J. Crop Prot. 2022, 12 (4): 525-535

Research Article

A field study on the effect of *Phelipanche aegyptiaca* management on tomato yield

Alireza Hasanfard[1], Ali Eslami[2], Seyed Mojtaba Saadat [2], Mohammadreza Ghorbani[2] and Mehdi Rastgoo[1*]

1. Department of Agrotechnology, Faculty of Agriculture, Ferdowsi University of Mashhad, Iran.
2. Research and Development Division, Razavi Agricultural Company (Nemuneh Farm), Mashhad, Iran.

Abstract: Egyptian broomrape *Phelipanche aegyptiaca* is a parasitic weed that infests its hosts and feeds on the sap, significantly impacting crop yields. This experiment aims to control the Egyptian broomrape in its seed germination stage and reduce the damage to tomatoes. Fertilizer treatments included urea, ammonium sulfate, and ammonium nitrate at the rate of 150, 250, and 300 kg h^{-1} respectively, which were applied in three divided stages. Organic herbicide, before transplanting at the rate of six per thousand, and the humic acid plus phosphorus at the rate of two and 60 kg ha^{-1} in two stages were used in wet soil using calibrated backpack sprayers equipped with a nozzle. Also, four applications of sulfosulfuron (Apiros®, 75% WG) at the rate of 35 g ha^{-1} at intervals of 30, 40, 50, and 60 days after planting seedlings, and not weeding the Egyptian broomrape (broomrape-infested tomato) were among the other treatments in the experiment. The results revealed that the effect of experimental treatments on the studied traits of tomato and Egyptian broomrape was significant. Application of four stages of sulfosulfuron increased fruit number per plant and yield by 41% and 77%, respectively, compared to the weed-infested control. Herbicide application reduced Egyptian broomrape density by 89% per tomato plant compared to the weed-infested control. Applying sulfosulfuron and humic acid plus phosphorus reduced the dry weight of Egyptian broomrape by 78% and 69%, respectively, compared to the weed-infested control. Also, the relationship between the studied traits in Egyptian broomrape and tomatoes was inconsistent and significant. Based on our results, four applications of sulfosulfuron was recognized as the most effective in reducing the morphological characteristics of Egyptian broomrape and increasing tomato yield in the field. Also, applying two stages of humic acid plus phosphorus effectively reduced broomrape's adverse effects and increased tomato yield.

Keywords: Egyptian broomrape, humic acid, parasite, sulfosulfuron, tomato

Introduction

Parasitic weeds cause many concerns in agricultural fields. Orobanche and Phelipanche genera are among the most important factors limiting the yield of Solanaceae crops. These weeds cause significant damage in many regions of the world. As reported, about $1.3 to 2.6

Handling Editor: Ali Mokhtassi-Bidgoli

* Corresponding author: m.rastgoo@um.ac.ir

Received: 15 September 2022, Accepted: 27 January 2023
Published online: 08 February 2023

[DOR: 20.1001.1.22519041.2022.11.4.10.7]

billion of the annual loss of crops is due to the invasion of the broomrape (Ghannam *et al*., 2012). In the past years, the implementation of control methods for this parasite has not been effective, and its damage has caused a significant decrease in crop yields (Das *et al.,* 2020). Since the stages of infestation in plant hosts are below the soil surface, this parasite does its most damage before its emergence. Hence, a large part of the damage occurs before the infestation is detected (Ghannam *et al.,* 2012).

Broomrape seeds remain dormant in the soil for many years until chemical signals from a host plant root stimulate their germination. Seeds begin to germinate under the influence of the exudation of stimulating substances from the host plant root and continue their life cycle after being attached to the root (Cartry *et al.,* 2021). After germination, broomrape seeds can only survive for a few days unless they reach and bind with the host root. The seeds of this parasite develop a specialized penetration organ called the haustorium, which establishes connections to the host's xylem and phloem (Ekawa and Aoki, 2017). Haustorium allows broomrape to attack hosts by successive functions.

Broomrape lacks chlorophyll and cannot carry out photosynthesis; Hence, it obtains the resources required for its survival from the host plant. The broomrape is a root parasite weed causing losses in host plant productivity. The weedy root parasite, attaching to the roots of dicotyledonous plants, causes damage to the host plant (Scharenberg and Zidorn, 2018). The life cycle of broomrape species has mechanisms that make their life process coordinate with the host. The adverse effect of this parasite has been observed at vegetative and reproductive growth stages in tomatoes. Its control is complicated due to its morpho-physiological relationship with the host plant, causing damage before emergence and producing abundant seeds that can survive in the soil for a long time (Cartry *et al.,* 2021). Symptoms of its damage include chlorosis, moisture stress, decreasing plant growth, and wilting of the host plant. It has been reported that Egyptian broomrape *Phelipanche aegyptiaca* causes a decrease in the yield of tomatoes by disrupting the morphological attributes of this plant, such as reducing plant height, root dry weight, and shoot dry weight (Eizenberg *et al.*, 2007). Parker (2009) also reported that a field infested with broomrape could decrease crop yield by 5 to 100%, depending on host susceptibility, level of infestation, and environmental conditions.

