more branched stem, moderately dense to lax inflorescence, pubescent stamens, larger corolla (>25mm), and blue flowers. In contrast, *Orobanche ramosa* has smaller corollas (<20mm long), laxer inflorescences, glabrous stamens, and white to pale blue flowers at the base and blue distally.

Both *Orobanche ramosa* and *Orobanche nana* have a smaller calyx (4-7mm) and corolla (10-16 mm) distinguishing them from *Orobanche mutelii* with its larger calyx (7-15mm) and corolla (16-22mm). In addition, *Orobanche mutelii* has pubescent filaments and corollas, with pale blue-purple to violet corollas. *Orobanche ramosa* is distinguished from *Orobanche nana* by its height (17-35cm), longer and laxer inflorescence (10-25cm), and triangulate and acuminate calyx teeth. This contrasts with the usually dwarf plants of *Orobanche nana* (8-21 cm), which are less branched, and have shorter and denser inflorescences (5-7cm), and lanceolate to triangulate calyx teeth.

In addition to traditional taxonomy, Plaza et al. (2004) studied the micromophology of *Orobanche* seeds in the Iberian Peninsula and found enough variability to develop a key identifying *Orobanche* species including *Orobanche ramosa*, *Orobanche nana*, and *Orobanche mutelii*. In *Orobanche ramosa* the seed coat epidermal cells have unevenly thickened anticlinal walls while in the other two species these cells have evenly thickened anticlinal walls. *Orobanche nana* is characterized by smaller seed size (<0.40mm) compared to *Orobanche mutelii* (>0.40mm).

The second species cluster of agronomically important broomrapes is in the Section Orobanche which includes *Orobanche crenata*, *Orobanche cenua,* and *Orobanche cumana*. As expected, these species share many morphological characteristics such as the unbranched stem, absence of bracteoles, and calyx with two lateral segments. Among the three species *Orobanche crenata* has a unique morphology and easily separated from the other two species. *Orobanche crenata* has corolla lobes with erose or denticulate (irregularly notched) margins in contrast to the entire margins in *Orobanche cernua* and *Orobanche cumana*. Also, *Orobanche crenata* has dense inflorescence, fragrant flowers, and a long corolla (> 20 cm) which is usually white with purple veins.

Orobanche cumana is often confused with *Orobanche cernua*. While *Orobanche cumana* is almost exclusively confined to cultivated sunflower, *Orobanche cernua* is known from many

hosts including wild plants. These two species differ in a number of ways. *Orobanche cumana* plants are taller (40-65cm), more slender, and with longer and laxer inflorescence than plants of *Orobanche cernua* (35cm tall). *Orobanche cumana* has entire, sometimes bifid calyx segments, glandular anther hairs, and white to pale blue flowers compared to *Orobanche cernua* which has bifid calyx segments, glabrous filaments, and blue, dark, violet or purple flowers. *Orobanche cernua* corollas are inflated at the base, upright, constricted in the middle, and bent at the tip while in *Orobanche cumana* corollas are not inflated (uniformly tubular) and markedly curved downward. The two species differ further in other morphological and ecological characteristics in addition to their oil and fatty acid contents (see Pujadas-Salvà and Velasco, 2000).

Overall, the genus *Striga* poses fewer problems in taxonomy and identification. The broomrapes, on the other hand, contain several species which require considerable effort to identify. Unlike the witchweeds, species of *Orobanche* have received considerable attention from taxonomists including a plethora of names of species, varieties, and even forms. The application of powerful molecular techniques used by several plant systematists working on the genus is providing increasing clarity of relationships and taxonomic levels.

References:

Aigbokhan, E. I., Berner, D. K., Musselman, L. J. and Mignouna, H. D. 2000. Evaluation of variability in *Striga aspera, Striga hermonthica* and their hybrids using morphological characters and random amplified polymorphic DNA markers. *Weed Research* 40, 375-386.

Aigbokhan, E. I., Berner, D. K., and Musselman, L. J. 1998. Reproductive ability of hybrids of *Striga aspera* and *Striga hermonthica*. *Phytopathology* 88:563-567.

Andary, C. 1994. Chemotaxonomical study of the genus *Orobanche.* In: Pieterse A. H., Verkleij J. A. C., and ter Borg S. J., eds. *Proceedings of the 3rd International Workshop on Orobanche and related Striga research*. Amsterdam, The Netherlands: Royal Tropical Institute, pp. 121–126.

Berner, D. K., Cardwell, K. F., Faturoti, B. O., Ikee, F. O. and Williams, O. 1994. Relative roles of wind, crop seeds, and cattle in dispersal of *Striga* species. *Plant Disease* 78, 402-406.

Manen, J. F., Habashi, C., Jeanmonod, D., Park, J. M. and Schneeweiss, G. M. 2004. Phylogeny and intraspecific variability of holoparasitic *Orobanche* (Orobanchaceae) inferred from plastid *rbcL* sequences. *Molecular Phylogeny and Evolution* 33, 482-500.

Mohamed, K. I., Musselman, L. J. and Riches, C. R. 2001. The genus *Striga* (Scrophulariaceae) in Africa. *Annals of the Missouri Botanical Garden* 88, 60-103.

Mohamed, K. I., Musselman, L. J., Aigbokhan E. I., and Berner, D. K. 1996. Evolution and taxonomy of agronomically important *Striga* species. In: Moreno, M. T. and Cubero, J.

I. eds. *Advances in Parasitic Plant Research*, *6th International Parasitic weed Symposium*, Cordoba, Spain, pp. 54-73.

Mohamed, I. K. 1994. Biosystematics and diversification in the genus *Striga* Lour. (Scrophulariaceae) in Africa. Ph.D. Dissertation, Old Dominion University, Norfolk, Va.

Olmstead, R. G., dePamphilis, C. W., Wolfe, A. D., Young, N. D., Elisens, W. J. and Reeves, P. A. 2001. Disintegration of the Scrophulariaceae. *American Journal of Botany* 88, 348-361.

Parker, C. 1991. Protection of crops against parasitic weeds. *Crop Protection* 10, 6–22.

Parker, C. 1988. Parasitic plants in Ethiopia. *Walia* 11, 21-27.

Plaza, L., Fernández, I., Juan, R., Pastor, J. and Pujadas-Salvà, A. 2004. Micromorphological studies on seeds of *Orobanche* species from the Iberian Peninsula and the Balearic Islands, and their systematic significance. *Annals of Botany* 94, 167-178.

Pujadas-Salvà, A. J. 2002. *Orobanche* L. In: LoÂpez, J. A., CatalaÂn, P., and SaÂez, L. I., eds. *Plantas paraÂsitas de la PenõÂnsula IbeÂrica y Baleares*. Madrid: Mundi-Prensa, pp. 348-440.

Pujadas-Salvà, A. J. and Velasco, L. 2000. Comparative studies on *Orobanche cernua* L. and *O. cumana* Wallr. (Orobanchaceae) in the Iberian Peninsula. *Botanical Journal of the Linnean Society* 134, 513–527.

Román, B., Alfaro, C., Torres, A. M., Moreno, M. T., Satovic, Z., Pujadas-Salvà, A., and Rubiales, D. 2003. Genetic relationships among *Orobanche* species as revealed by RAPD analysis. *Annals of Botany* 91, 637-642.

Sherif, A. M., Fessehaie, R., and Parker, C. 1987. Parasitic weeds in Ethiopia. In: Michieka, R.W. (Ed.) *Proceedings, 11th East African Weed Science Society Conference*, Nairobi, Kenya, pp. 66-72.

Uhlich, H., Pusch, J., and Barthel, K. J. 1995. Die Sommerwurzarten Europas. Gattung *Orobanche*, Westarp Wissenschaften, Magdeburg: Westarp Wissenschaften.

Velasco, L., Goffman, F. D. and Pujadas-Salvà, A. J. 2000. Fatty acids and tocochromanols in seeds of Orobanche. *Phytochemistry* 54, 295-300.

OROBANCHE MANAGEMENT

Integrated *Orobanche* management

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Summary

The situation of *Orobanche* problem in North Africa and the Near East is described as well as the possible methods to be implemented for the control of these parasitic weeds. The major problematic species of this genus are *Orobanche aegyptiaca* Pers./*Orobanche ramosa* L., *Orobanche cernua* Loefl., *Orobanche cumana* Wallr., *Orobanche crenata* Forsk., *Orobanche minor* Sm. and *Orobanche foetida* Poir., most of them affecting several leguminous, solanaceous crops and sunflower. Some eco-biological characteristics of these plants are also emphasized. Their management should be based on good knowledge of their seed germination, factors affecting it, plant growth and others.

La Gestion Integrée du *Orobanche*

Résumé

La situation du problème d'Orobanche en Afrique du Nord et au Proche Orient est décrite comme une méthode possible à mettre en application pour la gestion de ces mauvaises herbes parasites. Les espèces problématiques principales de ce genre sont *Orobanche* ramosa L., *Orobanche* cernua Loefl., *Orobanche aegyptiaca* Pers., *Orobanche cumana* Wallr., *Orobanche foetida* Poir., *Orobanche minor* Sm. et *Orobanche crenata* Forsk. La plupart d'eux affectent plusieurs cultures légumineuses et solanacées, ainsi que le tournesol. Certaines caractéristiques eco-biologiques de ces plantes parasites y sont également soulignées. Leur gestion devrait être basée sur la connaissance de la germination des graines, des facteurs qui les affectant, du développement des plantes et autres.

I. Introduction

The centers of origin of *Orobanche* species are thought to be Italy, Spain, Turkey and Morocco (Sauerborn, 1991). Then different species achieved broader distribution through international trade and commercial exchange of contaminated seeds which contributed to the worldwide spread of these species. The majority of *Orobanche* species are found in the Mediterranean region. Out of the 140 known species of *Orobanche* (Kroeschel and Klein, 2002), about ten species are of economic importance, and represent a serious threat to a wide range of cultivated hosts, namely; *Orobanche aegyptiaca* Pers./*Orobanche ramosa* L., *Orobanche cernua* Loefl., *Orobanche cumana* Wallr., *Orobanche crenata* Forsk., *Orobanche minor* Sm. and *Orobanche foetida* Poir. The following species have been found in the participating countries:

Table 1. *Orobanche* species in selected countries

Country	*O. aegyptiaca ramosa*/	*O. crenata*	*O. cernua*	*O. cumana*	*O. minor*	*O. foetida*
Algeria	x	x				
Egypt	x	x	x		x	
Ethiopia	x	x	x			
Morocco	x	x		x		x
Sudan	x	x	x		x	
Syria	x	x				
Tunis	x	x				x

Orobanche seeds germinate occurs when they are preconditioned (warm moist conditions for several days) then exposed to germination stimulants exuded by host roots and some non-hosts. Upon germination, a germ tube, which is in close proximity to the host roots, elongates towards the root of the host, develops a haustorium through which the parasite attachs and deprives its host from water, mineral nutrients and carbohydrates, causing stunted growth of the susceptible host plants which contribute to reduction of its yield. Most of the seeds in the soil will not be reached by the stimulant, but will remain viable for more than ten years, forming a seed reservoir for the next cropping seasons. After several weeks of underground development the parasite emerges above the soil surface and starts to flower and produce seeds within a short period of time. Seed production is enormous, up to 100 000 seeds or even more can be produced by a single plant and lead to a re-infestation of the field. Thus, if host crops are frequently cultivated, the seed population in the soil increases tremendously leading to the failure of cultivating host crops.

II. Impact of *Orobanche*

A considerable loss in growth and yield of many food and fodder crops is caused by root-parasitic flowering plants. Globally, the damage caused by *Orobanche* on field and vegetable crops is significant in the Near East (Abu-Irmaileh B. E. 1994; Linke *et al.* 1989), South and East Europe and in various republics of the former Soviet Union. It causes yield losses ranging from 5-100 percent (Linke *et al.* 1989).

Thus, *Orobanche* hinders cultivation of many strategic crops including legumes, industrial crops, oil crops, vegetables, and threaten the livelihood of many nations. It attacks fruit trees as well as coffee and Catha plantations. Over one million hectares of broad bean are infested by *Orobanche crenata* or at risk around the Mediterranean region of which: 113 000 ha in Morocco and 5 600 ha in Syria, 10 000 ha in Tunisia (Sauerborne, 1991). *Orobanche* can limit the choice of crop rotation to non-host crops, which in most cases, are less rewarding. Many farmers abandoned cultivation of faba beans, tomato, and tobacco in heavily infested fields. Many others abandoned agriculture altogether, forced to migrate and seek other means of income outside the rural domains.

Recent estimates on the impact of *Orobanche* in the participating countries, as obtained from farmers, officials, and recent literature can be summarized as the following:

Syria

Heavy infestations with *Orobanche crenata* are encountered in food legume major growing areas (ex. Idlib) in 60 percent of the area causing 30-100 percent yield loss. Farmers were forced to replace lentil, faba bean and vegetables with less profitable crops such as black cumin, coriander, or cereal.

Heavy infestations with *Orobanche ramosa* are common in solanaceous crops in many regions. *Orobanche ramosa* infests over 70 percent of tomato, tobacco and eggplants in Dara'a governorate with infestation ranging between 25-50 percent inflicting 15-50 percent yield losses. It is estimated that *Orobanche* impact accounts for 5-15 percent of the total production management constraints facing agriculture in the country

Egypt

Orobanche is second important problem after foliar diseases in faba bean and tomatoes and is number one pest in peas (El Hassanein and Salim. 1999). Once Egypt was exporting faba bean, but *Orobanche* infestations is impacting its production and threatening the livelihood of the nation, forcing the Egyptian government to import faba bean to meet the dietary demand of the population. Faba bean cultivation was abandoned in Upper Egypt due to either many *Orobanche* or FBNYV infestation. *Orobanche* infestation in the newly reclaimed lands approached 30 percent of the 16 000 ha cultivated in this area.

Sudan

Orobanche species present in Sudan include: *Orobanche crenata, Orobanche cernua and Orobanche minor*. The major species is *Orobanche ramosa* infesting tomatoes and potatoes and hosted by many other vegetable crops (Babiker et al, 1994). It was also found on onions and many weedy hosts. Heaviest impact of *Orobanche ramosa* is in Khartoum and Al Jezira states on Nile soils. Infestation approached 100 percent of tomatoes and potatoes areas; consequently, large areas were put out of tomato production. Impact of *Orobanche ramosa* on potatoes is somewhat less than in tomatoes. Yield loss in potatoes was estimated by 30 percent.

Infestation with *Orobanche crenata* was only recently encountered, but spreading at a fast pace, in the two main states of faba bean production, threatening food security of the nation.

The first report on the presence of *Orobanche crenata*, was in 2001 in one site of about one hectare. Infestation spread within a 3 year period to cover over 28 sites in the Nile states with an average infestation of 1 percent from the total 21 000 ha, and 12 percent in the Northern state, with an average yield loss ranging from 6-90 percent.

Ethiopia

Orobanche surveys indicated that several districts are plagued with *Orobanche* (Gojam and Gondar,Tatch Gayint, south Welo, Kedijo and Flagober). According to farmers, crop loss could reach as high as 75 - 100 percent. Farmers in Kedijo area indicated that the weed appeared for the first time in 1983 in Dehit area (Goshi-locality).

Infestation with *Orobanche ramosa* on tomatoes is concentrated in the River Awash basin of the Central Rift Valley threatening both the large scale commercial farms and the small scale subsistence farming communities. *Orobanche cernua* is serious pest of tobacco in Awara

Malka and Nura Era. Due to *Orobanche* problems, some State Farms have had to give up growing tomato. The average yield reduction ranged from 30-40 percent.

The first collection and identification of *Orobanche crenata* was in 1993 in Amhara district - in one site (10ha), presently infesting 19 locations in two districts.

