Factors Affecting the Efficacy of *Orobanche cumana* Control in Sunflower

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Introduction

The parasitic weed broomrape (*Orobanche* spp.) is chlorophyll-lacking root parasite that parasitizes many dicotyledonous species, causing severe damage to vegetable and field crops worldwide (Figure 1). Sunflower broomrape (*O. cumana* Wallr.) is a specific noxious weed of sunflower (*Helianthus annuus* L.). The overall objective of the current study was to evaluate the control efficacy of *O. cumana* in sunflower with imazapic. The specific objectives were: (i) to detect the effect of growing degree days (GDD) on the initial subsurface development of *O. cumana* on sunflower roots and (ii) to study the relations between *O. cumana* parasitism at different seed-burial depths and at different seed densities, its development, and the efficacy of chemical control.

Figure 1. **Sunflower field infested with *O. cumana* in Israel.**

Materials & Methods

Sunflower seeds were planted in two 1-m³ containers, in a temperature-controlled greenhouse. The containers were artificially infested with *O. cumana* seeds, where non-infested containers served as a control.

Sunflower plants growing in one of the containers were treated with herbicide while the other container served as the non-treated control. The herbicide was applied at 620 GDD, based on minirhyzotron observations (Figure 1). The threshold for application was 10 attachments tube^{-1} (Figure 2). A rate equivalent to 10 ml ha^{-1} of the Cadre herbicide (Imazapic 240 g a.i. l^{-1}) was applied to the sunflower foliage. A minirhyzotron system was weekly used for subsurface detection of the parasite. The observation tubes were placed diagonally at a 45° angle to the soil surface at a depth of 100 cm. Approximately 100 *O. cumana* seeds per 10 mm length of minirhyzotron observation tube were spread along a 10-mm-wide strip on the upper face of the tubes.

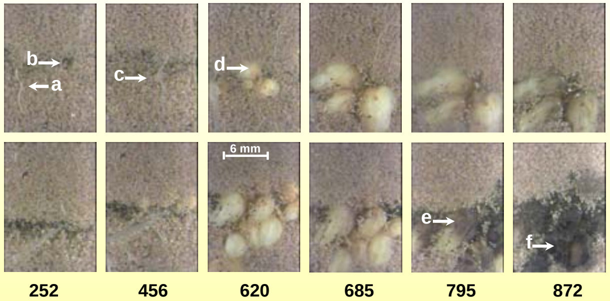

Figure 2. **Repeated minirhizotron observations of *O. cumana* development on sunflower roots with GDD. Images were captured at a depth of 30 cm below the soil surface. Top images were captured from a non-herbicide-treated sunflower and the bottom images were captured with a 2.4 g a.i.ha^{-1} imazapic-treated (at 620 GDD) sunflower. (a) sunflower root; (b) *O. cumana* seeds; (c) *O. cumana* attachment; (d) *O. cumana* tubercles; (e) necrotic spots of controlled *O. cumana*; (f) complete control of *O. cumana*.**

$$Y = Y_0 + \frac{a}{1+\left(\frac{x}{x_0}\right)^b}$$

Equation 1. **Four parameter logistic function. Y represents the number of emerged shoots or control efficacy; a and Y_0 represent the upper and lower asymptotic limit (maximum and minimum), respectively, x_0 is the median GDD from planting to 50% of the maximum; and b is the slope at x_0.**

Figure #	Y_0	a	b	x_0	p	R^2
3	0	16.3	90	1494	0.0001	0.98
4 (0-50)	3	85	15	700	0.0045	0.98
4 (50-80)	3.7	68	13	700	0.0125	0.96
5 (1-10)	6.2	90	41	700	0.0022	0.98
5 >10	11	75	21	795	0.0001	0.99

Table 1. **Coefficients of nonlinear regressions (*Equation 1*) between *O. cumana* shoots or control efficacy. The parameters related to Figures 3, 4 and 5.**

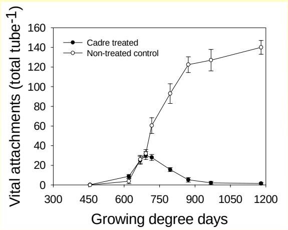

Figure 2. **Effect of foliar application of 2.4g a.i.ha^{-1} imazapic (Cadre) on *O. cumana* attachments at 620 GDD. Vertical bars represent standard error of the means.**

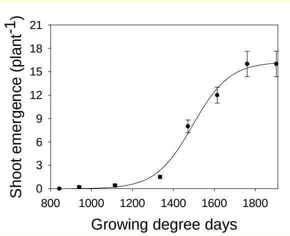

Figure 3. **Effect of foliar application of 2.4 g a.i.ha^{-1} imazapic at 620 GDD on *O. cumana* shoot. Vertical bars represent standard deviation of the means.**

Results and discussion

Parasitism of *O. cumana*, including attachments is presented in Fig 1. The number of vital and controlled attachments on the roots of the treated and control sunflower plants is presented in Figures 2. In the untreated control, this number continued to increase rapidly and significantly (Fig. 2) and decreased down to zero in the controlled treatment. Sunflower broomrape shoot emergence was significantly related to GDD (Fig. 3). This relationship is described as four-parameter sigmoid function. The control efficacy in the upper soil layer was significantly higher than in the deeper soil layer (Fig. 4). The significant difference in control efficacy was first observed 4 days after herbicide application and remained significant until the end of the experiment. The number of *O. cumana* attachments per frame significantly affected the control efficacy (Fig. 5). Significantly lower control efficacy was observed when the number of broomrape attachments per frame was 10 or more. An expression to this

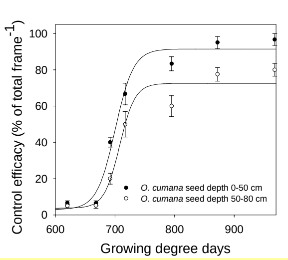

Figure 4. Effect of foliar application of 2.4 g a.i.ha^{-1} imazapic on *O. cumana* control efficacy, classified into two soil-depth layers. Vertical bars represent standard error of the means.

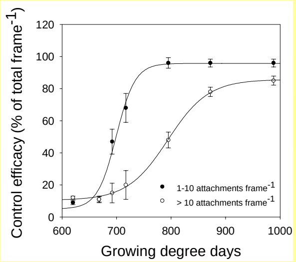

Figure 5. Effect of foliar application of 2.4 g a.i.ha^{-1} imazapic on *O. cumana* control efficacy classified into two attachment densities. Vertical bars represent standard error of the means.

Conclusions

The results obtained in this study indicate that sunflower broomrape could be controlled by the systemic herbicide imazapic. Appling systemic herbicide with basipethalic translocation required a certain amount of broomrape attachments. Early detection of the parasite with the minirhyzotron camera allows applying the herbicide in an optimal timing. Control efficacy was affected by attachment depth and density: it was the highest in the topmost layer, but decreased with depth and attachment density. The results obtained in this study emphasis the need for validation under long term field conditions for developing a decision support system based on GDD.