Plant nutrition and biological and chemical herbicides are considered among the means used to decrease the density of broomrape (Ghaznavi *et al.,* 2019; Das *et al.,* 2020). Therefore, Ghaznavi *et al.* (2019) reported that the application of 200 kg h^{-1} of ammonium nitrate decreased the height and biomass of broomrape by 19% and 34%, respectively, and increased the yield of tomatoes by 27%. These researchers observed that the use of biological herbicides decreased the height and biomass of the broomrape by 45% and 59%, respectively. In addition, the use of herbicides such as glyphosate caused a decrease in the height of the parasite and consequently improved the host plant's vegetative and reproductive growth conditions (Sajedi *et al.,* 2013). In an experiment, it has been observed that the application of rimsulfuron in the rates of 100, 150, and 200 g a.i. ha^{-1}, respectively, 14, 28, and 42 days after sowing caused the control of the broomrape (Eizenberg *et al.,* 2005). Oxadiazon used in drip irrigation around tomato roots has also decreased the damage of this parasite (Foy *et al.,* 1989). It was also observed in a greenhouse experiment that chlorsulfuron, pronamide, and pendimethalin effectively control the parasite. Meanwhile, chlorsulfuron had the best weed control and the least damaging effect on tomatoes (Qasem, 1998).

Tomato *Lycopersicum esculentum* L. is one of the world's most consumed vegetables, with an annual production value of more than $90 billion (FAOSTAT, 2019). This plant is rich in minerals, carbohydrates, and vitamins. Due to its economic importance in processing industries, Tomato has the second production rank after potato *Solanum tuberosum* L. (Prajapati *et al.*, 2014). The cultivation area, production, and average yield in Iran have been reported as 9414 ha, 360 thousand tons, and 38 t ha^{-1}, respectively (Agricultural Statistics of Iran, 2019). Tomato is one of the most sensitive crops to broomrape (Mariam and Suwanketnikom, 2004). The annual loss of this plant in Iran is estimated to be about 40%, depending on the variety, parasite infestation level, and environmental conditions (Nezamabadi and Minbashi Moeini, 2016). Hence, adopting appropriate management methods in the short and long term will increase this crop's production and profitability.

Although much research has been carried out in recent years to reduce the damage caused by broomrape in tomato fields, their efficiency has been affected by application method, variety, study location, species, and density of broomrape. Using different methods and comparing tomato yield and characteristics related to broomrape under various treatments can effectively adopt accurate practices for managing this parasite. When the broomrape emerges above ground, most of the damage to the tomato has already been done, and control would be ineffective. Hence, the most crucial purpose of this study has been to control the broomrape in the germination stage. The present experiment was conducted to, compare and select an appropriate method of control of the Egyptian broomrape in the tomato field.

Materials and Methods

Site description and procedure

The experiment was conducted at Astan Quds Razavi Nemuneh farm of Mashhad, Iran (Lat 36° 15′ N, Long 59° 28 E; 985 m Altitude) with a history of infestation with broomrape in 2021. The average annual precipitation is 286 mm for Mashhad. The absolute minimum and maximum air temperature based on the data for 20 years (1993-2013) was -21 °C and 43.8 °C in Mashhad. Based on the Amberje climate classification method, the climate of Mashhad is a cold arid climate. Soil samples collected from the different field sites were analyzed for their physical and chemical properties by adopting standard procedures and depicted in Table 1.

Table 1 Main chemical properties of the soil at the experimental site.

Texture class	pH	EC (dS m^{-1})	O. M (%)	N (%)	P (mg kg^{-1})	K (mg kg^{-1})
Silt loam	7.3	2.09	0.83	0.075	51	280

pH is a measure of acidity or alkalinity; EC: electrical conductivity; O. M: organic matter; N: Nitrogen; P: phosphorus; K: potassium.

In March 2021, tomato (cv. Zomorod) seeds were planted in the seedling trays in the greenhouse of the Nemuneh farm. Irrigation and other influential factors in seedling production, including temperature and relative humidity in the greenhouse, were adjusted so that would be suitable for the growth stages of the seedlings. Arandomized complete block design with three replications was used.

Field preparation, experimental design and treatments

Before the transfer of tomato seedlings, common fields preparation operations such as disking, leveling, and irrigation was done for transplanting. Seedlings at the four- to the six-leaf stage in May 2021 were transferred to a field with a history of broomrape infestation and cultivated.

A randomized complete block design with three replications was used. The plots consisted of 4 rows, 6 m long and 1 m apart. Seedlings on the row were transplanted 20 cm apart. At the end of experiment samples were taken from the four middle rows to eliminate the marginal effects.

During the experiment, stages of growth such as earthing up in two stages and at an interval of 10 days in the middle of July 2021 using sweep, hand-weeding, and using metribuzin (Sencor®, 70% WP, 1 kg ha^{-1}) was applied at the stage of two to four leaves of weeds. Drip irrigation was done with an irrigation cycle of about 48 h.

Organic herbicide broomrape (sodium chloro glycol silicate) before transplanting as pre-emergence at the rate of six per thousand (0.6%) and the humic acid plus phosphorus at the rate of two and 60 kg h-1 in two stages (before and 30 days after transplanting) were used in wet soil after calibrating backpack sprayers equipped with a nozzle. Fertilizer treatments included urea, ammonium sulfate, and ammonium nitrate, respectively, at the rate of 150, 250, and 300 kg h-1 were applied in three divided stages (before, 30 days after transplanting, and in the middle of the flowering stage). Also, the use of four stages of sulfosulfuron (Apiros®, 75% WG) in the amount of 35 g ha^{-1} at intervals of 30, 40, 50, and 60 days after planting seedlings and not weeding the broomrape (control, broomrape-infested tomato) were among the other treatments in the present experiment. Sulfosulfuron is a herbicide from the sulfonylurea chemical family, mainly used for the selective control of wheat weeds and broomrape species in tomatoes (Paporisch *et al.,* 2020; Pandey *et al.,* 2006).