Average yield loss for the whole farm production is estimated to be 36 percent and under extreme conditions yield losses in severely infested fields can reach up to 62 percent.

Algeria

The dominant *Orobanche* species in Algeria include: *Orobanche crenata* in northern Wilayats (Sahel) where several farmers abandoned growing legume crops and replaced them with cereals and vegetables; *Orobanche ramosa* on industrial tomatoes in Annaba and Ainn Defleh areas; and *Orobanche cernua* Southern Algeria, Saharan area. It was estimated that 60 percent of the area in the middle coast is infested with *Orobanche crenata.*

The available information indicated that average yield losses in legumes are 25 percent in the Sahel area. *Orobanche* ramosa infests autumn planted vegetable crops (tomatoes, pepper, carrots, lettuce and cucumber). Estimate of infestation in tomatoes in Ain Defla was about 70 percent in Boumadfaa, and about 55 percent in Al-Ataf.

Morocco

The main species of *Orobanche* in Morocco are *Orobanche crenata* and *Orobanche ramosa*. The more virulent species, *Orobanche foetida* was also reported to occur. Infestation of *Orobanche* in legumes progressed from 12 percent in 1981, 26 percent in 1994, to 30 percent in 2001 (Ben Yassine et al 2002) and reached 51 percent in 2003 growing season. The estimated average yield losses due to *Orobanche crenata* were 37.4 percent in 1998, forming about 55.4 percent of annual local legume consumption. The estimated percent of the impact of *Orobanche* infestation alone amounted to 40 percent of the total impact of all other stresses in crop management. Legume acreage has been declining for the past 30 years for many reasons of which *Orobanche* infestation stands among the major reasons. This forced the government to pass a general regulation, in 1992, preventing the export of faba bean in order to ensure food security.

Tunisia

The main *Orobanche* species in Tunisia include *Orobanche crenata, Orobanche foetida* and *Orobanche ramosa.* The exact estimates for the impact of *Orobanche* in Tunisia are lacking (Kharrat and Halila, 1994). However, it was indicated that about 5 000ha out of 70 000ha planted to food legumes might have *Orobanche* infestation. Some farmers replaced food legumes by sunflower and garlic. Yield losses ranged from 20 to 80 percent. *Orobanche foetida* is common in the Northern parts on large and small seeded faba bean beside other species of different families. Production failure occurs under high infestations. *Orobanche ramosa* was also cited attacking leguminous crops, as well as many vegetables and tobacco.

The estimated levels of *Orobanche* incidence in different countries are not very well quantified. They are approximate estimations in many cases. Yet, these estimates could point out the magnitude of the parasite problem. However, the incidence of parasitism varies within the same location with time according to the prevailing weather conditions, especially

temperature and soil moisture and level of soil fertility. Mesa-García and García-Torres (1991) showed that crop rotation, irrigation, fertilization, variety and sowing date affect *Orobanche* infestation affect the severity of infestations.

Research results indicate that there is a great potential for improving the productivity and yield stability if the biotic and abiotic stress factors are effectively controlled and the inherent yield potential of the cultivars is improved. Various workshops on parasitic weeds at large or specifically on *Orobanche* discussed various management methods, claiming various levels of successes. In spite of the diverse methods of *Orobanche* control, the adoption of many methods is hampered by many draw backs in the subsistent farming systems.

III. Control methods

Hand pulling of *Orobanche* flowering shoots is the main control method, if any. Only small percentage of faba bean acreage received glyphosate treatment for *Orobanche* control in Egypt and Morocco.

Many control methods have been tried to manage broomrapes, *Orobanche* spp. However, there is no one single method can give satisfactory control. Compared with other weeds, broomrapes are characterized by the production of extremely high number of very tiny seeds per plant. Seeds can remain viable in the soil for more than ten years. Seeds can easily be disseminated over long distances by various means, including wind, grazing animals, contaminated transferable items such as crop seeds, machinery, farm produce, soil, vehicles, etc., and can pass country borders through unqualified quarantine centers unnoticed. Seed germination is enhanced by germination stimulants from plant roots. In addition to the possibility for the occurrence of mutations which can modify host-parasite interactions. These characteristics limit the development of successful control measures which can be accepted and applied, especially by subsistent farmers. However, several control methods are available for the control of *Orobanche*, including cultural, mechanical, physical, chemical, germination stimulants resistant varieties, biological and other innovative techniques.

3.1 Preventive methods

One of the most important control methods is to prevent the introduction and distribution of the parasite seeds from infested to un-infested areas. Negligence and lack of knowledge are responsible for the spread and the increase of *Orobanche* problem. National and international trade of contaminated crop seeds contributes to the seed dispersal over long distances. Local seed production in infested areas, uncontrolled movement of grazing animals, moving contaminated farm machinery and equipment, improper phytosanitary measures and the spread of contaminated manure intensify spread of *Orobanche*. Improper farming practices could be easily overcome by raising the awareness about the biology of *Orobanche*, and the means of its spread among farmers, technical staff and officials.

The following preventive methods proved effective, but need to be adapted to the present farming systems.

3.1.1 Planting uncontaminated or certified seeds

Planting uncontaminated or certified seeds ensures clean fields during the season if the soil was not previously infested with *Orobanche.* Certified seeds are normally beyond subsistent farmer's affordability, and cleaning crop seed from the minute seeds of *Orobanche* are not normally feasible. Since farmers exchange locally produced seeds, it is possible to have farmers exchange seeds produced in areas that are known to be *Orobanche*-free.

3.1.2 Spreading organic manure

Fresh contaminated manure aggravates *Orobanche* problem. Farmers should be instructed to use fermented manure, as fermentation process kills the seeds of the parasite. Pre-plant composting fresh manure under plastic mulch in the planting rows causes *Orobanche* seeds to lose viability within six weeks, and reduces *Orobanche ramosa* infestation on many vegetables. This practice could be a useful asset in high value crops. Fermenting manure in the farm can be easily practiced by subsistent farmer without much input and can aid sustainable farming strategy.

3.1.3 Phytosanitation

Proper phytosanitary measures in and around the field are necessary to reduce the spread of *Orobanche*. Farm equipment and machinery should be cleaned prior to their use in un-infested fields. *Orobanche* shoots should be removed prior to flower opening. The collected shoots should be burnt or disposed off properly. Good extension agents could easily convince the farmers to execute such task, especially when they made aware of the tremendous production of *Orobanche* seeds per plant. One important spreading agent of various weeds, including *Orobanche,* is the uncontrolled movement of grazing animals. Grazing animals should be forbidden to enter un-infested fields after grazing infested areas.

3.1.4 Quarantine

Strict quarantine measures, at various levels, national and international, help in preventing the introduction of the parasite into parasite-free areas. Technical inspection of imported agricultural materials should be carried out by a subject matter specialist in parasitic weeds.

3.2. Cultural methods

3.2.1 Crop rotation

Crop rotation, including trap and catch crops, will gradually decrease *Orobanche* infestation. But complete control will be achieved after a very long period, due to the long life-span of *Orobanche crenata* seeds. It can however reduce the infestation level if integrated with other control methods. Crop rotation is already a current farmers practice. In many farms, susceptible crops are abandoned. Rotating with trap and catch crops can reduce *Orobanche* seed bank if properly managed. However, if the market price is in favor of the host crop, rotation practice becomes hindered to a large extent.

3.2.2 Weeding

Weeding of *Orobanche* is mainly accomplished after the parasitic damage has already been done. It is not likely to show any yield increase in the short term. Weeding is laborious and

time-consuming, and not very promising in highly infested areas. However, in combination with other methods, it can reduce the seed bank very efficiently.

3.2.3 Planting date

Planting date could be manipulated so as to avoid infestation, as environmental factors affect germination and development of the parasite. Germination of *Orobanche crenata* tends to be very much reduced below 8°C and further development is greatly reduced at low temperatures (Saxena et al., 1994). Delaying the planting date affects *Orobanche* more than its hosts; the delay should be two weeks only from the date optimal for sowing in an un-infested field. However, this method must be adapted for different regions and for different hosts. Earlier planting dates are beneficial in certain instances. The change of the sowing date seems not to be very promising due to uncertainty of the environmental conditions, specifically temperature and rainfall situation. Farmer's negative perception to this method is controlled by the inherent traditional soil preparation which is largely linked to the onset of rain, and to the market demand for the produce.

3.2.4 Fertilization

Orobanche tends to be associated with less fertile soil conditions. High levels of nitrogen fertilizer or chicken manure showed a suppressive effect. There is no full understanding of the mechanism of such suppressive effect. The main effects could be due to:

- reduction of stimulant exudation;
- direct damage to *Orobanche* seeds and seedlings in the soil;
- reduced osmotic pressure in the parasite relative to the host;
- a toxic effect of nitrogen on *the parasite* development;
- alternation of host root and shoot balance.

The input of nitrogenous fertilizers to the rain-fed cropping system of food legumes is of low consideration due to the high cost of fertilizers. In addition, nitrogenous fertilizers adversely affect nodulation and nitrogen fixation processes. It is not very promising to increase the input of fertilizers in order to reduce *Orobanche* infestation.

3.2.5. Deep plowing

Plowing may reduce the infestation, if the top soil layer is properly turned to the bottom. Where equipment is available and soil condition permits, this technique can be useful in the integrated control management.

3.2.6 Resistant / tolerant cultivars

Resistance to *Orobanche* is the best long-term strategy for limiting the damage caused by *Orobanche*. Conventional plant breeding has produced few crops with stable resistance, while genetic engineering offers the possibility of creating novel resistance mechanisms that may be introduced into many commercial crops. While tolerant crop plants are not suitable for solving the *Orobanche* problem, because they maintain *Orobanche* development to maturity and hence contribute to the steady increase of the *Orobanche* seed bank in the soil, breeding of *Orobanche*-resistant crop plants as a long-term measure for *Orobanche* control appears more attractive than costly and doubtful chemical or physical control procedures.

However, evidence is available for mutative modifications in *Orobanche*, by which host specificity and aggressiveness can change. Resistant varieties will only be accepted if they meet all the requirements requested by farmers and the market.

3.3 Physical methods

These methods include flooding, soil solarization, bio fumigation, microwave and others.

3.3.1 Flooding

Flooding requires the availability of water which is scarce in Near East countries. Flooding for an extended period can kill the parasite seeds in the soil. This practice proved useful in Iraq, where host crops are planted after rice. *Orobanche* infestation was drastically reduced in such rotation.

3.3.2 Solarization

Solarization has proven effective in reducing several soil borne pests including *Orobanche.* Solarization is not applicable in rain-fed systems for economic reasons, but under irrigation systems, soil solarization with plastic sheets could be an additional measure to reduce the *Orobanche* infestation. The relatively high cost of this method can be partly compensated by the control of difficult-to-control pests like most other weeds, fungal, nematodes, and bacterial pathogens and an improved nutrient status of the soil. Furthermore, there is a residual effect over several years following the solarization treatment, resulting in increased crop yields (Abu-Irmaileh. 2003).

3.4 Biological control

Bioagents include insects such as *Phytomyza orobanchia* and fungi such as *Fusarium oxysporium* fsp *orthoceras.* Only *Phytomyza orobanchia* (Diptera, Agromyzidae) seems to be of interest for the biological control of *Orobanche*. Seed production in *Orobanche* was found to be reduced significantly in many countries (Kroschel and Klein, 2003). Natural enemies can reduce the fly population considerably. The only way to make use of *Phytomyza orobanchia* is to collect *Orobanche* infested with the fly's larvae, and to distribute these shoots in the field at the time when *Orobanche* is expected to emerge. Several fungi have been reported to be virulent on *Orobanche*. Current investigations concentrate mainly on *Fusarium oxysporum* f. sp. *orthoceras*, a pathogen with high potential to control *Orobanche cumana* (Abuelgasim and Kroschel, 2003).

3.5 Chemical control

This method includes the application of soil fumigations, seed dressing with selective herbicides, preplant and/or premergence application of herbicides (glyphosate, Imidazolinones and the Sulfonylureas). The most limiting factor in the use of the promising herbicides is their degree of selectivity among the crops at the required rate for parasite control, and the critical time of application, especially of the foliar applied systemic herbicides. Glyphosate was the first promising herbicide developed for *Orobanche crenata* control in faba bean (Schmitt et al. 1979). The crops in which the use of glyphosate is well confirmed, so far, include faba bean, carrot and celery. However, the corresponding yield increase is inconsistent especially under heavy infestation. Application must be carried out at the earliest stage of infection, long before emergence, and repeated in time interval of two to

four weeks, because *Orobanche* seeds germinate throughout the season. Knowledge of the phenology of *Orobanche* is essential for effective chemical control. The right moment of the application has to be determined by inspections of the faba bean roots twice per week for the presence of *Orobanche* tubercules. The exact dosage of glyphosate is important for better efficiency, and for reducing phytotoxic symptoms on the crop. The effective dose to kill *Orobanche* varies according to the number of tubercules attached and according to the weather conditions. Phytotoxicity symptoms leave negative impact on farmers.

In addition to glyphosate, other herbicides, e.g., sulfonylurea and imidazolinone proved to be effective in many host crops. Slight phytotoxicity symptoms have been encountered from some herbicides. But the increase in yield due to the efficiency of controlling *Orobanche* balances the slight phytotoxic symptoms. It has been shown that the phytotoxicity of some post-emergence herbicides on crops can be avoided or reduced by altering their application and delivery technique. For example, by chemigation chlorsulfuron and triasulfuron into the soil, *Orobanche aegyptiaca* can be successfully controlled and the yield of tomato increased without damaging the crop (Kleifeld et al. 1999). Promising results were also obtained by soaking or coating the seeds of faba bean, pea seeds, or lentils in low concentration of imazethapyr or imazapyr, respectively (Garcia-Torres et al. 1999). Seed germination and crop growth were not affected by phytotoxicity of both herbicides. Herbicide application is too technical and expensive in subsistent farming. Intensive farmer training and effective extension services are required.

The following treatments proved effective for controlling *Orobanche* in legumes, at experimental or field demonstration levels (Lutzeyer et al, 1994):

- Pre-emergence applications (at "tubercle" and "bud stage" of *Orobanche* development).
  - a- Glyphosate:
    - in faba bean 1 to 3 x 80g a.i./ha according to infestation;
    - in field pea 2 x 60g a.i./ha;
    - in chickpea 2 x 20 ga.i./ha;
    - in lentil not useful; low tolerance also in tomato and eggplant.
  - b- Imazaquin: excellent results in field peas at a rate of 2 x 20g a.i./ja; slightly less effective in faba bean at 2 x 30g a.i./ha; in lentil 2 x 10g a.i./ha.
  - c- Imazethapyr: in faba bean 2 x 30g a.i./ha; in lentil 2 x 10g a.i./ha.
  - d- Oroban (Imazapic 1%) - 1-2 X 500 ml/ha lentils.
  - e- Recent reports (Lins *et al* 2005) indicated that imazamox alone or combined with bentazon proved effective for controlling *Orobanche minor* in red clover.

Soil fumigation with methyl bromide is effective. But, with the phase out of methyl bromide, other methods should come as a replacement. This method is expensive. Other fumigants include metham sodium, dazomet, and 1,3, dichloropropene.

3.6 Integrated Management

Single methods are not sufficient to control parasitic weeds effectively in one cropping season. Therefore, combinations of control methods and their yearly application are the only solution to reduce the infestation on a tolerable level. Integrated management strategies need

to combine low cost control methods that enhance crop tolerance to the parasite through improvement of soil fertility, particularly nitrogen status, utilize the most tolerant cultivars that are available, in addition to potential preventive means. Cultural methods such as; manipulating seeding rate, planting date, proper phytosanitary measures, help in reducing infestations. Herbicides application could be carried out by trained farmers. The aim of integrated management is to constantly reduce the parasite population leading to the reduction of the soil seed bank.

