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Broomrape intimidation to rapeseed-mustard production in semi-arid regions

Abstract

Orobanche commonly known as broomrape, *Margoja*, *Rukhri* or *Gulli*, is posing a serious threat to the rapeseed-mustard (*Brassica* sp.) cultivation particularly in the semi-arid tracts of the world and cause 5-100% loss in seed yield. *Orobanche aegyptiaca*, the most common species among root parasite to rapeseed-mustard is an underground obligate holoroot parasite lack of chlorophyll.1 It obtain carbon, nutrients, and water through haustoria which connect the parasite with the host vascular system.2 The attached parasite functions as a large metabolic sink, often named "supersink", strongly competing with the host plant for water, minerals and food assimilates. The diversions of these substances to the parasitic weed causes moisture and assimilate starvation, host plant stress and growth inhibition leading to drastic reduction in crop yield and quality in infested fields. The problem becomes more severe under rainfed conditions and sandy soils which are inherently facing the water and nutrient starvations.

Keywords: Broomrape, Rapeseed-Mustard, Host-parasite interaction, Yield loss, Control measures

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Host-parasite interaction

Orobanche grows underground on the roots of rapeseed-mustard plant in response to germination stimulants secreted by host plant roots after 7-10 days of sowing. The minute size seeds can survive for few hours of life after germination, therefore quickly attach to a host root before their resources exhausted. The parasite attacks the host root through haustoriums and develops underground for about 25-40 days, after which depending upon conditions outside, produce the flowering stalks above ground and looks like a straw to purple coloured scales. It grows upto 15-30 cm in height in clusters above the ground. *Orobanche* plants are without leaves and upper 2/3 part of stem bears inflorescence which is rather sparse. Each flower bears a small capsule which contains 40,000 to 50,000 or even more minute seeds (0.15-0.5 mm long). The seeds remain viable in soil for up to 20 years (Figure 1). The germinating seed (host dependent seed conditioning and stimulation) produces a germ tube or radical which elongates chemotropically and forms a haustorium that is strongly attached to the plant vascular system.[4,5] Life cycle of *Orobanche* has seed germination, haustorial initiation, attachment, penetration and establishment in the host and emergence of the flowering stalk above soil.[6]

Control measures

Parasitic weeds are among the most destructive and difficult to control among all weeds. There is no single technique provides complete control of *Orobanche*, and expelling its infestation is unavoidable. Physical methods are very useful but tedious, time-consuming and costly. Chemical, agronomic control methods and host resistance appear to be the most appropriate measures and affordable. Moreover, some biological and crop resistance approaches are promising but they are too expensive and control may not be complete, by this, still need more research. It was claimed that integrated approaches combining several techniques could be more effective. However, these integrated programmes are practiced only on a small scale in a few countries because of cost and technical problems. While, avoidance of dispersal of broomrape, crop resistance, and prevention measures could be effective and the most economical methods to reduce this root parasitic weed infestation in agricultural fields. It is important both to assess the most severely infested areas in order to target these control measures most effectively, and maintain the seed bank of less infested areas beneath a threshold level of damage. Habimana et al.,[7] reported that Broomrapes (*Orobanche* sp.) are a root holoparasitic plant devoid of chlorophyll and entirely depending on the host for nutritional requirements. They cause considerable yield losses (5-100 %) in the crops, especially in the drier and warmer areas of Europe, Africa and Asia where it is reported to mainly parasitize species of leguminous, oilseeds, solanaceous, cruciferous and medicinal plants. It is a serious root parasite threatening the livelihood of the farmers with its devastating effect on some of the aforementioned crops. Compared with the non-parasitic weeds, the control of *Orobanche* has been proved to be exceptionally difficult due to its underground location, lack of photosynthesis, late appearance of parasitic shoots, closer association with host plant roots and complex mechanisms of seed dispersal, germination, and longevity.[8] Several attempts were made to control this parasite including the use of herbicides, synthetic germination, stimulation, crop rotation, nitrogenous fertilizers and soil solarization.[9] Ali[10] found that maintaining weed free condition beyond 40 days after sowing (DAS) did not prove beneficial and the critical period of crop-weed competition was first 8 weeks after sowing and allowing competition till crop maturity reduced seed yield by 34 per cent. Understanding the factors behind germination of *Orobanche* and their actual seed load in the soil is crucial for the development of management strategies to deplete the soil seed bank of *Orobanche*.[11] A major difficulty for the breeder is the fast development of new pathotypes of *Orobanche* sp. e.g. *Cumana*, which overcomes the resistance of newly developed sunflower lines. Hence, need for molecular and biochemical studies will be stressed which