Data collection

The parameters related to tomatoes in two harvests included the height of the tomato plant, the number of tomato fruits per plant, the weight of tomato fruits per plant, and the yield of tomato fruit after removing non-marketable fruits (deformed, infected, and rotten).

After the emergence of the broomrape in the field, the number of broomrape plants per tomato plant, the number of broomrape stems in one square meter, fresh and dry weight of the broomrape (by placing the samples in an oven at a temperature of 75°C for 48 h) and the height of the plant samples in one square meter area of the two middle rows in each plot was measured.

Statistical analysis

Data analysis was performed in SAS software (*v*. 9.4, SAS Institute Inc, Cary, NC, USA), and the means were compared by Duncan's Multiple Range test (DMRT) at a 95% confidence interval. Drawing graphs and investigating the relationship between traits was done by GraphPad Prism (*v*. 8.0.1, La Jolla, CA. USA).

Results

Tomato plant height

Among the applied treatments, the highest average tomato plant height (91 cm) was observed in the application of sulfosulfuron (Fig. 1, A). In using four stages of sulfosulfuron, the average height of the tomato plant was 50% higher than the infected control (broomrape-infested tomato). Next to this herbicide, using two stages of humic acid plus phosphorus treatment led to a higher plant height (39%) than the infected control.

Number of tomato fruits

The highest average number of tomatoes, with 23 fruits per plant, was observed in the application of sulfosulfuron (Fig. 1, B). Compared to the infested control, this herbicide had an average of 41% more fruit per plant.

Weight of tomato fruits

The highest fruit weight per plant belonged to the use of sulfosulfuron (4.5 kg per plant) and humic acid plus phosphorus (3.8 kg per plant) (Fig. 1, C). The lowest fruit weight belonged to the infested control, with fruit weight of 1.8 kg per plant.

Yield of tomato

The highest tomato yield (103 t ha^{-1}) belonged to the application of sulfosulfuron and the use of humic acid plus phosphorus (76 t ha^{-1}) (Fig. 1, D). In other words, the lack of control of the broomrape reduced the tomato yield by 77% and 69%, respectively, compared to its management using sulfosulfuron and humic acid plus phosphorus.

Density of broomrape per tomato plant

In the application of sulfosulfuron, the density of broomrape was 89% lower compared to the infested control. Next to the sulfosulfuron treatment, the application of humic acid plus phosphorus showed a favorable result with a 71% decrease in the density of broomrape (Fig. 2, A).

Number of broomrape stems

The most effective treatment for decreasing the number of broomrape stems was sulfosulfuron. the decrease in the number of stems due to the application of sulfosulfuron was 84% compared to the infested control (Fig. 2, B). Next to sulfosulfuron, the use of humic acid plus phosphorus also led to a 51% decrease in the broomrape stem compared to the infested control. Other treatments were placed in the same statistical group and showed similar efficiency in decreasing the number of stems per unit area.

[DOR: 20.1001.1.22519041.2022.11.4.10.7]