3.7 Sustainability

The first step towards sustainable *Orobanche* management is to make the farmer aware of the biology of the parasite and the means of its spread. On farm research and extension practices should incorporate farmers, in order to asses whether the introduced management method is too technical or easy to adopt. The limitations for the introduction of control strategies should be properly analyzed in order to develop an economically viable integrated control strategy for both large and small-scale farmers. *Orobanche* management should be analyzed with respect to the existing cropping system, making use of the farm resources and farmer capabilities, considering the introduction of external production equipment and plant protection methods. On farm training (FFS) through farmer-field schools could be effective in raising farmer's awareness and help them avoid or reduce the present infestations. Easy rewarding techniques would always be welcome. Upgrading farm resources would reduce the production costs and improve returns. Facilitating marketing of the produce is a very important element in farming sustainability.

Risk factors should be avoided or reduced to the minimum. The priority should always be set for ensuring life improvement in such fragile agro ecosystems. Any risk encountered from the introduced techniques will slow adoption, and lead to the loss of faith in the newly introduced methodology, especially in subsistent farming communities.

Raising the awareness among officials about the impact of *Orobanche* on national agriculture and national economy would help them in setting priorities for managing the parasite problem in the developmental projects. At present, most weed problems are dealt with by general agriculturists, or at best by plant protection specialists, entomologist or plant pathologists in many countries.

Extension and quarantine facilities should be staffed with the appropriate subject matter specialists to aid farmers in their better management of the cropping situation, and to prevent the introduction of the parasite from being introduced to un-infested areas. Environmental impact assessment of the introduced strategies should be assessed in order to develop ecologically justifiable control strategies.

IV. Future Perspectives of integrated management of *Orobanche*

4. 1 Biotechnology

Utilization of biotechnology for developing resistant cultivars to *Orobanche* might be the best approach, if the cultivars meet the required horticultural features desired by the farmer and/or the market. However, growing genetically modified crops are still under discussion in many

countries around the world. GM-crops which tolerate herbicides used to control *Orobanche* facilitate selective management of the parasite.

4. 2 Organic Farming

Organic farming is recent advancing trend in many countries. With the development of resistant cultivars, and through the use of non-chemical approaches to solve *Orobanche* problem would encourage organic farming. It can be said that farming communities in most of the cultivated areas in subsistent farming situation are somewhat organic, as most of the cultivation practices are devoid of the use of the agro-chemicals.

4.3 Socioeconomic of farming communities

Socioeconomic status of the farming community should always be emphasized in order to assure sustainable management of *Orobanche*. Most farmers are aware of the existence of *Orobanche* problem in their fields, in as much as they are aware of the existence of other problems. However, the main concern of the farmers, especially subsistent farmers, is how much return will gain at the end of the growing season. *Orobanche* problem should be dealt with as one part of a holistic perspective. Farmer's participatory approach should always be incorporated in field research and extension activities. Unless *Orobanche* is the limiting production factor, i.e., heavy infestations, farmers do not complain much about the parasite. Most farmers are poorly educated and require close attention from extension specialists. Young farmers tend to migrate for better rewarding conditions anywhere in the country or abroad. The advancement of urbanization and farm fragmentation reduce the interest in farming career.

4.4 Risk avoidance

Orobanche management should be analyzed with respect to the existing cropping system**,** making use of the farm resources and farmer capabilities, considering the introduction of external production equipment and plant protection methods. Risk factors should be avoided or reduced to the minimum. The priority should always be set for ensuring life improvement in such fragile agro ecosystems. Any risk encountered from the introduced techniques will slow adoption, and lead to the loss of faith in the newly introduced methodology, especially in subsistent farming communities.

References:

Abuelgasim, E. and J. Kroschel. 2003. Progress on management of parasitic weeds. In: Weed management for developing countries. FAO palnt production and protection paper No.120. Addendum 1, pages: 109-144.

Abu-Irmaileh B. E. 1994. An overview of parasitic weed problems in some Near East countries. In: FAO Report of the Workshop *Orobanche* and Cuscuta Parasitic Weed Management in the Near East. Amman, 8-23.

Abu-Irmaileh B. E. 2003. soil solarization. In: Weed management for developing countries. FAO palnt production and protection paper No.120. Addendum 1. pages 211-223.

Babiker, A., E. Mohamaed and M .El Mana . 1994. *Orobanche* problem and management in the Sudan. in: A.Pieterse, J.verkleij and S. ter borg,(eds) Biology and Control of *Orobanche*. Proceedings of the Third International Workshop on *Orobanche* and Related *Striga* Research. Amesterdam 8-12 Nov. 1993. pages:672-676.

El Hassanein and A. Salim. 1999. country paper about *Orobanche* and its control in Egypt. In: In: J. Kroschel, M. Abderabihi and H. Betz (eds.), Advances in Parasitic Weed Control at on-farm Level. Vol. II. Joint Action to Control *Orobanche* in the WANA Region. Margraf Verlag, Weikersheim, Germany, pages:27-35.

Garcia-Torres, L., Lopez-Granados, F., Jurado-Exposito, M. and J. Diaz-Sanchez, 1999. Chemical control of *Orobanche* spp. in legumes: Advances in Parasitic Weed Control at On-farm Level: Achievement and constraints. In Kroschel, J., Abderahibi, M. &, Betz, H., eds. Vol. II. Joint Action to Control *Orobanche* in the WANA Region. Margraf Verlag, Weikersheim, Germany, 239-250.

Kharrat M. and M.H. Halila .1994. *Orobanche* species on faba bean (Vicia faba L.) inTunisia: Problems and management. In: A.H.Pieterse, J.A.C. Verkleij and S.J. ter Borg (eds.) Biology and Management of *Orobanche* , Proceedings of the Third International Workshop on *Orobanche* and related *Striga* research. Amsterdam, The Netherlands, Royal Tropical Institute. 639-643.

Kleifeld, Y., Goldwasser, Y., Plakhine, D., Eizenberg, H., Herzlinger, G. and S. Golan, 1999. Selective control of *Orobanche* spp. in various crops with sulfonylurea parasitic weed control at on-farm level. Vol. II. Joint Action to Control *Orobanche* in the WANA Region. Margraf Verlag, Weikersheim, Germany. 251-257.

Kroschel, J. and O. Klein, 2002. Biological control of *Orobanche* spp. in the Near East and North Africa by inundative releases of the herbivore Phytomyza orobanchia. In: BioControl, Vol. 47, (3) Pages: 245 – 277.

Linke, K.H. 1998. Status quo of *Orobanche* control: preventive, cultural and physical control. Joint Action to control *Orobanche* in the WANA-region: Experiences from Morocco. 30 March - 2 April 1998, Rabat Morocco.

Lutzeyer H.J., Kroschel J. & Sauerborn J. (1994) *Orobanche* crenata in legume cropping farmers perception, difficulties and prospects of control - a case study in Morocco. In: A.H.Pieterse, J.A.C. Verkleij & S.J. ter Borg (eds.)

Lins, R.D., J.B. Colquhoun, C.M. Cole, and C.A. Mallory-Smith. 2005. Postemergence small broomrape (*Orobanche* minor) control in red clover. Weed technology 19:411-415.

Mesa –García, J. and L. García-torres. 1991. Status of *Orobanche* crenata in faba bean in the Mediterranean region and its control. Options Méditerranéennes - Série Séminaires - n.O 10: 75-78.

Sauerborn, J. 1991. parasitic Flowering Plants, Ecology and management. Verlag J. Margraf Scientific Books. Hohenheim. Pages 128.

Saxena,M. K. Linke and J. Sauerborn. 1994. Integrated control of *Orobanche* in cool-season food legumes. In: Peiterse A., J. Verklaj and S. terBorg(eds.). 1994. Proceedings of the 3rd intenational workshop on *Orobanche* and related *Striga* research. Amsterdam. 8-12 Nov. 1993. pages: 419-431.

Schmitt, U., Schluter, K. and P.A. Boorsma, 1979. Control quimico de *Orobanche* crenata en habas. Boletin Fitosanitario FAO, 29: 88-91.

Orobanche management in Algeria

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Summary

Food legumes are of a big importance in the human feeding mainly based on grains. However, these cultures are subjected to abiotic and biotic stresses that compromise seriously the yields. Among the menacing biotic stresses, the parasitic weed *Orobanche crenata*, which is known to be very detrimental. This parasitic plant is very easily disseminated by the wind, equipment, exchange of seeds, animals grazing etc.. A plant of *Orobanche* can produce up to 500 000 seeds and these besides their very small size and their extremely lightweight, can have a longevity of more than 12 years in the soil.

Several methods of control were developed in different countries in the Mediterranean region but these methods were not totally remedial they only allow the reduction of infestations. It is therefore necessary to apply an integrated control strategy.

Toensure the success of the introduction of this strategy, at on-farm level, it is imperative to make farmers participating actively in their own training, through the adoption of the participative approach. The farmers need to know the *Orobanche* and to understand its cycle and the conditions of its development; they also have to acquaint with available control options and to use them.

La Gestion d'*Orobanche* en Algérie

Résumé

En Algérie, les légumineuses alimentaires revêtent une grande importance dans l'alimentation humaine essentiellement basée sur les céréales. Cependant, ces cultures se trouvent soumises à des contraintes abiotiques et biotiques qui compromettent sérieusement les rendements. Parmi les contraintes biotiques menaçantes les maladies et les plantes parasites du genre *Orobanche* et plus particulièrement l'*Orobanche crenata* qui est connue pour être très préjudiciable. Cette plante parasite est très facilement disséminée à travers divers moyens, le vent, l'équipement et les outils agricoles, l'échange de semences, le pâturage des animaux sur les parcelles infestées, etc.. Elle est particulièrement redoutable, un plant d'*Orobanche* peut produire jusqu'à 500 000 graines et celles-ci en plus de leur taille très petite et de leur poids extrêmement léger, peuvent avoir une longévité de plus de 12 ans dans le sol.

Plusieurs méthodes de lutte ont été testées dans différents pays du pourtour méditerranéen: lutte chimique (glyphosate), utilisation de variétés résistantes, lutte biologique et le semi tardif. Ces méthodes ont seulement permit de réduire partiellement les infestations, cependant aucune méthode curative n'est encore connue. Il est donc nécessaire d'appliquer une stratégie de lutte intégrée, en combinant deux ou plusieurs méthodes de lutte, afin d'assurer une réduction des infestations de manière durable dans le temps, et d'éviter sa dissémination ou sa propagation vers les zones encore saines.

Pour assurer le succès de l'introduction de cette nouvelle approche en milieu agriculteur, il est impératif de faire participer activement les agriculteurs dans leur propre formation et ce par l'adoption de l'approche participative. Les agriculteurs ont besoin de connaître l'*Orobanche* et de comprendre son cycle et les conditions de son développement, ils doivent aussi prendre connaissance des options de lutte disponibles et apprendre à les utiliser. Ceci permettra aux agriculteurs de développer leur propre stratégie de lutte intégrée compatible avec leur système de production. Le but n'est donc pas l'application de telle ou telle méthode de lutte mais plutôt l'amélioration du niveau de connaissance des agriculteurs, de l'*Orobanche* et des options de lutte.

Compte tenu du problème que pose l'*Orobanche* sur les cultures des légumineuses au niveau des pays nord africains, ces derniers ont exprimé le souhait dans l'initiation d'un plan d'action visant à former le personnel technique présent sur le terrain, dans la lutte contre ce phanérogame parasite, l'échange d'information et de matériel végétal résistant. Ce plan d'action comprendrait aussi l'application des mesures de prévention de la dissémination des graines de la plante parasite vers les zones non infestées, et une meilleure exploitation de la présence naturelle du *Phytomiza orobanchia* pour l'application de la lutte biologique.

I. Introduction

Legumes crops are largely grown all over the world. These crops are known to be a cheap source of proteins. In Algeria they play an important role in the human nutrition essentially based on cereals. In addition to the nutritional importance they also play a key role in the soil fertilization in the crop rotation schemes. In Algeria, the most important crops are faba beans, that occupies 50 percent of the total area dedicated to food legumes, with a total acreage of 60 263ha, a total production of 21 560 tonnes and an average yield of 6,7qx/ha (Feliachi, 2002).

Orobanche crenata is an obligatory parasitic plant of broad bean and other leguminous cultures, and generates serious damages on these cultures, ranging from five to 100 percent (Sauerborn & Saxena 1980). Ducellier on 1923 reported that 60 percent of fields in certain localities of the Algerian Sahel were unsuitable for cropping legumes. Abu Irmaileh in 1994 reported that 10 percent of legumes acreage is infested by *Orobanche crenata*.

Actually *Orobanche crenata* is causing serious damages on beans and peas, especially in the region of Ain Dem. The region of the Sahel (littoral) (ITGC's experimental station at Oued Smar, INA, Baraki, Rouiba and Reghaia) became non suitable for this crop, and farmers abandoned the culture of legumes (Zermane 1998). In 2005, *Orobanche crenata* was found for the first time on lettuce in the region of Al Arabataache (W. Boumerdes) during a prospection made during the current TCP.

Orobanche ramosa is mainly present on tomatoes for industrial purposes in Annaba, on potatoes in Tarf and on tobacco in Boumerdes (Issers). *Orobanche cernua* was reported in regions of Sahara. It is also found in the oasis of Ghardaia, Tamanarasset and the southern east of Naâma. No information is available on damages caused in those areas.

Few studies have been made on *Orobanche* in Algeria. There is no data concerning the acreage infested, crop losses, degrees of infestation and the major crops affected by this parasitic plant. The survey recently carried out showed that farmers do not know this parasitic

plant, its biology and do not try to control it. They wrongly understood that these parasites reproduce via underground rhizomes and never paid any attention to prolific seed production of the plant.

II. Materials and methods:

The activities of the project started with the organization of a two-week workshop of Training of trainers (TOT) aimed at raising necessary awareness on the problem caused by the parasitic weed *Orobanche*, and train the participants on participatory approach for farmers training and *Orobanche* biology and control. The knowledge acquired during the TOT was the required one for the trainees to act as facilitators of the future Farmer Field Schools (FFS). At the end of the TOT, three FFSs simulations were conducted by the facilitators among themselves, which included aspects of the biology, ecology and control of *Orobanche*, and following the participatory approach for training. At the end of the TOT workshop guidelines (fig. 1 and table 1) were prepared for the use of the facilitators in the organization of FFS.

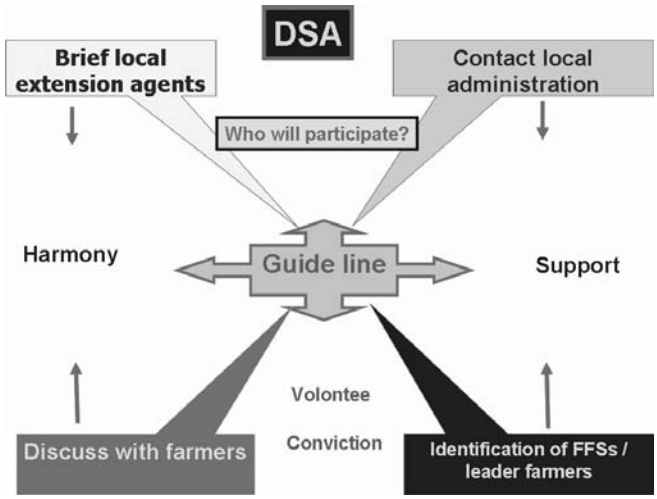

Fig. 1 Guidelines for FFS

FFS organization started with the identification of the leaders of each farmers group. To this end field days were conducted to create initial awareness about the damages caused by *Orobanche* and its potential threat for the development and sustainability of their legumes crops. Later, once the FFS started, farmers received information about the whole process of training. A special emphasis was made for having enough women participating in these exercises. The programme for training was prepared by the national expert of the project together with the facilitators of each FFS. Interactive discussions took place during the training to emphasize the importance of controlling *Orobanche crenata*. Posters and photos were used to illustrate the problem.

