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Review paper

Field dodder – How to control it?

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SUMMARY

Broad geographic distribution and spectrum of hosts make field dodder, *Cuscuta campestris*, one of the most widespread and most harmful pests among flowering parasitic plants. Field dodder may become a problem in vegetable nurseries (e.g. tomato, sweet pepper and cabbage) or in potato or some other crop grown in plastic greenhouses. However, the most devastating damage comes from field dodder outbreaks in newly-established perennial legume crops (alfalfa, clover, etc.), which are generally the preferred hosts of this parasitic flowering species. Apart from alfalfa and clover, an expansion of field dodder has been observed in recent years in sugar beet, too.

Different measures are available for controlling field dodder, from preventive (pure seeding material, tolerant cultivars, etc.), to mechanical removal (mowing and hand weeding) to herbicide treatments. The most successful control of field dodder requires a systematic approach ensured through integrated protection, which contributes to a more effective control of parasitic flowering plants.

Keywords: Field dodder; Herbicides; Control

INTRODUCTION

Autotrophic flowering plants constitute the predominant group among weed species but weeds also include some semiparasitic and parasitic flowering plants. Parasitic plants are represented by approximately 4200 species classified in 274 genera, which make a little more than 1% of all flowering plants. Only some 11% of all genera include species that may be considered as parasites of cultivated plants. The worst economic damage in important host crops is caused by species from only four genera: *Cuscuta*, *Arceuthobium*, *Orobanche* and *Striga* (Nickrent, 2002).

Cuscuta campestris is considered the most widespread *Cuscuta* species globally. Even though North America is assumed to be its place of origin, the species is cosmopolitan and considerably widespread throughout South America, Europe, Asia, Africa and Australia (Holm et al., 1997). Distribution and frequency of *Cuscuta* species in anthropogenic habitats in Serbia (i.e. various types of crops and ruderal habitats in urban and rural areas) have been researched by Vrbničanin et al. (2008), and they detected their presence in 25% of the assessed 10x10 km squares on the UTM (Universal Transverse Merkator) grid.

Most of the damage caused by these parasitic flowering plants results from the fact that parasitism is the most acute form of negative interaction between vascular plants in which one of the partners becomes a heterotroph living at the expense of the other, its host.

Plants infested with field dodder gradually weaken, their lush growth dwindles and they have very small vegetative and generative yield (Koskela et al., 2001; Fathoulla & Duhoky, 2008). Damage caused this way may eventually cause total destruction of the host plant. We are therefore focusing in this review on various control options for field dodder, from preventive ones (e.g. mechanical measures or choice of tolerant cultivars) to biological and chemical methods of control.

BIOLOGICAL CHARACTERS OF FIELD DODDER

The genus *Cuscuta* includes some 200 annual and sporadically perennial non-herbaceous plants that have no roots and parasitize on host stalks. The stem of a field dodder plant is threadlike and twining, it has no leaves or they may only appear as inconspicuous scales. After field dodder seeds have fully matured they fall off and accumulate on the ground. They may germinate during the following season if a suitable host plant is growing nearby or may stay dormant until such conditions have occurred (Swift, 1996). When a seedling touches the stalk or trunk of a host plant it becomes firmly attached to it and twines around it by forming thick growths known as appressoria. Sharp pointed haustoria develop from appressoria that enable the parasite to draw organic and mineral matter from its host. The ability to form specialized organs for absorption, i.e. haustoria, is the chief adaptive character of all higher parasitic plants (Hibberd & Jeschke, 2001). Obligate parasites are unable to develop without assimilates drawn from their host plants because they are either unable to perform photosynthesis (Kujit, 1969; Losner-Goshen et al., 1998) or their photosynthetic capacity is very small (Hibberd & Jeschke, 2001). Even though dodder plants possess a functional photosynthetic apparatus within a ring of cells surrounding vascular tissue (Hibberd & Jeschke, 2001) the amount of organic matter produced there is too small to provide for the plant, so that 99% of the required carbon is still drawn from the host (Jeschke et al., 1994). Holoparasites are believed to use primarily products conducted through the phloem but their haustoria reach into the xylem too for nutrients such as calcium, which is deficient in the phloem. However, field dodder has been reported to get not only organic matter from its host through the phloem but minerals too, such as nitrogen, magnesium and calcium, although they are to be found in greater amounts in the xylem than in the phloem (Hibberd & Jeschke, 2001). Field dodder parasitism interferes with the balance of contents of nitrogen, phosphorus, potassium, organic and inorganic matter in the host plant (e.g. alfalfa or sugar beet) (Sarić-Krsmanović et al., 2013a). It exhausts the host plant, so that it becomes weak, its lushness of growth declines, and fruit and seed maturation become significantly thwarted (Wolswinkel, 1974). Also, host plants change their habit as their axillary buds sometimes become suppressed (Tsivion, 1981), and damage may expand into total plant destruction. Significant changes can be detected in plant morphology and anatomy, so that field dodders cause changes in stalk anatomy (epidermis, cortex, pith or diameter) and leaves (upper epidermis, palisade tissue, spongy tissue, leaf mesophyll, underside epidermis or vascular bundle cells) of host plants (Sarić-Krsmanović et al., 2012; Matković et al., 2012). At an appropriate moment during maturation, field dodder plants form inflorescences with abounding hermaphrodite and actinomorphic flowers. The seeds of this parasitic flowering plant germinate on soil surface from May throughout June. Field dodder is a thermophylic species and its optimal temperature for germination is 30°C (Sarić-Krsmanović et al., 2013b). Its seeds retain vitality in soil over 10 years or more. A single plant is able to form up to 15.000 seeds, and their abundance constitutes the main mode of survival of that parasite in the environment (Benvenuti et al., 2005). Its reproduction may also be vegetative through segmentation of its tread-like stem. Such reproduction mode is frequent in alfalfa and clover crops after harvests and haying, and transfer from infested plots to noninfested fields (Babović, 2003).