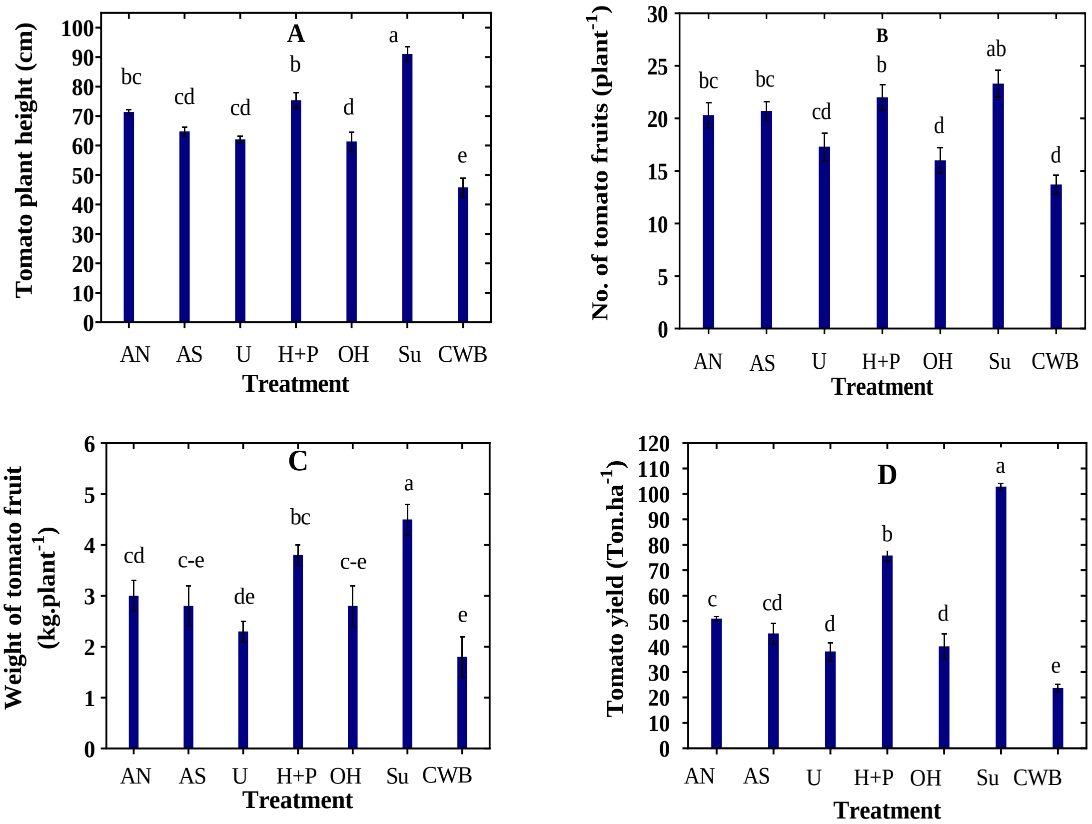


Figure 1 The effect of experimental treatments on tomato plant height (A), number of tomato fruits (B), weight of tomato fruits (C), and tomato yield (D). Vertical lines indicate the standard error (SE) of the treatments. In each column, means with similar letters do not have a significant difference at the probability level of 0.05 based on Duncan's Multiple Range Test (DMRT). AN: ammonium nitrate, AS: ammonium sulfate, U: urea, H + P: humic acid plus phosphorus, OH: organic herbicide, Su: sulfosulfuron, CWB: control with broomrape.

Fresh weight and dry weight of broomrape

Based on the results, all experimental treatments decreased the fresh weight of broomrape. However, sulfosulfuron and humic acid plus phosphorus decreased the fresh weight more than other treatments. Application of sulfosulfuron and humic acid plus phosphorus reduced 78% and 70% of the fresh weight of broomrape, respectively, compared to the infested control (Fig. 2, C).

Sulfosulfuron and humic acid plus phosphorus treatments decreased the dry weight of broomrape by 78% and 69% compared to the infested control (Fig. 2, D).

Height of broomrape

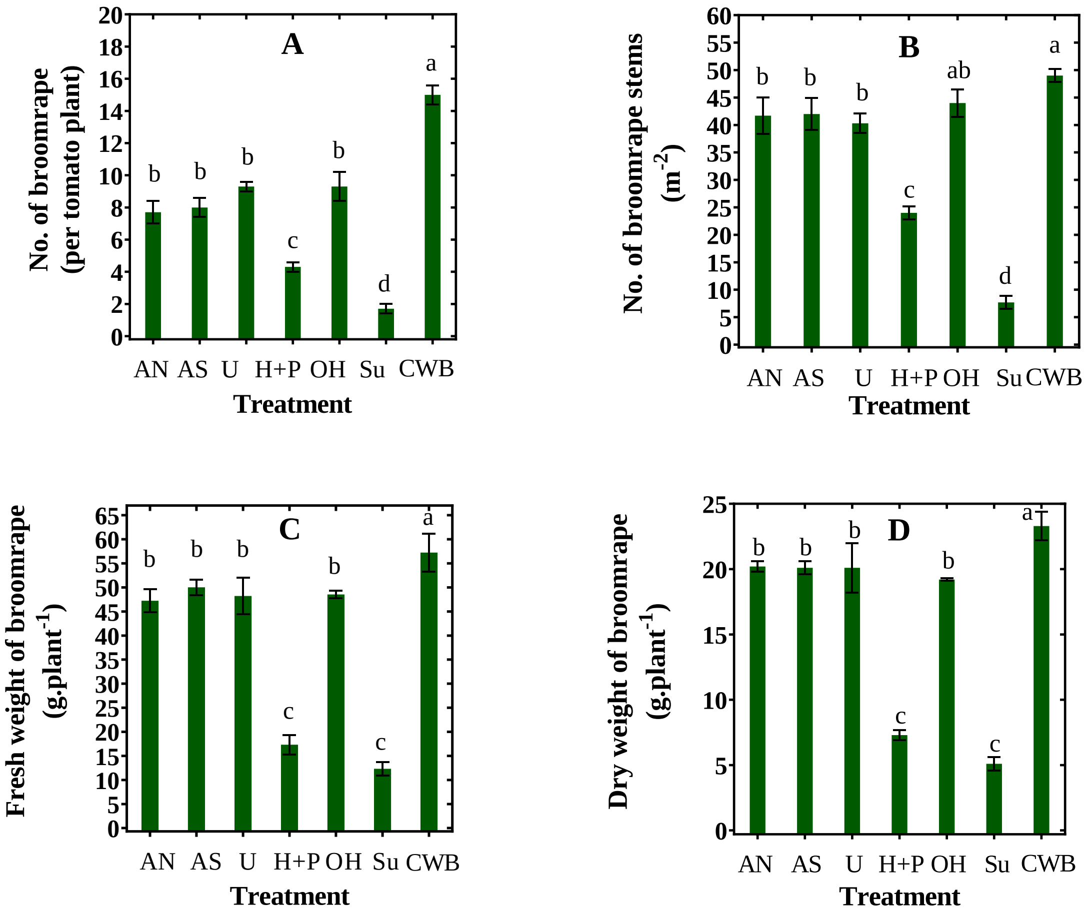
In the treatments of sulfosulfuron and humic acid plus phosphorus, compared to the infested control, the height of the broomrape plant was reduced by 22% and 20%, respectively (Fig. 2, E). Other experimental treatments were included in the same statistical group as the infested control.

Relationship between attributes

In this experiment, there are high regression coefficients between the yield of tomatoes and the traits broomrape (Fig. 3). According to Figures 3 (A and B), the increase in the number of broomrape per tomato plant and the increase in the number of stems per unit area caused a decrease in the yield of tomatoes (R^2 = 93 and R^2 = 97, respectively). On the contrary, a decrease in these traits caused an increase in the yield of tomatoes. Other characteristics of broomrape were also significantly and non-

[DOR: 20.1001.1.22519041.2022.11.4.10.7]

linearly related to the yield of tomatoes. So that the increase in fresh weight (R^2 = 95), dry weight (R^2 = 94), and the height of broomrape (R^2 = 59) led to a decrease in tmato yield, and their decrease led to an increase in yield (Figs. 3, C, D, and E).