Table 1. FFS field guide

Activitie/sub-activities	Period							Actors/obs
	Nov.	Dec.	Jan.	Febr.	Mars.	Apr.	May.	
Theme (1): **Presentation of*Orobanche*.**								
-What is a parasitic weed ?-what is *Orobanche*?-where it grows?(crops) -colors, forms, size?								
-How's the form of the *Orobanche* seeds?-When are they produced?-How they spread? -Where, how and for how long time the seeds can live?								
comment elle se disperse?où, comment et combien de temps elle se conserve?								
Theme (2): Life Cycle								
-how it reproduces? -what are the conditions of its development?-when and how occurs the seed germination ? -how to not make confusion between lumps of the broad bean with the tubers of the *Orobanche* (underground stage)								
Thème (3): Control options								
Hand weeding, crop rotation, late sowing, resistant varieties								
Chemical control								
Integrated control								
Revision of the acquired knowledge								
Summary of the sessions realized during the season								
Evaluation of the acquired knowledge by questionnaire								

Three sites in Wilayate were selected for FFS (Table 2), and a total of 16 facilitators trained in the previous TOT participated in these training exercises for farmers. Fourty-four percent of the facilitators were phytopathologists with scarce knowledge about parasitic weeds, life cycle, spread and control.

Table.2. Pilote Wilayate selectionned for the FFSs.

Wilaya	Legumes surface (ha)/average yield (Q/ha)	Importance of the parasitic weed in the region	Distance from Algiers
Ain Defla	5140/8.5	**++++**	**170**
Algiers	140/12	**++++**	**-**
Boumerdes	458/11.2	**++++**	**50**

III. Results and discussion

The survey of *Orobanche* infestation showed that high stand of *Orobanche*, up to 85 percent, was found on tomatoes grown under greenhouses in Ain Defla. Dense infestations can also be found on faba bean mainly in the region of Bordj El Bahri. During field surveys *Orobanche crenata* on lettuce was reported for the first time in Algeria in the Wilaya of Boumerdes.

The main finding during the FFS was that nearly all farmers do not apply any method to control *Orobanche*. When infestations are high they plant other crops not affected by the parasite, which subsequently reduces the area devoted to faba beans. Most of the farmers in the region of Al Arbataache (Wilaya of Boumerdes) currently abandoned growing more than five years before the project started.

The discussions with farmers indicated that some infestations of their farms/plots are of the recent appearance, while some others suffered this problem since many years ago. Based on these findings we tried to identify possible sources of infestations.

Farmers ignore the ways of *Orobanche* reproduction, some believe they propagate themselves through subterranean rhizomes, most of the farmers never paid any attention to seed production, and have never seen those tiny seeds produced by the plant. Normally they hand pulled the parasitic plants, flowered or with seed set, and left them on the field. No burning was ever practised with the weeded mass.

Legume seeds are purchased at the market without any certification, and not knowing whether they are really clean. The seeds are sold in different regions, and this lack of control of the seeds contributed to the dissemination of the parasite at long distance.

Animals grazing in infested areas are very common and it also contributes to the dissemination of the parasite. Farmers also rent machinery and implements, which are coming unclean from highly infested areas.

Farmers do not know either that several crops, including cereals, are not affected by *Orobanche*. In fact, they applied crop rotation in infested areas without such knowledge.

Some farmers delay or anticipate planting date as a method for preventing *Orobanche* infestation. In Wilaya of Ain Defla some farmers practice an early sowing, to make the flowering period coincide with low temperatures, and thus limiting the germination of *Orobanche* seeds, and reducing infestation. For the other areas in Wilayate, Algiers and Boumerdes, some farmers delay the sowing date to avoid rainfall, thus reducing the development of *Orobanche*. These practices are difficult to follow since those environmental factors are uncontrolled.

The chemical control was completely unknown among farmers. They knew glyphosate, which was largely used as a herbicide in orchards. After long discussions with farmers some trials were set up to check the effectiveness of the herbicide. Where the application was made correctly and at the right time no *Orobanche* plants were recorded, while untreated plots had up to 20 *Orobanche* shoots per faba bean plant.

As a result of the discussion with the farmers on the need to adopt an integrated approach for the control of *Orobanche*, farmers selected three main control methods: crop rotation, late/early planting and application of glyphosate.

The whole technical content of FFS is described in table 2.

Table 2. FFS technical content

Theme	subtheme	Aim & tools
Presentation of the parasitic weed, *Orobanche*.	**-What is a parasitic weed ?** -what is *Orobanche*? -where it grows?(crops) -colors, forms, size?	To know *Orobanche*, and make its visual identification through drawings and photos.
Ways of Dissemination and longevity in the soil.	-How's the form of the *Orobanche* seeds? -When are they produced? -How they spread? -Where, how and for how long time the seeds can live?	Get knowledge of the dissemination means and conservation.
Life cycle of the parasitic weed	-how it reproduces? -what are the conditions of its development? -when and how occurs the seed germination? -how to not make confusion between lumps of the broad bean with the tubers of the *Orobanche* (underground stage)	-knowledge of the life cycle to understand the control strategies. -knowledge of the importance of the respect for delay in chemical control. All to be accomplished in field visits and with illustrations.
Control options 1.The chemical control (application of an herbicide)	-what are the herbicides selective for *Orobanche* control in faba beans?	- understanding the mode of action, safe handling, right rates and time of application. Field exercises.
Analysis of the agroecosystem	- Analysis in the field	- preparation for the selection of other control options.
1.Control options against *Orobanche*: 2. hand weeding, rotation, late/early sowing, resistant varieties	why clean seeds? - when to hand weed? - Crops to use in the rotation? - Late planting? - Available resistant varieties?	- knowledge of other control options, to restrict infestations and reduce the *Orobanche* weed seed bank in soil. Importance of the long-term control.
Integrated control (combined control)	- is the application of a single method of control enough sufficient, and why? - how to choose the best options?	- knowledge of the Integrated management of *Orobanche*. .
Revision of the acquired knowledge	- Information already acquired?	- Summary of FFSs results.

- Didactical production: a master CD has been produced, containing all courses that have been delivered during the TOT. Three posters have been elaborated according to the themes treated during the FFSs. Two films (reports) have been produced, one on the TOT course and a one on the FFSs course entitled "The farmer and the *Orobanche*". These materials have been distributed to extension directorates of the Ministery of Agriculture and Rural Development.

IV. Conclusion and recommendations

Orobanche crenata infestation in legumes is a serious problem in Algeria. The exact magnitude of the problem, which increases year after year, is not yet well evaluated. Most of the farmers affected by the problem neither control the parasite nor prevent its spread.

The participatory approach applied in FFS showed to be effective. As a result of the training 16 facilitators/extension agents were trained, who were later able to conduct training for farmers. In Wilaya a total of 94 farmers were trained during two cropping seasons. Other neighbouring farmers not included in this exercise asked to be trained as well. Trained farmers acquired knowledge about the behaviour of the parasite and the ways to control it.

For the future there is an urgent need to conduct a survey in the country to assess the extent of the problem of *Orobanche*, its crop losses and infested area. It is as well important to carry out some research for defining well the best crop rotation for affected legumes, suitable chemical treatments for the control of *Orobanche* in affected crops, to shape other control and preventive strategies, such as planting date and use of cover crops, use of clean seeds and how to reduce the existing weed seed bank in soil. Screening of local and introduced faba bean genotypes resistant to *Orobanche* is also required. Integrated management should also be validated working directly with farmers for them to decide the most feasible control options.

References

Abu-Irmaileh, B.E. 1994. Overview of the *Orobanche* problem in the Near East. In A.H. Pieterse, J.A.C. Verkleij and S.J. Ter Borg (eds.). Biology and Management of *Orobanche*. Proc. 3rd Inter. Workshop on *Orobanche* and related *Striga* research. Amsterdam, The Netherlands, Royal Tropical Institute. pp.677-683

Ducellier, L., et Maire, R. 1923. Végétaux adventices observés dans l'Afrique du Nord. *Bull. Soc. Hist. Nat. Afr. Nord.* 14,304-325.

Feliachi, K. 2002 . Proceedings du 2ème Séminaire du Réseau REMAFEVE / REMALA, "Le Devenir des Légumineuses Alimentaires dans le Maghreb", Hammamet, Tunisie. pp.32-39.

Sauerborne, J., and Saxena, M.C. 1980. A review on agronomy in relation to *Orobanche* problems in faba bean (*Vicia Faba* L.). In: S.J. ter Borg (ed). Biology and control of *Orobanche*. Proc. Of workshop on biology and control of *Orobanche*. Agricultural University, Wageningen, the Netherlands. pp.160-165.

Zermane, N. 1998. Contribution à l'étude des phanérogames parasites de l'Algérie: inventaire, répartition géographique, plantes hôtes, dégâts et quelques méthodes de lutte. Thèse de Magister, INA, Algérie.209p.

Training on *Orobanche* management in leguminous crops in Egypt

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Summary

During the winter growing seasons of 2004-2005 and 2005-2006, the activities of the project TCP/INT/3004 "Training on *Orobanche* management in leguminous crops in Egypt" took place according to the project work plan which included extension agents, farmers and weed scientists who worked in the field of *Orobanche* management. A national training of trainers course (TOT) on *Orobanche* management was conducted, where 25 extension agents in El Kanater El Kharia were trained on participatory approach for farmers training and *Orobanche* parasitic weed management. The curriculum of *Orobanche* management included the biology of the parasite, germination, life cycle, haustorium's attachment and reproduction, and strategies management, including cultural practices, hand pulling, chemical control and other control options.

Four Farmer Field Schools (FFS) were conducted in the governorates of Nubaria, Behara, Fayoum and Monofia during the above mentioned growing seasons. About 100 farmers attended these training sessions. A similar curriculum to TOT on *Orobanche* management was implemented for FFS. Here farmers have the possibilities to inspect *Orobanche* infestations in their own infested fields, and to implement the control measures at the right time, e.g. application of glyphosate at initial tubercle formation. A manual on Farmer Field Schools for *Orobanche* management was prepared and distributed. Field days were additionally organizad at harvest time.

Formation sur la gestion d'*Orobanche* dans les récoltes légumineuses En Egypte

Résumé

Pendant la saison des cultures des années 2004/2005 et 2005/2006, les activités du projet TCP/INT/3004, FAO"Formation sur la gestion d'orobanche dans les légumineuses" a commencé avec la préparation du plan de travail du projet y inclus la formation des vulgarisateurs, des agriculteurs et des malherbologistes. Une formation nationale des formateurs en matière de gestion de l'orobanche a été conduite à la fin de 2004 dans la localité El Kanater El khairia, Egypte avec la participation de 25 vulgarisateurs. L'objectif de cette formation était la gestion des méthodes d'approche participatives à développer avec les agriculteurs ainsi que les méthodes intégrées de lutte contre l'*Orobanche.* Pendant la formation on a énuméré les caractéristiques et les principes d'approche participatives, les principes de l'enseignement informel des adultes, et les aspects plus pertinents à la biologie des parasites, à la germination, à l'attachement de l'haustorium, à la reproduction, au cycle de

vie des parasites, et à la gestion à travers l'utilisation des méthodes des cultures, de l'arrachage, du contrôle chimique et des autres méthodes de gestion.

Quatre écoles de champ (CEPs) ont été organisées pour les agriculteurs et conduites dans les gouvernorats des Nubaria, Behera, Fayoum et Monofia pendant les saisons des cultures auxquelles ont pris part un total de 100 agriculteurs. Les agriculteurs ont pu évaluer l'infestation d'Orobanche dans leurs champs infestés, observer des plantes de fève parasitées, surtout à leur stade souterrain, apprendre à appliquer correctement le glyphosate et éviter la fitotoxicité, mais aussi bien faire l'arrachage pour réduire son effet sur la fève. Un manuel de l'école du champ a été préparé par les agriculteurs et les techniciens et distribué aux agriculteurs.

I. Introduction

Orobanche spp. (broomrapes) are consistently listed worldwide as the major constraint for the production of food legume and vegetable crops. Prevailing *Orobanche* species in Egypt are *Orobanche crenata* which parasitizes faba bean, peas, lentil, chickpeas and lupines; *Orobanche aegyptiaca/ramosa* that parasitize tomatoes, faba bean; and *Orobanche minor* which attacks clover.

Broomrape is extremely damaging to the legume crops it parasitizes. For instance, *Orobanche crenata* can cause yield reductions of faba bean (*Vicia faba* L.) ranging from 5 to 100 percent depending on the severity of infestation (Parker and Riches 1993). As a result, farmers lose yield, income, and in some cases they choose to stop growing broomrape-susceptible crops. Heavy infestations of *Orobanche crenata* in Egypt forced a 41 percent reduction in the cropping area of faba bean between 1992 and 2005 (Sauerborn 1991, and NVRSRP 2005). The economic impact of broomrape might be attributed to its parasitic lifestyle, which has both a direct detrimental effect on the host plant, and a specific biology that resists conventional weed-control strategies. The lack of a single effective control method for this parasitic weed calls for an Integrated Pest Management (IPM) approach that uses multiple strategies in order to limit broomrape infestation and alleviate crops damage.

The infested fields of faba bean with *Orobanche crenata* in some Egyptian studied governorates varied from 6.5 percent to 47.6 percent, whereas the infestation severity varied from 1.5 to 12spikes/m^2. Research results indicated that there is a negative correlation and linear regression between the number or weight of *Orobanche* spikes and faba bean yield. One spike can decrease faba bean seed yield (g/plant) by 14.4 percent, and 5g fresh weight of *Orobanche* spikes/plant can reduce faba bean seed yield/plant by 19.5 percent (Hassanein and Omar 2004).

In order to reduce the present problems caused by *Orobanche crenata* in leguminous crops, FAO implemented the project TCP/INT/3004 "Training on *Orobanche* management in leguminous crops", which was executed through the 2004-05 and 2005-06 growing seasons. In this project farmers participatory training through the implementation of farmers field school FFS was implemented according to the methodology described by Khisa (2004), Labrada (2004), FAO (2004), El Safar (2004) and Ibrahim *et al* (1998). The main activities of the project were to: 1) conduct a national Training of Trainers (TOT) course on *Orobanche* management; 2) to organize and implement four Farmer Field Schools; 3) to participate in a regional four-day training on *Orobanche* prevention carried in ICARDA, and in another one of three days duration on biological control in Rabat, Morocco.

II. Methods currently used by farmers to control *Orobanche*

- Delay sowing in infested area till mid–November (some farmers started to adopt this recommendation).
- The use of *Orobanche* tolerant varieties such as Misr 1 Giza 843, Giza 674, Giza 429 and Misr 2. Suitable amounts of certified seeds of these varieties should be available to farmers.
- *Orobanche* spike hand pulling. This technique is usually carried out by farmers especially in low infested area and should be immediately implemented after the appearance of *Orobanche* spikes above the ground and burning it to reduce seed bank is a must.
- Application of Glyphosate at 75 ml/Feddan added to 120 L/feddan, 2-3 times by using knapsack sprayer starting three weeks from the flowering phase at three weeks interval. Phytotoxicity is the main problem occurred when this method is used caused by the herbicide as a result of using motors.
- Crop rotation after rice, especially in rice growing areas, declines seed bank of *Orobanche* as a result of rice flooding.