may lead to more advanced breeding strategies.[12] In Turkey, a survey studies showed presence of *Orobanche aegyptiaca/ramose* 27.72% in tomato greenhouses and 80% in tomato fields, *Orobanche crenata* and *O. aegyptiaca/ramose* were present 57.89% in fababean and 75.51% in lentil fields.[13] The fact that herbicides, targeting specifically the amino acid biosynthesis, have a major impact on broomrapes tends to prove that these plants have their own machinery for amino acid metabolism. In *O. foetida*, tubercles accumulate preferentially soluble amino acids, especially aspartate and asparagine, suggesting an important role for a glutamine-dependent asparagines synthetase in the N metabolism of the parasite. The parasite (*O. cernua*) develop a sink strength and gained 99% of its carbon and 95% of its nitrogen from tobacco phloem.[14]

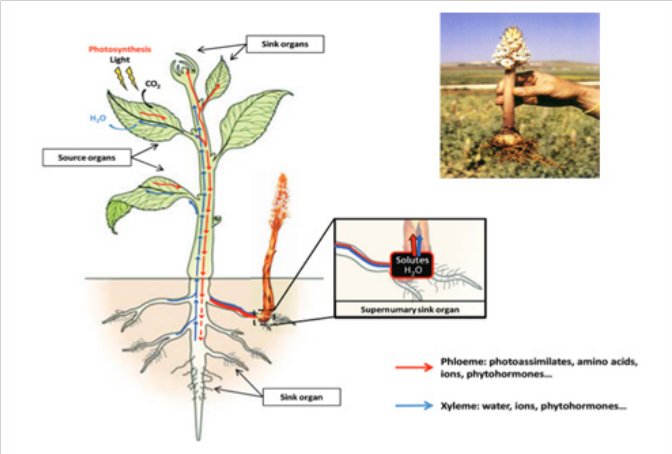

Figure 1 Source–sink relationship in a host plant–*Orobanche* interaction.[3]

Extensive work done by Punia et al.,[15] in rapeseed-mustard in India reported that nitrogenous and potassic fertilizers, soybean oil, CAN and calcium nitrate did not prove effective in inhibiting germination of *Orobanche aegyptiaca* in rapeseed-mustard, post mergence application of kerosene oil and paraquat causes toxicity to the crop. Preceding crop of cowpea, black gram, moth bean, sunn hemp, cluster bean, and sesame significantly reduced *Orobanche* menace in succeeding mustard crop while sorghum, pearl millet, chilies, and green gram did not influence broomrape infestation in mustard.[16] Several methods for managing *Orobanche* including hand weeding, deep ploughing, host plant tolerance, alteration in seeding windows and N-fertilizer scheduling, application of organic manures and biofertilizers, chemical seed treatment, and kerosene/soybean oil droplets spray have been attempted, but, they were often inconsistent over the years and have limited effectiveness.[17] A reduction of 90% *Orobanche* infestation in mustard due to soil solarization in Israel has been reported by Singh.[18] Mustard crop heavily parasitized by the *Orobanche aegyptiaca* Pers, caused 15–49 per cent seed yield loss.[19] While, Purna et al.[20] reported that presence of weeds throughout growing period resulted in 36-42 per cent reduction in seed yield of mustard. Dashora et al.[21] opined that the period upto 30 DAS was more critical for weed crop competition in mustard. Hence, it is necessary to remove weeds either manually or by using herbicides during that period. Chauhan et al.[22] reported that weed competition in mustard is more serious in early stage because crop growth in winter (*rabi*) season remains slow during the first 4-6 weeks after sowing and during later stage it grows vigorously and suppressing effect on weeds. Singh[23] reported that increasing seed rate has reduced the weed population and weeds dry matter production which has impact in increasing seed yield of mustard. He observed that the lowest seed rate of 4 kg/ha recorded significantly higher weed density and dry matter accumulation than higher seed rates of 5 and 6 kg/ha, respectively. Sharma et al.[24] reported that *Fusarium solani* infection on *Orobanche* increased the number of dead spikes of broom rape. Germination of *Orobanche* is generally erratic and following the stringent criteria i.e., soil moisture and temperature during the preconditioning period, availability and reception of host signals as root exudates and finally the viability of seeds.[25] *Orobanche* also need proper attention to understand the host-pathogen/plant interaction and its management strategy to check its spread in wide areas with time.[26]

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None.

Conflicts of interest

Authors declare that no competing interests exist.

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