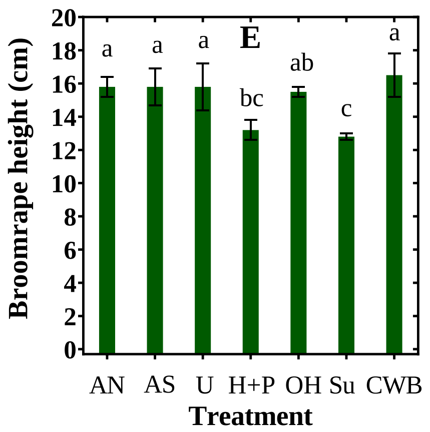
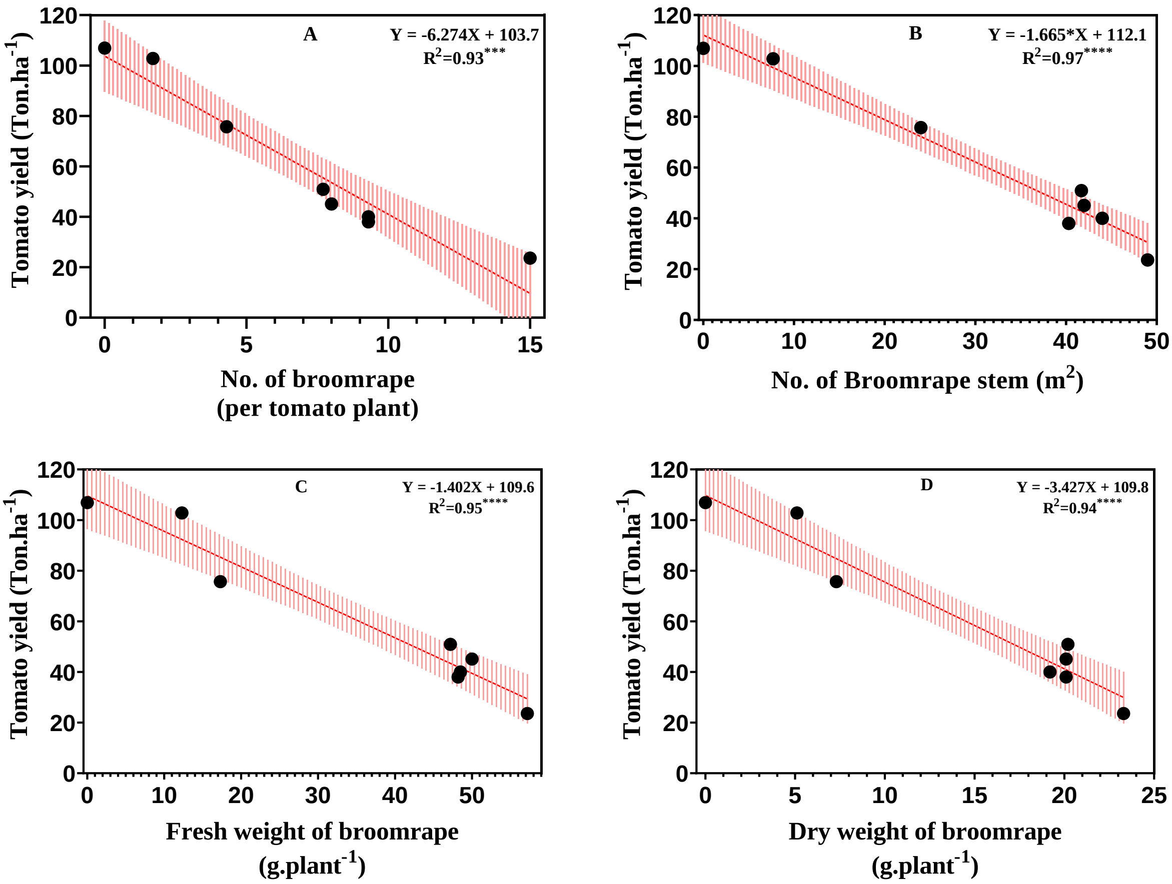


Figure 2 The effect of the application of experimental treatments on the density of broomrape per tomato plant (A), number of broomrape stems (B), fresh weight of broomrape (C), dry weight of broomrape (D), and broomrape height (E). Vertical lines indicate the standard error (SE) of the treatments. In each column, means with similar letters do not have a significant difference at the probability level of 0.05 based on Duncan's Multiple Range Test (DMRT). AN: ammonium nitrate, AS: ammonium sulfate, U: urea, H + P: humic acid plus phosphorus, OH: organic herbicide, Su: sulfosulfuron, CWB: control with broomrape.



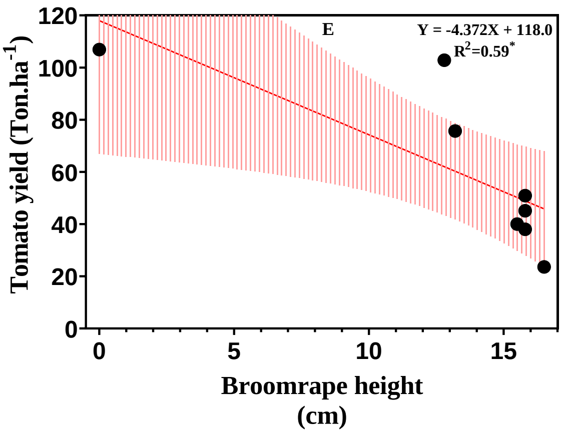


Figure 3 Correlation between tomato yield and the density of broomrape per tomato plant (A), number of broomrape stems (B), fresh weight of broomrape (C), dry weight of broomrape (D), and broomrape height (E). Dashed lines represent the 95% confidence interval of the fitted line. ****: significant at $p \leq 0.0001$, ***: significant at $p \leq 0.001$ and *: significant at $p \leq 0.05$.