III. Main results and findings of Farmers Training

3.1. Training of Trainers (TOT)

A national Training of Trainers (TOT) course on *Orobanche* management with the participation of 25 extension agents was organized in Egypt during December, 18-27, 2004 in El-Kanater EL-Khairia. The objective of the course was to conduct training on participatory approach for farmers training and the control of *Orobanche* parasitic weeds. The training was conducted under the supervision of a national expert recruited by FAO and other national experts in FFS and *Orobanche* biology, management and food legumes production.

The specific objectives of TOT course were:

1. to provide information on *Orobanche* biology and ecology in the seed bank;
2. to impart control options and emphasize ways for preventing flowering and seed setting;
3. to assist trainers in improving their skills in order to work directly with farmers; and,
4. to enhance training skills and learn how to set up Farmer Field Schools to facilitate improved decision-making by farmers.

The course included how to organize and manage Farmer Field Schools (FFS) for *Orobanche* control, characteristics of the successful facilitator, characteristics and principles of the participatory approach, and principles of adults learning, which includes the learning cycle, curriculum of *Orobanche* management through faba bean growing season including the biology of the parasite, germination, haustorium's attachment, reproduction and life cycle of *Orobanche*. In addition, the *Orobanche* seeds bank and extension models were also emphysised. The components of *Orobanche* control strategies such as land preparation, planting dates, application of manures, crop rotation, hand pulling, tolerant varieties,

chemical control and imparting control options. By the end of the training course, an evaluation was made and certificates were distributed.

A number of 25 high level extension staff was the target group of the course. This group was chosen from the areas of El Nubariah, Fayoum, Behera and Minofia governorates, where faba bean is cultivated and are affected by *Orobanche*. The participants were specialists working either on faba bean or in plant protection. Existing information about *Orobanche* biology and management was little or not enough. It was their first time for the trainers to be exposed to information about methodology, constructing and managing *Orobanche* parasitic weeds field schools which seriously affect faba bean leading to severe losses when not managed in the right way. In fact the participatory approach and the interaction of the group proved to be very fruitful in building up the training capabilities.

The outcome of this workshop was reflected in the performance of the trainers when they organized field schools in their own governorates. Weekly visits and exercises were conducted through the two growing seasons in the field. The training was participatory with facilitators and farmers, and in the field experiments for the application of *Orobanche* control measures in faba bean, i.e., seed identification by using magnifying glass, *Orobanche* faba bean attachment, exhausting seed bank, glyphosate application, symptoms of the effect of glyphosate on *Orobanche*, *Phytomyza* activities in faba bean fields, suitable time of hand pulling and other methods in sequent schedule.

3.2 Farmer Field Schools

Four FFSs were established in Fayoum, Nubariah, Behera and Menofia. The locations of the schools reflect the extent and importance of *Orobanche* problem in those areas.

The selected farmers and locations aimed at introducing better serving for the small farmers' communities in addressing the *Orobanche* problem. The chosen locations were among the faba bean areas and gender issues were considered in farmers' selection for the training. Each farmers' school was attended by 25 farmers, managed by a moderator, a facilitator and joined by weed scientists from weed Research Central Laboratory and Food Legume extensions, or from the Agricultural Research Center in Egypt. Each school consisted of eight days-sessions during January and February, and two days-sessions during March. In these sessions farmers had the opportunity to learn about the life cycle of *Orobanche*, including its subterranean development, the way of *Orobanche* parasites host crops and possible methods for its prevention and control.

The FFS took place from January till March 2005, and from October 2005 till March 2006. Each moderator introduced the daily agenda, and promoted farmers to know each other. Farmers raised issues about losses caused by *Orobanche*, low yields of faba beans, existence of tolerant/resistant varieties, proper sowing dates under different cropping patterns, crop rotation for decreasing *Orobanche* infestation, and the plant stage for identifying the *Orobanche* symptoms in the field. Farmers'groups discussions took place on the effect of glyphosate spraying on faba bean yields and *Orobanche* reduction. The sessions of FFS during the second cycle in 2005-06 focused on *Orobanche* soil seed bank, how to estimate *Orobanche* spike productivity of capsules and seeds, the approximate amount of seeds produced by the parasite, and the number of seeds affected by *Phytomyza.*

As a result of all this work, a control manual on *Orobanche* was prepared, which was later distributed among the technicians and farmers.

IV Conclusions and recommendations

At the beginning of the project it was clear that farmers lacked information on *Orobanche* biology and the methods for its control. This was the first time farmers were extensively exposed to *Orobanche* problem. As a result, farmers started to adopt planting dates, use of crop clean seeds and recommended tolerant varieties, crop rotation, hand pulling, manure free from *Orobanche* seeds. They also learned to apply glyphosate at 75 ml/feddan two or three times depending on *Orobanche* infestation and about the biological activity of *Phytomyza* for reducing the production of *Orobanche* seeds.

References

Anonymous (2005) NVRSRP, Nat. Coord. Meet. Cairo, Egypt 12-13 Sept., Food Legume Research Program.

Anonymous, FAO, (2000) Farmer field school Integrated management of soil and plant nutrition. Extension manual included essential principles and some training models, FAO, Doc AGL/MISC/27/2000. pp 188 (in Arabic).

Anonymous GTZ, (2001). Manual of extension by participatory approach group of farmers learning and work in the same time part III extension villages Agricultural extension administration Egyptian German program for developing cotton sector Cairo PP 230 (in Arabic).

El-Safar A. (2004). Training program for preparing facilitators of farmer field schools of integrated management of *Orobanche*. Lecture in El-Kanater training course of *Orobanche* in El-Kanater 18-19, December FAO.

Hassanein E.E. and O. Mamdouh (2004) Integrated management of *Orobanche* on food legumes system of the Egyptian experience in IPM of *Orobanche* FAO/INRA/ICARDA Morocco pp 32-53.

Hassanein E.E., H.M. Ibrahim, A. S. Kholosy and Z. R. Yehia (2005). Manual of farmer field school for integrated *Orobanche* management (in Arabic).

Ibrahim, H.M., E.E. Hassanein, A.S. Kholosy and H.T. Al-Marsafy. 1998. Es-[parasitic weeds: A computerized Expert system for parasitic weed identification and management with special reference to *Orobanche*. The Fourth International Workshop on *Orobanche* Research, 23-26 September, Albena, Bulgaria. Abstracts of Current Problems of *Orobanche* Research P 24.

Khisa G. (2004) Farmer field school methodology Training of trainers manual. Project coordinator Kenya, East African integrated production and pest management farmer field school project/FFS Master trainer, FAO, Kenya pp 101.

Kroeschel, J., and O. Klein. 1999. Biological control of *Orobanche* spp. with *phytomiza orobanchia* Kalt., a review. In Advances of parasitic weed control of at on farm level. Vol. II. Joint Action to Control *Orobanche* in the WANA Region. (J. Kroeshel, M. Abderabihi, H. Betz, eds.), Magraf Verlag, Germany, 135-159.

Labrada R. (2004) The IPM approach and participatory training for management of parasitic weeds integrated management of *Orobanche* in food legumes in the Near East and North Africa. Editors Rachid Dahan and Mohammed El-Mourid FAO/INRA/ICARDA pp 72-75.

Linke, K.H., C. Vorländer and M.C. Saxena. 1990. Occurrence and impact of *phytomyza orobanchia* (Diptera: Agromyzidae) on *Orobanche crenata* (Orobanchaceae) in Syria. Entomophaga 35 (4): 633-639.

Parker, C. and C. R. Riches. 1993. Parasitic Weeds of the World-Biology and Control. CAB International, Wallingford, UK.

Sauerborn, J. (1991). The economic important of the phytoparasites *Orobanche* and *Striga*. In Proceedings of the 5th International Symposium on Parasitic Weeds, (J.K. Ransom, L.J. Musselman, A.D. Worsham and C. Parker, eds.), Nairobi, 137-143.

Integrated *Orobanche* Management in Food Legumes (faba bean): Experience of farmers' field school (FFS) in Dessie-zuria District, Ethiopia

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Summary

This paper reports on the *Orobanche* Integrated Pest Management-Farmer Field Schools (IPM-FFS) pilot project conducted in year 2005 main season in Dessie Zuria district. The purpose was to address the life cycle and management of *Orobanche* and other aspects of food legume (faba bean) production. Trainers and the national expert of the project were acquainted with the participatory approach for farmers training and Integrated *Orobanche* Management as main aspects to be included in the curriculum of three FFSs, where 25 farmers participated per field school. An experiment consisting of the use of herbicides and improved cultural practices were conducted as part of the curriculum of the FFS and session activities. Farmers learnt also about the growth of the affected crop and life cycle of *Orobanche*, and later they have the opportunity to validate practically all this knowledge through the identification of *Orobanche* species, following the cycle of the parasite, application of improved cultural practices, preventing of *Orobanche* seed dispersal, and herbicide application and its safe handling. Almost all farmers have no knowledge about the life cycle and management of *Orobanche* before the training started. They only rely on hand pulling for *Orobanche* control.

Gestion Intégrée d'*Orobanche* dans les légumineuses- fève: L'Expérience de Champ Ecole Paysans dans le district Dessie-zuria District, Ethiopie

Résumé

Cet article est un compte rendu du projet pilote de lutte intégrée contre *Orobanche* conduit pendant la saison des cultures de l'année 2005 dans la zone de Dessie Zuria. Le but est de comprendre le cycle de vie et la gestion d'*Orobanche* ainsi que les autres aspects de la production de la fève. Les formateurs et l'expert national du projet ont été mis au courant de l'approche participative des producteurs et de la gestion intégrée contre *Orobanche*, aspects principaux à inclure dans le programme d'études des trois écoles de champ, où 25 paysans par école de champ y ont participés. Une expérience comprenant l'utilisation des herbicides et des pratiques culturelles améliorées ont été conduite en tant qu'élément du programme d'études des activités de FFS et de session. Les paysans ont également été instruits sur la croissance de la culture affectée et sur le cycle de vie d'*Orobanche*, et plus tard ils ont eu l'occasion de mettre en pratique toutes ces connaissances par l'identification des espèces d'*Orobanche*. Ils ont pu suivre le cycle du parasite, l'application des pratiques culturelles améliorées, les mesures pour la prévention de la dispersion des graines d'*Orobanche*, et l'application des herbicides et leur manipulation sans risque pour leur santé. Presque tous les paysans n'avaient aucune connaissance sur le cycle de vie et sur la gestion d'*Orobanche* avant d'avoir

commencé leur formation. Ils connaissaient uniquement l'arrachage manuel comme méthode principale de lutte contre *Orobanche*.

I. Introduction

Orobanche species are parasitic weed problems on various crops in Ethiopia. Four species are widespread and represent serious problems in the country, which includes *Orobanche crenata* Forsk., *Orobanche minor* Sm., *Orobanche ramosa* L. and *Orobanche cernua* loefl. The Zeway Horticultural Enterprise has already abandoned to grow solanaceous crops due to the *Orobanche* problem. *Orobanche* is also currently threatening tomato production on the Nura Era Horticulture Enterprise, which comprises four state farms and the Merti Processing Plant (Abuelgasim1996). According to survey results, nearly 1 000ha of tomato production area has been affected on these farms. Losses are estimated to total up to 60 percent. The problem clearly threatens the continued availability of the famous tomato paste and juice products of the enterprise at reasonable prices on the local and foreign markets, unless appropriate research packages can produce a solution in the near future (Aluelgasim1996).

The *Orobanche crenata* problem has also been considered the first in the overall rank of agricultural problems as felt by the members of FFS in Dessie zuria district. It attacks the whole range of food legumes such as faba bean, field pea, chickpea, lentils and grass pea.

Two other more *Orobanche* species namely, *Orobanche minor* and *Orobanche ramosa* have been noticed attacking food legumes in the area. In Dessie-zuria and kutaber districts more than 5 000ha, each has been severely affected, totaling the infested area to about 10 000ha. According to the members of FFS, the productivity of faba bean used to be 20–30qt/ha in the absence of *Orobanche*. More than 400 000ha of faba bean producing small scale-farmer holding is still at risk of *Orobanche* infestation in Ethiopia. Crop loss is reported to be total failure or 100 percent. Reportedly not only the seed yield, but the straw of faba bean affected by *Orobanche* is left completely unpalatable to the animals due to high degree of parasitism inflicted on it. Faba bean straw is highly preferred by the framers for its unique nutritive feed value.

The project area is about 2 600–2 700m.a.s.l. dominated with black soils and gets ample rain fall, but the per-capita land holding is so small. Land shortage and fertility in this area has rendered the use of crop rotation almost impossible. Farmers are obliged to grow food legumes every other year (season) to maintain soil fertility.

Farmers hand-pull *Orobanche* as a sole means of control in Ethiopia. Some times farmers weeded out *Orobanche* by detaching its nodules (tubercles) from the roots of faba bean following the newly emerged *Orobanche* shoots by digging out the soil very deep. In order to reduce drudgery for *Orobanche* control, an integrated approach is needed. Most faba bean Ethiopian farmers have very little knowledge about the life cycle and management of *Orobanche* species. Therefore, to reduce the effect of the parasite on food legume production and increase seed and straw yield per unit area, it was found necessary to build the capacity of smallholder farmers on the life cycle and management of *Orobanche*.

II. Materials and Methods

The FFS activity was conducted in Dessie-zuria district at Kedijo in 2005 main season. Kedijo (PA No. 17) was selected based on secondary information from the previous works (Assefa & Besufedak et al., 1994 & 1999), which revealed significant *Orobanche* problem in the area. Farmers' group formation or FFS members' identification was based on voluntary basis. Consequently, three FFS namely, 'Tatessa', 'Tesfa' and 'Alem-tsega' have been established with an average of 25 farmer participants per field school. Prior to the execution of the activity a training workshop of trainers was conducted to introduce the facilitators to the FFS approach, methodology and curriculum.

After the group formation, gap analysis, curriculum (Table 1) and guideline development, FFS's organization and starting up the sessions were major activities carried out. Additional appraisal of constraints related to food legume production was also made through group discussion and PRA methods, during earlier sessions of the FFS, for in-depth analysis of farmers' knowledge and practices with respect to *Orobanche* management and other food legume production constraints. In this appraisal almost all farmers participated as respondents from each farmer field school. At the end of every activity evaluation was carried out to assess the knowledge gained by the farmers.

Based on the discussions made with the members of FFS, an experiment comprised of herbicide and improved cultural practices were considered as the major aspects for the FFS field and session activities. The three FFS experimented application of herbicide and fertilizer in common where as 'Tesfa' and 'Alem-tsega' experimented crop rotation and time of planting combinations in addition to the above technologies respectively. Two treatments, Integrated management and traditional farmers practice (FP) were considered in all the three schools. Improved faba bean (Degaga) seed with raw–spacing and pulling of *Orobanche* were used as a complement to the Integrated practices.

III. Results and Discussion

3.1 FFS's Organization

Among the participating farmers we found that 75 percent of them ranged from 20 to 65 years old, 75 percent were male and the remaining female.

Major faba bean (food legume) production constraints

The farmers practice appraisal indicated that they were unaware of how *Orobanche* multiplies and disseminated and believe that the faba bean or other food legumes are the causes for the problem. Only 5 percent of them doubtedly believed that *Orobanche* multiplies by seeds while 95 percent were skeptical to believe. As it has been mentioned by members of FFS, the unique features of the life cycle of the parasite such as the microscopic nature of the seeds and the specific host-parasite relationship contributed much for this. Because of this, farmers were all pulling and throwing the pulled *Orobanche* on the road as the elders told them. By so doing they thought that it would be cursed and eliminated from the area. Moreover, all farmers did not have any concept about the use of improved cultural practices (proper pulling and disposal of the pulled *Orobanche*, the use of crop seed and manure free of *Orobanche*, and trap crops), natural enemies and herbicide application.