Discussion

In this study, the higher height of the tomato plant when broomrape was controlled, indicates the proper utilization and allocation of the resources available to the plant in the lower density of this parasite. Researchers reported that using sulfonylurea herbicides, in addition to preventing the reduction of tomato's vegetative growth through broomrape control, does not harm the host plant (Ghannam *et al.*, 2012).

All treatments to control the broomrape showed a positive effect on the number of tomato fruits compared to the infested control. Still, the treatments of humic acid plus phosphorus, ammonium nitrate, and ammonium sulfate with the most suitable treatment (sulfosulfuron) showed no difference in this trait.

Applying sulfosulfuron and humic acid plus phosphorus treatments in the fields infected with broomrape will probably lead to an increase in tomato production potential above the country's average (38 t ha^{-1}). Although the application of other treatments also led to a rise in the control of the broomrape and an increase in the yield of tomatoes, they were less effective compared to sulfosulfuron and humic acid plus phosphorus treatments. The present experiment indicated that the yield of tomatoes is directly related to broomrape control. Even if the soil physicochemical conditions are favorable, the yield of tomatoes will be significantly reduced when the broomrape is not controlled. It has been reported that the application of sulfosulfuron significantly increased the yield of tomatoes compared to the infested control, and increasing its concentration from 20 to 30 g h^{-1} led to a further increase in tomato yield (Modares and Minbashi Moeini, 2018). Similar experiments have also shown that using sulfonylurea herbicides, including sulfosulfuron and ethoxysulfuron, was effective in controlling the broomrape and increasing the weight of tomato fruit (Puma *et al*., 2016). Broomrape seeds can germinate until the end of the cropping season due to the absorption of stimulants from the roots of their host; Hence, in the present experiment, the application of sulfosulfuron in four stages during the growing season has led to its proper control and increased tomato yield.

The application of sulfosulfuron significantly decreased the density of broomrape compared to the infested plot. ALS (acetolactate synthase) enzyme inhibitors, such as sulfonylureas, effectively control species of broomrape. Sulfonylurea herbicides block the biosynthesis of the branched-chain amino acids (Rastgoo *et al.*, 2022). Previous studies have reported that the sulfonylurea herbicides applied at the initial stages of parasitism, *i.e*., the preconditioning and germination stages, inhibited parasite development (Hershenhorn *et al*., 1998; Wallach *et al*., 2022). According to the soil analysis results (Table 1), soil pH is 7.3, and the application of humic acid plus phosphorus has probably decreased soil pH. Since the stimulation of seed germination and the growth of this parasite is favored by high soil pH due to the low percentage of absorption of nutrients and the weak seedlings of the host; Probably, the reduction in the density of the broomrape with the application of humic acid plus phosphorus occurred due to decrease in soil pH. According to the high yield of tomatoes in the application of humic acid plus phosphorus (Figure 1, D), this treatment, while reducing the density of the broomrape, has probably had a favorable effect on improving the yield of tomatoes. In this regard, it has been reported that using 3 mM of gallic acid has decreased the broomrape's density and increased the growth of tomatoes (Salimi *et al*., 2021). It has been reported that using sulfosulfuron in doses of 20, 30, and 40 g h^{-1} has decreased the number of broomrape stems. This decrease was significant with the increase in the herbicide concentration (Modares and Minbashi Moeini, 2018).

Applying the mentioned treatments affected the morphological attributes such as fresh weight by reducing the growth of broomrape. In this way, the growth of broomrape is probably slow due to the decrease in obtaining resources from the host plant. Because of this, the fresh weight of the parasite has also decreased. The use of sulfosulfuron prevents the attachment of the broomrape to the tomato root and depriving it from plant sap, and the same issue leads to a decrease in the parasite's dry weight with this treatment. It has been reported that double postemergence application of sulfosulfuron (40 and 60 days after transplanting) at 35 g ha^{-1} resulted in ~ 60% reductions in Egyptian broomrape biomass in tomatoes (Shirdel *et al*., 2014). Similarly, researchers reported that using sulfonylurea herbicides, including sulfosulfuron (100 g ha^{-1}), leads to a significant decrease in the dry weight of broomrape (Hershenhorn *et al*., 1998). In the present experiment, applying fertilizers and organic

[DOR: 20.1001.1.22519041.2022.11.4.10.7]

herbicide did not decrease the height of the broomrape. On the contrary, it has been reported that the application of 200 kg h^{-1} of ammonium nitrate caused a 19% decrease in the height of the broomrape (Ghaznavi *et al*., 2019).

Based on our findings, it is necessary to evaluate broomrape's morphological characteristics because they influence the final tomato yield. The high correlation of traits evaluated in a study indicates their influence on each other. Hence, the quantitative change of any attributes of the broomrape that leads to a decrease or an increase in tomato yield can be investigated in this method.

Conclusion

Although the hand-pulling of the broomrape shoots before the production of seeds prevents seeds from entering the soil and strengthening the seed bank, before seedling emergence, this parasite damages tomatoes and decreases their yield. Hence, hand pulling of broomrape is ineffective in severe infestations because only emerging broomrapes are removed. Furthermore, in mechanical control, the tomato roots may be damaged due to the hand-pulling of broomrape shoots from the soil. On the other hand, the hand-weeding of parasites in large fields is not cost-effective for farm managers in terms of labor costs. Despite the importance of decreasing the use of chemical methods due to environmental pollution, it seems that due to the high density of this parasite and its significant damage in tomato fields, it is possible to use sulfosulfuron to reduce the density of this parasite and gradually reduce its seeds in the soil. It is also possible to improve the soil with appropriate fertilizers based on the results of field soil analysis and correct its acidity with compounds such as humic acid plus phosphorus. Due to the rapid development of resistance to sulfonylurea herbicides, there is probably a high potential for developing sulfonylurea-resistant broomrape. Hence, their use in agricultural systems should be rational to decrease the risk of resistance to these herbicides.

Disclosure Statement

The authors declare that there are no conflict of interests to declare.

References

Agricultural Statistics of Iran, Crops (2016-17). 2019. Ministry of Agriculture Jihad, Iran.

Cartry, D., Steinberg, C. and Gibot-Leclerc, S. 2021. Main drivers of broomrape regulation. A Review. Agronomy for Sustainable Development, 41(2): 1-22.

Das, T. K., Ghosh, S., Gupta, K., Sen, S., Behera, B. and Raj, R. 2020. The weed Orobanche: species distribution, diversity, biology and management. Journal of Research in Weed Science, 3(2): 162-180.

Eizenberg, H., Colquhoun, J. and Mallory-Smith, C. 2005. A predictive degree-days model for small broomrape (*Orobanche minor*) parasitism in red clover in Oregon. Weed Science, 53(1): 37-40.

Eizenberg, H., Lande, T., Achdari, G., Roichman, A. and Hershenhorn, J. 2007. Effect of Egyptian broomrape (*Orobanche aegyptiaca*) seed-burial depth on parasitism dynamics and chemical control in tomato. Weed Science, 55(2): 152-156.

Ekawa, M. and Aoki, K. 2017. Phloem-conducting cells in haustoria of the root-parasitic plant *Phelipanche aegyptiaca* retain nuclei and are not mature sieve elements. Plants, 6(4): 60.

FAOSTAT, Food and Agriculture Organization of the United Nations. 2019. http://fao. org/faostat/en.

Foy, C. L., Jain, R. and Jacobsohn, R. 1989. Recent approaches for chemical control of broomrape (*Orobanche* spp.). Reviews of Weed Science, 4, 123-152.

Ghannam, I., Al-Masri, M. and Barakat, R. 2012. The effect of herbicides on the Egyptian broomrape (*Orobanche aegyptiaca*) in tomato fields. American Journal of Plant Sciences, 3(3): 346-352.

Ghaznavi, M., Kazemeini, S. A. and Naderi, R. 2019. Effects of N fertilizer and a

[DOR: 20.1001.1.22519041.2022.11.4.10.7]

bioherbicide on Egyptian broomrape (*Orobanche aegyptiaca*) in a tomato field. Iran Agricultural Research. 38: 9-13.

Hershenhorn, J., Plakhine, D., Goldwasser, Y., Westwood, J. H., Foy, C. L. and Kleifeld, Y. 1998. Effect of sulfonylurea herbicides on early development of Egyptian broomrape (*Orobanche aegyptiaca*) in tomato (*Lycopersicon esculentum*). Weed Technology, 12(1): 108-114.

Mariam, E. G. and Suwanketnikom, R. 2004. Screening of tomato (*Lycopersicon esculentum* Mill.) varieties for resistance to branched broomrape (*Orobanche ramosa* L.). Agriculture and Natural Resources, 38(4): 434-439.

Modares, S. S. and Minbashi Moeini, M. 2018. Chemical control of egyptian broomrape, phelipanche aegyptiaca, with sulfosulfuron herbicide in tomato fields in hormozgan province. Pesticides in Plant Protection Sciences, 6: 140-153.

Nezamabadi, N. and Minbashi Moeini, M. 2016. Broomrape: Biology and Management. Ministry of Jihad–e-Agriculture Agricultural Research, Education and Extension Organization. Iranian Research Institute of Plant Protection.

Pandey, A. K., Gopinath, K. A. and Gupta, H. S. 2006. Evaluation of sulfosulfuron and metribuzin for weed control in irrigated wheat (*Triticum aestivum*). Indian Journal of Agronomy, 51(2): 135-138.

Paporisch, A., Laor, Y., Rubin, B. and Eizenberg, H. 2020. Effect of repeated application of sulfonylurea herbicides on sulfosulfuron dissipation rate in soil. Agronomy, 10(11): 1724.

Parker, C. 2009. Observations on the current status of Orobanche and Striga problems worldwide. Pest Management Science: formerly Pesticide Science, 65(5): 453-459.

Prajapati, H. N., Panchal, R. K. and Patel, S. T. 2014. Efficacy of bioagents and biological interaction of *Alternaria solani* with phylloplane mycoflora of tomato. Journal of Mycopathological Research, 52(1): 81-86.

Punia, S. S., Duhan, A., Yadav, D. B. and Sindhu, V. K. 2016. Use of herbicides against Orobanche in tomato and their residual effect on succeeding crop. Indian Journal Weed Science, 48(4), 404-409.

Qasem, J. R. 1998. Chemical control of branched broomrape (*Orobanche ramosa*) in glasshouse grown tomato. Crop Protection, 17(8): 625-630.