3.2 Field Session Activities

Activities for FFS implementation were based on filed sessions planned on the basis of the growth of the crop. Farmers collected and analyzed field data and studied the life cycle of *Orobanche* through group-discussion; farmer-to-farmer experience sharing, practicing and explanations made during field sessions.

According to the majority of the members of FFS, *Orobanche* grows in abundance in specific areas where animal manure has been applied on their farmland, while some other farmers realized that the *Orobanche* problem gets aggravated when it is grown on fertile soils regardless of the manure application. Through farmer-to-farmer experience sharing, however, this had been clarified that it was not the increase in the fertility of the soil that contributed for the increase of *Orobanche* infestation, but it was the manure, which acted predominantly as a source of *Orobanche* infestation. Moreover, based on the discussions made; though it needs further investigation, members of FFS decided to use compost, which might not contain *Orobanche* seeds in it. Farmers often use animal manure as sole means to increase the productivity of faba bean.

As to the majority of the members of FFS, the application of manure as opposed to the use of artificial fertilizer, enhances the growth of faba bean and exerts smothering effect on the germination and growth of *Orobanche* and increases the yield of faba bean.

It has been also discussed during field session that a considerable amount of *Orobanche* seeds was found when cleaning faba bean seed for planting. The farmers groups were aware that *Orobanche* seeds moved to new areas in this manner. Apart from the movement of run-off water and animals, members of FFS mentioned the use of a common threshing ground to have the same effect.

Members of FFS found that burning of the pulled *Orobanche* was problematic due to the unlimited amount of *Orobanche* spikes put in a single pit, termite attack, and animal movement. Hence members of FFS decided to limit the amount of *Orobanche* spikes going in to a single pit in order to overcome the ease of burning. Furthermore, they decided to put stones underneath before putting the pulled *Orobanche* in order to avoid termite problem which makes burning more difficult by degrading and incorporating it to the soil. Members also decided to keep sheep and the other animals away from feeding on the pulled *Orobanche* until it is burnt. Farmers asserted that sheep manure contains a huge amount of *Orobanche* seeds in it. Finally, all understood the importance of some prophylactic measures after hand pulling *Orobanche*.

3.3 Field Activities

Participants in FFS distinguished well the differences between the nodules formed by *Orobanche* and the *rhizobium*. They also understood that the first *Orobanche* nodules (tubercles) are formed 45-50 days after planting, and that this is the right time for the application of glyphosate. They also were aware that the seeds of *Orobanche* germinate at certain time intervals as the roots of the host plant elongates. Such an understanding helped them to reason out why the second and probably the third glyphosate application and hand pulling was needed. Priorly, they thought that *Orobanche* re-sprouts and more shoots emerge when it is pulled out.

According to the field data collected and the analysis made by the participants of FFS, the first application of glyphosate (83g a.i./ha) was made 48 days after faba bean planting, while the second one followed three weeks after. The phytotoxic symptoms of glyphosate on the crop were minimal in all the cases. To constate better the effectiveness of this treatment, the participants counted the emerged *Orobanche* and weighed its fresh weight and seed yields of faba bean of the plots with an integrated management and in the traditional ones (Table 1).

In general FFS participants noted that integrated management of *Orobanche* decreased significantly the number and fresh weight of *Orobanche* spikes, and increased the yield of faba bean in some specific areas where water logging is not a problem.

IV. Evaluation of farmers at the end of the school cycle

Generally, farmers participating in FFS found working in-group to be more advantageous. Almost all of them were able to recognize the ways of *Orobanche* reproduction by seeds, and the amount produced currently by a simple spike. Ninety percent of them understood the life cycle of the parasite, and also to differentiate the nodules of rhizobium from the "tubercles" formed by *Orobanche*. Half of them asserted to be able to implement the integrated management strategies for reducing *Orobanche* infestation, while 43 percent of the farmers still need additional training. More than half of participants considered to be ready to apply glyphosate at the right time, i.e. when the "tubercles" are started to be formed, and the care necessary to be taken at the time of the application.

Table 1. Mean, significance probability (p) and standard error of mean difference for the three Orobanche IPM experiments

***Orobanche* integrated management Experiment**	**Statistics**	**No. of *O.* shoots/10m^2**		**Fresh weight of *O.* shoots/10m^2**		**Seed yield of faba bean qt/ha**	
		Integrated	**Tradit.**	**Integrated**	**Tradit.**	**Integrated**	**Tradit.**
1	Mean	1862	6768	13.1	66.9	6.8	3.2
	P	0.003		0.001		0.458	
	s.e.d	1013.4		5.28		4.45	
2	Mean	370	5291	4	79	3.8	3.8
	P	0.003		0.009		0.794	
	s.e.d	1170.6		21.9		2.30	
3	Mean	248	919	2.0	23.0	0.9	20.1
	P	0.518		0.449		0.093	
	s.e.d	862.9		-		-	

Experiment 1 = effect of sowing date, glyphosate and fertilizer; Experiment 2 = effect of glyphosate and number and fresh weight of Orobanche and seed yields of faba bean.

IV Conclusion

In general integrated practices of control decreased significantly the number and fresh weight of *Orobanche* spikes and increased the yield of faba bean in some specific areas where water

logging is not a problem. The limited experience obtained during the FFS cycle clearly showed that lack of effective technology delivery system played the major role for the expansion of the *Orobanche* problem in the area.

Furthermore, participants suggested to continue using local faba bean variety and instead of animal manure to use compost free of *Orobanche* seeds in order to reduce parasite infestation and maximize the yield of faba bean.

References

Abuelgasim, E.M. 1996. an investigation on the possibilities of Biological control of *Orobanche* spp. in Ethiopia. M.Sc. Thesis. Addis Ababa University, Ethiopia.

Assefa Admasu & Endale Berhe 1994. *Orobanche* crenata: A potential threat to food legume in Ethiopia. Ethiopian weed science (EWSS) News letter 2:1.

Besufekad. et. al. 1999. *Orobanche* problem in south Wollo. In: Fassil Reda & D.G. Tanner (eds). Arem Vol. 5: 1-10. EWSS. Addis Ababa.

Dahan, Rachid and Mohammed El-Mourid (eds.) 2004. Integrated Management of *Orobanche* in Food Legumes in the Near East and North Africa. Proceedings of the Expert Consultation on IPM for *Orobanche* in Food Legume Systems in the Near East and North Africa, 7-9 April 2003, Rabat, Morocco. ICARDA/INRA/FAO. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. viii + 120pp.

Parker, C. and C.R. Riches. 1993. Parasitic weeds of the World – Biology and Control. CAB International, Wallingford, UK.

Stroud, A. 1989. Weed management in Ethiopia, an extension and training manual. Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.

Orobanche and its management in Lebanon

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Summary

The problem posed by the incidence of *Orobanche* parasitic weeds in Lebanon is described. The main species of this complex in the country are *Orobanche ramosa*, *Orobanche aegyptiaca, Orobanche crenata, Orobanche cernua* and *Orobanche nana*, which mainly attack various vegetables, leguminous crops as well as tobacco. *Orobanche ramosa* and *Orobanche aegyptiaca* are the major species infesting *Solanaceae* crops in the Beq'aa plain, while *Orobanche crenata* and *Orobanche cernua* are primarily found on broad bean in coastal areas. *Orobanche ramosa* seriously affect the production of potato. In some areas, yield losses may amount up to 60 percent.

Hand pulling is the most common control practice but it demands labour and it is too costly to implement in large areas. In addition, it seldom provides full season control. For this reason, an integrated management approach is recommended consisting of the use of crop seeds free of *Orobanche* seeds; deep tillage in infested areas during land preparation; rotation with vetch, barseem, flax and rye; solarization combined with chicken manure; chemical control with sequential foliar application of low rates of glyphosate (100-150gm ai/ha) to be applied in potato and broad bean.

La Gestion d'*Orobanche* au Liban

Résumé

Le problème posé par l'incidence d'*Orobanche* des mauvaises herbes que parasites au Liban est décrit. Les espèces principales de ce complexe dans le pays sont *Orobanche ramosa, Orobanche aegyptiaca Orobanche crenata, Orobanche cernua*, et *Orobanche nana*, qui attaquent principalement diverses cultures maraîchères, légumineuses aussi bien que le tabac. *Orobanche ramosa* et *Orobanche aegyptiaca* sont les espèces principales infestant des plantes Solanaceae dans la plaine de Beq'aa, alors que *Orobanche crenata* de et *Orobanche cernua* sont principalement trouvés sur la fève dans des secteurs côtiers. *Orobanche ramosa* affecte sérieusement la production de la pomme de terre. Dans quelques secteurs, les pertes de rendement de cette culture peuvent s'élever jusqu'à 60 pour cent. L'arrachage manuel est la pratique normal de lutte, qu'exige beaucoup main d'ouvre et est trop coûteuse pour l'appliquer en grande scale. En outre, elle fournit rarement un haut niveau de contrôle. Pour cette raison, une approche intégrée de gestion est recommandée comprenant l'utilisation des semences de culture exempt des graines d'*Orobanche*; labourage profond dans des secteurs infestés pendant la préparation de terrain; rotation avec la vesce, le barseem, le lin textile et le seigle; la solarization combiné avec l'application d'engrais de poulet; contrôle chimique avec l'application foliaire séquentielle de bas taux du glyphosate (100-150 GM ai/ha) à appliquer dans la pomme de terre et la fève.

I. Introduction

Broomrape *(Orobanche* spp.), known as Ja'afil in Lebanon, is an annual root holoparasitic plant, which affects a wide range of herbaceous dicots. The parasite prevails in semi-arid regions and constitutes one of the most severe constraints to the production of various agronomic and vegetable crops in the region (Haidar *et al*., 2003; Jacobsohn and Kelman, 1980; Parker and Riches, 1993). Most of these crops are extremely sensitive to *Orobanche* infestation, resulting in considerable reduction in marketable yield. Various methods for *Orobanche* control have been tested in Lebanon but none have been successful when applied individually.

II. Host Range and Distribution

Various species of *Orobanche* vary in ranges of hosts parasitized. Some species infest a wide range of crops, whereas others tend to be species specific. *Orobanche ramosa* and *Orobanche aegyptiaca* have the widest host range while *Orobanche crenata* is restricted to a few crops among them is broad beans. Common *Orobanche* species in Lebanon are *Orobanche ramosa*, *Orobanche aegyptiaca, Orobanche crenata, Orobanche cernua* and *Orobanche nana*, the first two being the most widely distributed. Major cash-crops attacked by *Orobanche* in Lebanon are potato, tomato, tobacco and broad bean (Table 1), while major weeds and ornamentals attacked are henbit (*Lamium amplexicaule*), wood sorrel (*Oxalis cernua)* and the ornamental Vinca pacifica red (*Catharanthus roseus*).

Table 1. Major crops affected by *Orobanche*

Family / Crop	**Crop**	***O. ramosa* L.**	***O. aegyptiaca* Pers.**	***O. crenata* Forsk.**
Compositae	Safflower	X	X	---
Cruciferae	Cabbage	X	X	---
Cucurbitaceae	Cucumber	X	X	---
Iridaceae	Saffron	X	X	---
Leguminosae	Faba bean	---	---	XXX
	Alfalfa	X	X	---
	Pea	X	X	---
Rosaceae	Almond	X	X	---
Solanaceae	Egg plant	XX	XX	---
	Potato	XXX	XXX	---
	Tobacco	XXX	XXX	---
	Tomato	XXX	XXX	---
Umbelliferae	Carrot	X	X	X
	Parsley	X	X	---

XXX= Seriously attacked; XX = Moderately attacked; X = Lightly attacked; --- = Attack doubtful

Although *Orobanche* is widely spread all over the country, the majority of *Orobanche* species are found in the Beq'aa plain and coastal areas. *Orobanche ramosa* and *Orobanche aegyptiaca* are the major species infesting *Solanaceae* crops in the Beq'aa plain, while *Orobanche crenata* and *Orobanche cernua* are primarily found on broad bean in coastal areas.

III. Problems caused by the parasites

Orobanche ramosa and *Orobanche aegyptiaca* are endemic to Lebanon, and constitute one of the most severe constraints to potato (Figure 1) and tomato production. Potatoes are a major crop in Lebanon, with approximately 120 000ha planted annually. Farmers face multiple difficulties including drought, disease and early frost but *Orobanche* is their number one enemy (AIDS of potato).

Figure 1. Potato field infested with *Orobanche ramosa* (Purple shoots)

Spunta is the most widely grown potato cultivar, but highly susceptible to and damaged by *Orobanche ramosa* and *Orobanche aegyptiaca* (Haidar and Bibi, 1995). We have estimated that over 90 percent of the irrigated potato "Spunta" fields are parasitized by *Orobanche* causing severe losses in quantity and quality of crops. Yield losses may amount to 60 percent of possible production. However, exact estimates of yield losses are difficult to obtain due to lack of *Orobanche*-free plots for use as controls.

Besides being difficult to control after germination, *Orobanche* compounds infestation problems by producing a huge amount of dust-like seeds (0.2-0.3 mm in diameter) that replenish annual losses from the soil seed bank. A single mature *Orobanche* plant can produce thousands of seeds (Parker and Riches, 1993) that might remain dormant in soil for more than ten years. Moreover, *Orobanche* seeds are easily dispersed by wind and other vectors, readily infesting neighbouring fields. Seeds germinate only in the presence of chemical stimulants exuded by roots of suitable hosts which are subsequently parasitized. Upon host root detection, physiological connections with host xylem and phloem are formed. At this stage (20-65 day under-ground stage), it is difficult to identify and kill the parasite without using either the host as a bridge to transfer chemicals to the parasite. Although a lot of research findings have been published on *Orobanche* management (Abu-Irmaileh, 1991, 1994; Elzein and Kroschel, 2003; Goldwasser *et al*., 2001; Haidar *et al*., 2000, 2003, 2005, 2006; Kassasian, 1973; Jacobsohn and Kelman, 1980; Parker and Riches, 1993; Westwood and Foy, 1999), yet none of them is effective in eliminating or radically controlling *Orobanche*.

IV. Status of management in Lebanon

The history of *Orobanche* research is short as compared to that on many other weeds, and major gaps exist in our understanding of its biology and control. Unless our knowledge is advanced beyond current levels, this endemic pest is expected to invade, dominate and persist in arable lands of Lebanon and the region for many years to come. Although preliminary research by our group and by others has advanced our understanding of *Orobanche* and its parasitic mechanisms, much remains to be done if we are to control the epidemic parasite. Thus, more ecophysiological and management research is necessary to overcome the increasing threat from this parasite in Lebanon, the Middle East and North Africa. *Orobanche* research efforts in Lebanon are effectively limited to the Faculty of Agricultural and Food Sciences (FAFS) of the American University of Beirut (AUB). However, due to paucity of research funding, our capabilities are restrained. A list of ongoing *Orobanche* research by our group at FAFS includes:

(1) biofumigation;
(2) fertilization regimes using a mixture of chicken manure and elementary sulphur;
(3) soil amendments (goat manure);
(4) mulching with barley;
(5) biological control.

Presently, funding is being requested for a biological control assessment of *Phytomyza* spp. This herbivorous insect is present naturally in Lebanon and has the potential to control *Orobanche* populations. Future plans include developing, evaluating and introducing integrated and ecologically-sound *Orobanche* management strategies, and employing digital imaging to map and model the distribution and impacts of *Orobanche* in potato.

The physiological relationship between *Orobanche* and its host means conventional methods of controlling *Orobanche* infestations are costly, complex, and frequently unsuccessful. A review of literature on management strategies indicates that many practices to control *Orobanche* have been evaluated, including solarization, herbicides, crop rotation, deep ploughing, trap and catch crops, selection and breeding of resistant crops, crop seed treatment, synthetic germination stimulants, animal manure, soil amendments, biological agents and the use of inorganic nitrogenous synthetic fertilizers (Elzein and Kroschel, 2003; Haidar *et al.*, 2000, 2006; Parker and Riches, 1993; Sauerborn *et al.*, 1994). All have met with limited success.

Lebanese farmers are concerned about losses caused by this parasite and are seeking methods to control it. No stand-alone successful control method has yet been developed. Furthermore, pre-emergence or post-emergence herbicides which have potential to control *Orobanche* are not available in the Lebanese market. Management of *Orobanche* by Lebanese farmers is mostly done by using clean crop seeds, hand pulling and soil fumigation with methyl bromide (very common in small areas). The latter method is expensive, hazardous, and may be soon subject to restrictions. Hand pulling is the most common control practice but it demands labour and it is too costly to implement in large areas. In addition, it seldom provides full season control. Thus, an integrated approach is more likely to be successful than a strategy based on a single method of control. Accordingly, we are recommending that Lebanese farmers adopt more than one method for *Orobanche* management. This integrated *Orobanche* management (IOM) is economically feasible and provides a long-term solution for the parasite. Some of the most common practices suggested by our team are listed below.

Management Practices

1. Clean seedlings and crop seeds and good *Orobanche* control is required throughout the season. Successful *Orobanche* management could be done by preventing parasite seed production and by reducing soil seed bank through the use of clean crop seedlings and crop seeds, hand pulling and rotation with cover and trap crops.

2. Deep tillage in infested areas during land preparation is very effective in reducing *Orobanche* seed bank in soil.

3. Hand-pulling This is one of the most common methods against *Orobanche* in Lebanon. However, it is tedious and time-consuming. The main advantage of hand-pulling is to prevent production of new seed. It is feasible as long as labour cost is low ($5-$10/person/day).

4. Planting date Early sowing of potato seeds in March (in Beqaa plain) instead of May/June was found to be an effective method in reducing *Orobanche* growth during the season. Many potato producers are adopting this method. In March the soil temperature is low and is not conducive to *Orobanche* seed germination.

5. Planting trap, catch and cover crops such as flax, barseem, vetch and rye two months prior to planting crop seeds followed by ploughing under and then sowing crop seeds is very effective in reducing *Orobanche* infestation. Rye (*Secale cereale*) or barley grown with potato or broad bean was also found to be an effective control against *Orobanche.*

6. Rotation with tarp, catch and cover crops The use of cover and trap crops such as vetch, barseem, flax and rye in rotation with susceptible crops is becoming popular practice among farmers as a way to reduce the incidence of *Orobanche* and to prevent the build-up of *Orobanche* seed bank in the soil.

7. Solarization combined with chicken manure Several farmers are currently using this technique against *Orobanche* and other weeds in small areas.

8. Chemical control Sequential foliar application of low rates of glyphosate (100-150gm ai/ha) was found to be very affective against *Orobanche* in potato and broad bean.

V. Challenges and Solutions

There are many challenges facing scientists and farmers in Lebanon and the region, mainly due to lack of funding for basic and applied research, training and demonstrations. Currently, the public sector is not funding any research on *Orobanche* and the only institution supporting *Orobanche* research is AUB. Furthermore, the agriculture extension office of the Lebanese Ministry of Agriculture is almost inexistent and generally ineffective. The office lacks information, data, demonstrations and skills for *Orobanche* management. I believe that *Orobanche* problem could be solved if we accelerated basic and applied research on this parasite, communicated better with farmers using new educational methods and through increased community awareness campaigns. There is a need to link research to farmers *via* extension. There is a need to establish task forces at the national and regional levels to work on (1) development of an information network; (2) transfer of technology; (3) forecasting

Orobanche infestation using remote sensing; (4) establishment of threshold and bio-economic models and (5) promoting IOM.

References

Abu-Irmaileh, B.E. 1991. Soil solarization controls broomrapes (*Orobanche* spp.) in host vegetable crops in the Jordan valley. Weed Technology 5, 575-581.

Abu-Irmaileh, B.E. 1994. Nitrogen reduces branched broomrape (*Orobanche ramosa*) seed germination. Weed Science 42, 57-60.

Elzein, A. and Kroschel, J. 2003. Progress on management of parasitic weeds. In Weed management for developing countries, Ed. Labrada R. Plant Production and Protection Paper, pp. 109-143. FAO.

Goldwasser, Y., Eizenberg, H., Hershenhorn, J., Plakhine, D., Blumenfeld, T., Buxbaum, H., Golan, S., Kleifeld, Y. 2001. Control of *Orobanche aegyptiaca* and *Orobanche ramosa* in potato. Crop Protection 20, 403-410.

Haidar, M.A. and Bibi, W. 1995. Common weeds of Lebanon. Arab and Near East Plant Protection Newsletter, Abstract, 34. Beirut, Lebanon.

Haidar, M. and Sidahmad, M. 2000. Soil solarization and chicken manure for the control of *Orobanche crenata* and other weeds in Lebanon. Crop Protection 19: 169-173.

Haidar, M.A., Bibi, W. and Sidahmad, M.M. 2003. Response of branched broomrape (*Orobanche ramosa*) growth and development to various soil amendments in potato. Crop Protection 22:291-294.

Haidar, M.A., Iskandarani, N., Sidahmed, M. and Darwish, R. 2005. Susceptibility of *Orobanche ramosa* and potato tolerance to rimsulfuron. Crop Protection 24: 7-13.

Haidar, M.A., Sidahmed, M.M., Darwish, R. and Lafta, A. 2005. Selective control of *Orobanche ramosa* in potato with rimsulfuron and sub-lethal doses of glyphosate. Crop Protection 24: 743-747.

Haidar, M.A. and Sidahmed, M.M. 2006. Elemental sulfur and chicken manure for the control of branched broomrape (*Orobanche ramosa*). Crop Protection 25: 47-51.

Kassasian, L. 1973. Control of *Orobanche*. PANS 19, 368-371.

Jacobsohn, R. and Kelman, Y. 1980. Effectiviness of glyphosate in broomrape (*Orobanche* spp.) control in four crops. Weed Science. 28: 692-699.

Mitich, L.W. 1993. *Orobanche*-The broomrapes. Weed Technology 7, 532-535.

Parker, C. and Riches, C.R. 1993. Parasitic weeds of the world: biology and control. Wallingford, UK: Cab International. 332 p.

Sauerborn, J. 1994. *Orobanche* species. In Weed management for developing countries, Ed. Labrada R., Caseley J.C. and Parker C.. Plant Production and Protection Paper, pp. 150-155. FAO.

Westwood, J.H. and Foy, C.L. 1999. Influence of nitrogen on germination and early development of broomrape (*Orobanche* spp.). Weed Science 47, 2-7.

Gestion d'*Orobanche* dans les Légumineuses au Maroc

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Résumé

Quatre familles botaniques ont fourni les mauvaises herbes parasites de totalité du Maroc: Lauranthaceae, Cuscutaceae, Santhalaceae et Orobanchaceae. Cependant, Orobanchaceae est le plus important basé sur la distribution de ses espèces, du secteur infesté et des dommages causés sur des récoltes de plantes hôtes. Selon un enquête, *Orobanche crenata* Forsk. (sur la fève, une lentille, un pois, un pois chiche et une carotte récents); *Orobanche aegyptiaca* Pers., *Orobanche ramosa* L. (sur la fève, la lentille, le pois, le pois chiche, la luzerne, la graine de colza, les tomates, le melon et la carotte) et *Orobanche foetida* Poir.(sur la fève et l'alfalfa) sont considérés comme les plantes parasites plus aggressives au Maroc.

Les dernières espèces mentionnées sont les plantes parasites plus dévastatrice des légumineuses, particulièrement, dans la fève. En effet, 69.2 pour cent des champs de fève sont infestés. La présence d'*Orobanche crenata* dans un champ de fève peut réduire le rendement par 0 à 46 pour cent selon le niveau d'infestation.

Pour affronter cette situation, les paysans applicaquent quelques méthodes de contrôle, soit chimique ou non chimiques ou toutes les deux. Presque 95 pour cent de paysans, de deux régions fortement infestées (Saiss et Pre-Rif), utilisent glyphosate (60g/ha appliqué deux à trois fois à l'intervalle de deux semaines su debut à de la floraison de la fève) pour eliminer l'*Orobanche*. Mais, seulement 54 pour cent de secteur infesté a utilisé le traitement chimique pendant les saisons des cultures 2003 et 2004. Le reste de producteurs appliquent des pratiques culturelles seul ou combinées avec le glyphosate. Ainsi, plusieurs options pour l'elimination d'*Orobanche* sont utilisées, comme le sarclage, des variétés courtes de saison, application d'engrais organique, dates de semis, culture de piège (Coriandrum L. sativum), augmentation de la densité de semis, rotation avec des cultures non hôtes, cultivation immediatement après la recolte et jachère.

Avec l'appui technique et financière de FAO, quatre champs écoles paysans (FFS) ont été entrepris dans trois régions du Maroc pendant deux saisons de cultures. Un total de 114 paysans (cinq femmes y compris) producteurs principalement de fève, pois et lentille sur 630ha. ont participé. Comparativement aux méthodes conventionnelles de vulgarisation, cette formation participative des producteurs a permis d'obtenir les résultats suivants: création d'un cadre pour des réunions regulières des producteurs, amélioration de leur connaissance au sujet de la bio-écologie d'*Orobanche* et de gestion, maîtrise de méthode chimique, validation des résultats précédents, et production de nouvelles données sur la gestion d'*Orobanche*. Pendant les deux saisons des cultures d'exécution de FFS, nous concluons que le problème d'*Orobanche* dans les cultures de légumineuses au Maroc n'est pas un problème des méthodes ou des techniques à employer, mais sur les méthodes d'apprentisage des paysans. En plus des résultats précédents, le FFS est venu pour couvrir les lagunes existantes dans la méthode de vulgarisation. Après cette formation les producteurs sont convaincus qu'une seule mesure de

contrôle ne résoudra pas le problème d'*Orobanche* dans les légumineuses. Il faut appliquer une approche intégrée de gestion contre l'*Orobanche*. La présence de Phytomyza orobanchia, un ennemi naturel indigène d'*Orobanche*) devrait être aussi profité au Maroc. L'utilisation de cet insecte en tant qu'agent biologique de lutte devrait être un composant important de la gestion intégrée d'*Orobanche*.

Orobanche management in legumes of Morocco

Summary

Four botanical families furnished the whole parasitic weeds of Morocco: Lauranthaceae, Cuscutaceae, Santhalaceae and Orobanchaceae. However, Orobanchaceae is the most important based on the distribution of its species, the infested area and the damages caused on host crops. According to a recent survey, *Orobanche crenata* Forsk.(on fababean, lentil, pea, chickpea and carrot); *Orobanche ramosa* L./*Orobanche aegyptiaca* Persl.(on fababean, lentil, pea, chick pea, alfalfa, rape seed, tomatoes, melon and carrot and *Orobanche foetida* Poir. (patches on faba bean and alfalfa) are considered to be the most damaging to crops in Morocco.

The former species is the most devastating parasitic weed of food legumes, especially, fababean crop. Indeed, 69.2 percent of faba bean fields are infested. The presence of *Orobanche crenata* in a faba bean field may reduce the yield by 0 to 46 percent according to the infestation level.

To face this situation, farmers implement some control measures, either chemical or non chemical methods or both. Almost 95 percent of farmers, from two highly infested regions (Saiss and Pre-Rif), use glyphosate (60g/ha applied two to three times at two weeks interval starting from the beginning of flowering stage of fababean) to control *Orobanche*. But only 54 percent of infested area was treated chemically during 2003 and 2004 growing seasons. The rest of farmers use cultural practices either combined with glyphosate or alone. Thus, several options for controlling *Orobanche* are used, such as hand weeding, short season varieties, organic manure, sowing dates, trap crops (*Coriandrum sativum L.*), seeding rate increase, rotation with non host crops, cultivation after early harvesting and fallow.

Initiated and supported technically and financially by FAO, four Farmer Field Schools (FFS) were undertaken in three regions of Morocco during two growing seasons. A total of 114 farmers (including five women) cultivated mainly fababean, peas and lentil on 630ha. Comparatively to conventional extension methods, this participatory farmers training allowed to get the following findings and results: creation of a framework for farmers gathering, improvement of their knowledge about bio-ecology of *Orobanche* and its control measures, mastering of chemical control, validation of previous results, and production of new data on *Orobanche* management. During the two years of FFS implementation, we concluded that the *Orobanche* problem in food legumes in Morocco is not a problem of methods or techniques to be used, but on farmers learning. In addition, the FFS came to fulfill this extension gap. Another finding is that farmers are convinced that a single control measure will not solve the *Orobanche* problem in food legumes. It is necessary to implement an integrated approach of control methods. Meanwhile, one should take advantage or benefit of *Phytomyza orobanchia* (an indigenous natural enemy of *Orobanche*) presence in Morocco. The use of this insect fly as biological control agent should be an important component of the integrated *Orobanche* control.

I. Introduction

Avec un effectif de 838 taxons, le Maroc possède l'une des flores les plus diversifiées floristiquement et biologiquement du Bassin Méditerranéen. Cependant, les plantes parasites ne représentent que 2 pour cent de l'effectif total. Les 17 espèces parasites recensées sont fournies par quatre familles botaniques: les Lauranthaceae et les Cuscutaceae qui attaquent exclusivement la partie aérienne des plantes hôtes, les Santhalaceae et les Orobanchaceae qui parasitent la partie souterraine (Boulet *et al*., 1989). Toutefois, la dernière famille reste de loin la plus importante du point de vue de l'aire de distribution de ses espèces, de la surface infestée et de l'ampleur des dégâts causés.

Les dernières prospections ont permis de souligner que *Orobanche crenata* Forsk., *Orobanche ramosa* L./*aegyptiaca* Persl. et *Orobanche foetida* Poir. sont les principales espèces problématiques des cultures au Maroc (Saffour, 2003). La première espèce reste la plus importante et la plus dévastatrice des légumineuses alimentaires (fève, lentille, petit pois et pois-chiche) et la carotte. La fève est la culture la plus touchée par cette espèce. Le taux d'infestation varie de 0 à 100 pour cent selon la région avec une moyenne de 69,2 pour cent. La sévérité d'attaque a été estimée à 13tiges/m^2. Ce niveau de parasitisme a causé une perte de rendement de la fève de 0 à 46 pour cent avec une moyenne nationale de 37,4 pour cent. Ceci correspond à une marge à gagner de 33,5 millions de dollars/an (Saffour, 2003).

Le complexe *Orobanche ramosa*/*aegyptiaca* vient en deuxième position en parasitant la fève, le pois-chiche, la lentille, la luzerne, le colza, le melon, la tomate et la carotte. Dans la fève, cette espèce a été rencontrée dans quatre régions seulement avec un taux d'infestation de 4,2 pour cent et une sévérité qui ne dépasse pas deux tiges /pied de fève.

La troisième espèce *Orobanche foetida* a été trouvée sous forme de quelques tâches localisées sur fève et luzerne dans quelques régions du Maroc. Le taux d'infestation et la sévérité ne sont pas alarmants à l'heure actuelle (Zemrag, 1994). Mais elle constitue une menace et un danger potentiel pour la fève si des mesures de prévention ne sont pas prises pour arrêter son extension et d'éviter le genre de situation observée en Tunisie.

II. Gestion de l'*Orobanche* dans les légumineuses alimentaires

Les moyens de lutte dont disposent les agriculteurs, pour contrecarrer les préjudices de l'*Orobanche*, dans les légumineuses en général et dans la culture de fève en particulier, sont nombreux et diversifiés et peuvent être de nature chimique ou non chimique. Cependant, l'utilisation des herbicides reste la méthode la plus pratiquée par les agriculteurs marocains (Karafi *et al*., 1999).