Rastgoo, M., Mirzaei, M., Gherekhloo, J. and Hasanfard, A. 2022. Effect of water hardness induced by bicarbonate and chloride forms of magnesium and sodium on the performance of herbicides for littleseed canarygrass control. Journal of Crop Protection, 11(3): 315-327.

Sajedi, A., Zand, E., Sajedi, N. and Nabaiy, S.M. 2013._Effects of application of different herbicides and sowing date on number of plant, height plant broomrape and agronomical traits of potato. Iranian Journal of Agronomy and Plant Breeding, 8: 7-18.

Salimi, A., Arshi, A. and Chavoushi, M. 2021. The effects of Gallic acid on broomrape and antioxidant enzyme activity in tomato (*Lycopersicum esculentum*). Journal of Plant Process and Function, 10 (42): 147-160.

Scharenberg, F. and Zidorn, C. 2018. Genuine and Sequestered Natural Products from the Genus *Orobanche* (Orobanchaceae, Lamiales). Molecules, 23(11): 2821.

Shirdel, K., Amani, S., Yarnia, M., Javanshir, A. and Dabbagh, M. N. A. 2014. The control of broomrape (*Orobanche aegyptiaca*) in tomato (*Lycopersicum esculentum* Mill) farms. Iranian Journal of Field Crops Research. 12: 476-483.

Wallach, A., Achdari, G. and Eizenberg, H. 2022. Good News for Cabbageheads: Controlling Phelipanche aegyptiaca Infestation under Hydroponic and Field Conditions. Plants, 11(9): 1107.

مطالعه مزرعه‌ای در مورد تأثیر مدیریت گل جالیز مصری *Phelipanche aegyptiaca* بر عملکرد گوجه‌فرنگی

علیرضا حسن‌فرد[۱]، علی اسلامی[۲]، سیدمجتبی سعادت[۲]، محمدرضا قربانی[۲] و مهدی راستگو[۱*]

۱- گروه اگروتکنولوژي، دانشکده کشاورزي، دانشگاه فردوسی مشهد، مشهد، ایران.
۲- بخش تحقیق و توسعه کشت و صنعت مزرعه نمونه شرکت کشاورزی رضوی، مشهد، ایران.
پست الکترونیکي نویسنده مسئول مکاتبه: m.rastgoo@um.ac.ir
دریافت: ۲٤ شهریور ۱٤۰۱؛ پذیرش: ۷ بهمن ۱٤۰۱

چکیده: گل جالیز مصری *Phelipanche aegyptiaca* یک علف هرز انگلی است که میزبان خود را آلوده می‌کند، از شیره آن تغذیه می‌کند و به‌طور قابل‌توجهی بر عملکرد محصول تأثیر می‌گذارد. هدف از این آزمایش کنترل گل جالیز مصری در مرحله جوانه‌زنی بذر آن و کاهش آسیب به گوجه‌فرنگی است.تیمارهای کودی شامل اوره، سولفات آمونیوم و نیترات آمونیوم به‌ترتیب به‌میزان ۱۵۰، ۲۵۰ و ۳۰۰ کیلوگرم در هکتار در سه مرحله به‌صورت تقسیط شده به خاک اضافه شدند. علفکش ارگانیک گل جالیزقبل از نشاکاری به‌صورت پیش‌رویشی به‌نسبت شش در هزار و ترکیب هیومیک اسید + فسفر به‌ترتیب دو و ۶۰ کیلوگرم در هکتار در دو مرحله به‌صورت تقسیط شده در خاک مرطوب پس از کالیبره کردن سم‌پاش پشتی مجهز به نازل شره‌ای مورد کاربرد قرار گرفتند. هم‌چنین کاربرد چهار مرحله علفکش سولفوسولفورون (آپیروس®WG 75%) به مقدار ۳۵ گرم در هکتار به فاصله ۳۰، ۴۰، ۵۰ و ۶۰ روز پس از کشت نشاء و عدم وجین گل جالیز (شاهد آلوده) از دیگر تیمارهای آزمایش حاضر بود. نتایج نشان داد که اثر تیمارهای آزمایشی بر صفات مورد بررسی گوجه‌فرنگی و گل جالیز معنی‌دار بود. در تیمار کاربرد چهار مرحله علفکش سولفوسولفورون تعداد میوه در بوته و عملکرد به‌ترتیب ۴۱ و ۷۷ درصد در مقایسه با شاهد آلوده بیشتر بود. علفکش یاد شده تراکم گل جالیز را به ازای هر بوته گوجه‌فرنگی در مقایسه با شاهد آلوده ۸۹ درصد کاهش داد. کاربرد علفکش سولفوسولفورون و هیومیک اسید + فسفر به کاهش وزن خشک گل جالیز به‌ترتیب به‌میزان ۷۸ و ۶۹ درصد در مقایسه با شاهد آلوده منجر شد. هم‌چنین ارتباط بین صفات مورد بررسی در گل جالیز و گوجه‌فرنگی غیرهم‌سو و معنی‌دار بود. براساس نتایج آزمایش حاضر کاربرد چهار مرحله علفکش سولفوسولفورون به‌عنوان مؤثرترین تیمار در کاهش خصوصیات مورفولوژیکی گل جالیز و افزایش عملکرد گوجه‌فرنگی در مزرعه شناخته شد. پس از تیمار یاد شده، کاربرد دو مرحله هیومیک اسید + فسفر نیز در کاهش اثرات نامطلوب گل جالیز مصری و افزایش عملکرد گوجه‌فرنگی مؤثر بود.

واژگان کلیدی: انگل، سولفوسولفورون، گل جالیز مصری، گوجه‌فرنگی، هیومیک اسید