2.1 Lutte chimique

Cette méthode de lutte, mise au point au Maroc à la fin des années 70 (Shmitt et al., 1979), est basée sur l'utilisation du glyphosate à la dose de 60g/ha en deux applications espacées de 15 jours chacune à partir du stade bourgeon du parasite et qui coïncide généralement avec le stade floraison de la fève (Schluter et Aber, 1980). Le sulfosate qui est un sel du glyphosate est aussi utilisé de la même façon que le glyphosate (Ezzahiri et al., 2006). Une enquête conduite par Karafi et al. (1999) dans les régions du Saiss et du Pré-Rif (zones très infestées)

a permis de souligner que 95 pour cent des agriculteurs utilisent le glyphosate pour lutter contre l'*Orobanche* dans la fève. Cependant, cette technique est loin d'être généralisée à l'échelle nationale étant donné qu'uniquement 50 pour cent de la surface a été traitée chimiquement, durant les campagnes 2003 et 2004. Ce pourcentage varie de 8 à 96 pour cent selon les régions (Tableau 1). Plusieurs facteurs expliquent la non généralisation de la lutte chimique contre l'*Orobanche* entre autres:

- l'ignorance de l'existence de la technique;
- la non maîtrise de la technique d'application;
- l'insuffisance des moyens financiers des agriculteurs;
- la faible rentabilité et la non compétitivité des légumineuses en général par rapport à d'autres cultures;
- l'inadaptation de l'emballage aux besoins;
- la difficulté d'approvisionnement en eau (500l/ha) pour l'application du produit;
- la non disponibilité du matériel de traitement.

Tableau 1: Importance des superficies de Fève traitées chimiquement contre l'*Orobanche*, campagnes 2003 et 2004 (Anonyme, 2004).

Région ou zone	**Superficie infestée (ha)**	**Superficie traitée (ha)**	**Proportion (pour cent)**
Taza	3600	2300	64
Taounate	12300	5376	47
Fès	1000	8400	84
Sefrou	8000	7700	96
El Hajeb	1660	816	49
Sidi Kacem	1200	100	8
Settat	8570	730	9
Ben Slimane	1500	150	10
Total	46830	25422	54

2.2 Lutte non chimique

Les agriculteurs marocains utilisent de nombreuses méthodes de lutte non chimiques seules ou combinées avec la lutte chimique. Ainsi, l'enquête réalisée dans le Saiss et dans le Pré-Rif a permis de relever que seulement cinq pour cent des agriculteurs adoptent ces méthodes pour faire face à la problématique de l'*Orobanche* dans la fève (Karafi et al. 1999). Les techniques culturales suivantes mérites d être citées:

- arrachage manuel dans le cas de faible infestation et/ou faible superficie cultivée;
- utilisation de variétés précoces dans le cas de la lentille;
- apport de la fumure organique;
- semis tardif de la fève cultivée pour la graine sèche;
- semis de coriandre en lignes intercalaires avec la fève;

- augmentation de la dose de semis;
- rotation de quatre à cinq ans au cours de laquelle les agriculteurs pratiquent d'autres cultures non hôtes du parasite ou moins sensibles à l'Orobanche;
- destruction mécanique avec des labours;
- jachère.

III. Champs Ecoles Paysans (CEP)

En plus des efforts de vulgarisation déployés par l'Etat en matière de contrôle de l'*Orobanche* dans la culture de fève en utilisant les méthodes conventionnelles (spots télévisés, dépliants, affiches, journées de sensibilisation, etc.), une nouvelle approche (CEP) a été initiée et expérimentée durant deux années avec l'appui technique et financier de la FAO. Cette méthode est basée sur les principes écologiques, la formation participative et les techniques d'éducation non formelle. Ainsi, quatre CEP ont été installés dans trois régions, regroupant 114 agriculteurs (de 20 à 77 ans) dont cinq femmes et touchant les trois principales légumineuses alimentaires (fève, lentille et petit pois) sur une superficie de 630ha. Malgré quelques difficultés d'ordre matériel, cette méthode participative de vulgarisation a permis d'atteindre les objectifs escomptés.

3.1 Acquis des CEP

Au terme des deux années d'exercice et de fonctionnement des CEP, les agriculteurs ont beaucoup apprécié l'expérience et ont avoué qu'ils ont appris par eux même beaucoup de choses en matière de gestion de l'*Orobanche* dans les légumineuses alimentaires. Ainsi, les principaux acquis relevés peuvent être résumés comme suit:

- création d'un cadre non formel de réunion et d'échange d'information et d'expérience au tour d'un thème;
- développement de l'esprit d'observation et de curiosité scientifique chez les agriculteurs
- amélioration des connaissances des participants. En général, le niveau des connaissances des agriculteurs participant aux CEP a été amélioré par rapport à la première année d'exercice et par rapport au démarrage de la deuxième année. Ainsi, plus de 60 pour cent des agriculteurs connaissent bien la biologie de l'*Orobanche*, plus de 70 pour cent maîtrisent la lutte chimique et 35 à 60 pour cent maîtrisent ou connaissent d'autres méthodes de lutte contre l'*Orobanche* (Tableau 2);
- développement chez les agriculteurs de la capacité d'appréciation des dégâts dus aux attaques de l'*Orobanche* (Tableau 3);
- maîtrise de la lutte chimique en termes de manipulation des herbicides, calibrage du matériel de pulvérisation, stade de traitement et évaluation de l'efficacité (Tableau 3);
- réduction de volume de bouillie recommandée par le référentiel marocain (500l/ha) à 150-250 l/ha;
- réussite d'utilisation du glyphosate à grande échelle sur la lentille (Tableau 3);
- reconnaissance des CEP, par les agriculteurs riverains, comme sites de vulgarisation de proximité sur la gestion de l'*Orobanche* dans les légumineuses alimentaires.

Tableau 2: Evaluation des connaissances des agriculteurs après formation

Thèmes	**Niveau de connaissance (pour cent des agriculteurs formés)**								
	CEP Sidi Ayad			**CEP Marrakechia**			**CEP Bir Anzarane et Semmamia**		
	faible	moyen	bon	faible	moyen	bon	faible	moyen	bon
Biologie de l'*Orobanche*	0	40	60	5	35	60	0	20	80
Technique d'application	0	10	90	5	25	70	0	20	80
Stade de traitement	0	0	100	10	20	70	0	0	100
Autres moyens de lutte	0	40	60	65	35	0	0	50	50
Moyenne pour tous les thèmes	0	23	77	21	29	50	0	23	77

Tableau 3: Etat d'infestation des champs et efficacité de la lutte chimique.

CEP	**Cultures**	**Espèces**	**Taux des champs infestés (pour cent)**	**Nombre de hampes/pied**	**Perte de rendement estimée (pour cent)**	**Effica-cité (pour cent)**
Sidi Ayad	Fève Petit pois Lentille	*O. crenata* *O. crenata* *O. crenata*	100 100 100	0-2 6-10 0-5	5 50 30	95 10 0
Marrakechia	Fève Lentille	*O. crenata* *O. crenata*	25 35	1-8 1-6	0-30 0-20	90-100 70-80
Bir Anzarane Semmamia	Fève	*O. crenata* *O. ramosa*	100	0-30	0-100	10-100

3.2 Contraintes

Bien que le bilan des CEP soit positif et les acquis soient nombreux, un certain nombre de problèmes ou contraintes ont été rencontrés lors du déroulement et l'exécution des principes fondamentaux des CEP. La levée des entraves suivantes est souhaitable afin d'améliorer davantage l'exercice et de valoriser, par conséquent, les efforts déployés par les différents acteurs impliqués. Les principales contraintes peuvent être regroupées en cinq points:

- insuffisance des moyens mis à la disposition pour la gestion des CEP
- centralisation de la gestion du budget alloué par la FAO
- absence de toute mesure incitative au profit des facilitateurs et du coordinateur national
- absence de certains inputs et/ou matériel nécessaires ou exigés pour adopter la gestion intégrée de l'*Orobanche*

- absence de référentiels en matière du contrôle de l'*Orobanche* dans la lentille, le pois chiche et le petit pois.

IV. Discussion

Durant les deux années de formation dans le cadre des champs écoles paysans, il s'est avéré que *Orobanche crenata* reste l'espèce problématique des légumineuses alimentaires au Maroc. De même, le taux d'infestation (35-100 pour cent) et les pertes de rendement (5-100 pour cent) estimés sont importants et confirment ceux des études antérieures (Zemrag, 2000; Saffour, 2003; Anonyme, 2004).

Pour faire face à ce fléau, les agriculteurs des CEP ont adopté des moyens de lutte non chimique et chimique. En absence de référence technique en matière de lutte chimique, la lutte non chimique a été limitée au petit pois et à la lentille. Ainsi, les hampes florales de l'*Orobanche* ont été détruites avec des labours, après avoir récolté en vert le petit pois, pour empêcher le parasite de produire les graines, et par conséquent, réalimenter le stock semencier du sol. L'utilisation d'une variété précoce de lentille (telle que la variété Bakria) qui a une durée de cycle de quatre mois et qui échappe aux attaques de l'*Orobanche* est fréquente. L'*Orobanche* apparaît une fois la lentille a déjà produit les gousses et commence à mûrir.

Dans le cas de la fève, la majorité des agriculteurs utilisent le glyphosate à la dose de 60g/ha en deux à trois applications pour le contrôle de l'*Orobanche*. Les niveaux d'efficacité obtenus par les participants sont prometteurs et varient de 0 à 100 pour cent selon les régions. Les faibles efficacités sont dues en général au sous dosage de l'herbicide ou à la non maîtrise de la technique d'application. Ces erreurs ou défaillances techniques ont été bénéfiques et exploitées comme leçons ou matière pédagogique dans le cursus de formation dispensé aux participants des CEP. L'adoption des agriculteurs de trois applications, au lieu de deux comme recommandé par le référentiel technique, permet aux agriculteurs de cadrer et avec certitude le stade propice d'intervention sans passer par la technique de dépistage et de prospection. Un effort de réduction de volume de bouillie de plus de 50 pour cent a été noté sans pourtant affecter ni l'efficacité ni la sélectivité du glyphosate. Un tel résultat pourrait être un facteur de généralisation des traitements surtout dans les zones ou l'eau est rare ou difficile à trouver.

La lutte chimique contre l'*Orobanche* n'est pas commune dans la lentille au Maroc. Cependant, l'utilisation du glyphosate sur la lentille et le niveau d'efficacité obtenu sont considérés un des acquis des CEP qu'il faut vulgariser dans d'autres régions où le problème menace le développement de cette culture. Toutefois, la dose utilisée (47g/ha) n'était pas suffisante pour donner une efficacité supérieure à 80 pour cent. En attendant la disponibilité d'un référentiel national, une légère augmentation s'avère nécessaire pour contrôler complètement ce parasite dans la culture de lentille.

Déjà avec ces résultats les agriculteurs sont satisfaits et pensent que les légumineuses alimentaires vont reprendre leur place de choix derrière les céréales qu'elles ont perdue depuis les années 70 à cause principalement de l'*Orobanche*. Toutefois, la problématique de l'*Orobanche* ne pourrait pas être résolue avec une seule méthode de lutte et en un lapse de temps. Il faut que le raisonnement des agriculteurs passe à un niveau de gestion du problème basé sur les principes de lutte intégrée comme démontré expérimentalement au Maroc

(Zemrag, 2000). Dans le même ordre d'idées, il est temps que le Maroc profite de la présence naturelle de la mouche *Phytomyza orobanchia* qui est un ennemi naturel de l'*Orobanche*. Les résultats obtenus avec cet insecte comme agent de lutte biologique, dans les conditions marocaines, sont prometteurs et appuient l'idée que cette méthode de lutte devrait prendre sa place dans l'approche de lutte intégrée contre l'*Orobanche* dans les légumineuses alimentaires (Klein et al., 1999).

V. Conclusions et recommandations

D'emblée et comparativement aux méthodes conventionnelles de vulgarisation, il s'est avéré que le problème de l'*Orobanche* dans les légumineuses alimentaires au Maroc n'est pas un problème technique. Il s'agit plutôt d'un problème d'apprentissage et de formation des agriculteurs concernés à prendre en charge eux même la responsabilité de régler ce problème. L'adoption de l'approche des CEP comme nouvelle méthode de vulgarisation de proximité a permis effectivement de corriger l'anomalie observée, de vérifier et d'améliorer le référentiel technique national en la matière et enfin de générer aussi de l'information qui mérite d'être vulgarisée. Toutefois, l'expérience reste limitée dans le temps et dans l'espace et mérite d'être développée, élargie et améliorée en prenant en considération les points suivants:

- combler les insuffisances en matière de formation continue des vulgarisateurs, de moyens mis à la vulgarisation et de méthodes de vulgarisation utilisées;
- appuyer et renforcer le rôle de la recherche agronomique à fournir des référentiels techniques en la matière (back up research) ;
- exploiter les atouts et bénéfices de l'existence de *Phytomyza Orobanchea* au Maroc comme moyen biologique de lutte contre l'*Orobanche*;
- changer les messages délivrés par la vulgarisation en présentant la lutte chimique comme la seule solution du problème par un message incitant l'adoption des principes de la lutte intégrée pour régler le problème de l'*Orobanche*;
- adopter une politique visant l'encouragement et le soutien de la production des semences sélectionnées des légumineuses alimentaires;
- adapter l'emballage des herbicides contenant le glyphosate aux besoins des petites exploitations.

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Références

Anonyme (2004) Lutte contre l'*Orobanche* sur la fève, constat et évaluation, campagne agricole 2003/2004. Ministère d'Agriculture et de Développement Rural, Direction de la Production Végétale, Rabat.

Boulet C., Tanji A. et Taleb A. (1989) Index synonymique des taxons présents dans les milieux cultivés ou artificialisés du Maroc occidental et central. Actes Inst. Agron. Vét., 9 (3 et 4), 65-98.

Ezzahiri B., Bouhache M. et Mihi M. (2006) Index Phytosanitaire Maroc. Edition 2006, Sogeliv, Casablanca.

Karafi A., El Ismaili A., Benlahboub Jazouli H. et Abdelouafi M. (1999) Evaluation de l'impact des actions entreprises en matière de lutte contre l'*Orobanche* en culture de fève dans le Sais et le Prè-Rif. Rapport du Projet ACLA, GTZ, Ministère d'Agriculture et de Développement Rural, Direction de la Production Végétale, Rabat.

Klein O., Kroschel J. et Sauerborn J. (1999) Lutte biologique contre l'*Orobanche* au Maroc: efficacité et possibilités. Journée Nationale sur les Plantes Parasites, AMM, Meknès, pp. 37-45.

Safour K (2003) Utilisation des herbicides et des sous produits d'olive (grignon et margines) dans le contrôle de l'*Orobanche* sur fève. Thèse de Doctorat. Université Mohamed ben Abdallah, Fès, Maroc, 179p.

Schluter K. et Aber M. (1980) Lutte chimique contre *Orobanche crenata* sur fève au Maroc. Bull. Protection des Cultures, INRA, 7, 1-10.

Schmitt U.M., Schlüter K. et. Boorsma P.A. (1979) Chemical control of *Orobanche* crenata in broad beans. FAO. Plant Protection Bulletin, 27, 88-91.

Zemrag A. (1994) Broomrapes devastation in legumes fields in Morocco. Fifth Arab Congress of Plant Protection. APPS, Fez, Morocco, pp.220.

Zemrag A. (2000) Contribution à l'étude de l'importance, la caractérisation et à la recherche des moyens de lutte contre l'*Orobanche* (*Orobanche crenata* Forsk.) associé à la culture de fève (*Vicia faba major* L.) et de févrole (*Vicia faba minor* L.). Mémoire d'accès au grade ingénieur en Chef, INRA, Rabat.