The field dodder is a parasite with a wide spectrum of hosts. Most field dodders are polyphagous species, parasitizing cultivated crops (e.g. *Medicago sativa*, *Beta vulgaris*, *Allium cepa*, *Allium sativum*, *Capsicum annum*, *Cucumis sativus*, *Cucurbita pepo*, *Daucus carota*, *Lactuca sativa*, *Lycopersicum esculentum*, *Nicotiana tabacum*) as well as weed and wild flora (e.g. *Amaranthus retroflexus*, *Polygonum aviculare*, *Chenopodium album*, *Ambrosia artemisiifolia*, *Matricaria chamomilla*, *Solanum nigrum*, *Xanthium strumarium*) (Kojić & Vrbničanin, 2000; Rančić & Božić, 2004, Vrbničanin et al., 2013).

About 10 *Cuscuta* species have been detected in Serbia, including the most frequent *Cuscuta campestris* (Kojić & Vrbničanin, 2000).

DAMAGE CAUSED BY FIELD DODDER

Apart from an immediate damage caused by reducing the biological yields of plants parasitized by field dodder, indirect forms of damage are also frequently considered: (1) livestock fed on hay (fresh biomass of legumes, primarily alfalfa and clover) containing 50-60% field dodder lose weight, (2) miscarriages are more frequent, (3) indigestion occurs, (4) dodder consumption in bulk feed causes diarrhea, vomiting, palpitation and heavy breathing in rabbits and horses (Movsesyan & Azaryan, 1974), (5) some *Cuscuta* species carry viruses, thus causing additional difficulties for crop growing and indirectly reducing yields. Besides its role of a vector of diseases, it may also itself be the host of viruses, such as the cucumber mosaic virus or tobacco rattle virus (Marcone et al., 1999).

Its widespread geographic distribution and a wide range of hosts make field dodder one of the most widespread and damaging flowering parasites (Parker & Riches, 1993). Problems with field dodder occur in vegetable nurseries (e.g. tomato, pepper, cabbage) and in greenhouses. Field dodder has also been recognized as a growing problem in sugar beet crops over the past few years (Sarić-Krsmanović & Dobriković, 2012). Lanini (2004) reported an up to 75% yield reduction from tomato infested with field dodder. Several other studies have shown that field dodder is able to reduce carrot yield from 70 to 90% (Bewick et al., 1988). It also causes considerable problems in onion (*Allium cepa*) crops as its control is difficult because there are no available herbicides with adequate selectivity to protect that crop (Rubin, 1990). Damage is primarily caused through increased volumes of unmarketable bulbs and roots (i.e. their size, form and weight). Cranberry infested with *Cuscuta gronovii* is known to sustain up to 50% yield loss (Bewick et al., 1988).

Field dodder is able to cause the most intensive damage in newly-formed perennial legume (alfalfa or clover) crops, which are the most frequent targets of dodder parasitism (Dawson et al., 1994). Damage done in these crops consists mainly of reduced fresh biomass yield, which may be upwards of 50%, and significantly reduced seed production by seed alfalfa (Cudney et al., 1992). Dawson (1989) reported a yield loss of 57% in an alfalfa crop artificially infested with *C. campestris* in Prosser, Washington (USA) over a period of two years. Two years later, potato was sawn in the same location and the crop was totally destroyed by field dodder (Dawson et al., 1994). Mishra (2009) reported some 60% yield reduction in alfalfa infested with *C. campestris*. Some other legumes, e.g. beans, have shown different levels of sensitivity to dodder parasitism. Bean crops have demonstrated tolerance of the presence of *Cuscuta chinesis* (Rao & Reddy, 1987), while being sensitive to *C. lupuliformis* (Liu et al., 1991). Conversely, *Cuscuta chinesis* has been reported to cause considerable damage to soybean (Li, 1987). Stojanović and Mijatović (1973) reported a yield reduction of around 80% in alfalfa infested with *C. campestris*, and some 20% in red clover. Furthermore, Stojšin et al. (1992) recorded major losses in sugar beet crops in Serbia, estimating them at around 40%, while sugar content decreased between 1.3 and 2.6%. In Khirghistan, *C. campestris* has been reported to cause a significant reduction in sugar beet yield, around 4 t/ha, and sugar content to 1.5-1.9% (Belyaeva et al., 1978). Serious problems have also been reported in sugar beet crops in Slovakia, where an average yield loss of some 37% was reported in the 2002-2004 period, while sugar content reduction was around 12% (Tóth et al., 2006).

Ornamentals make another group of frequent hosts of this parasitic flowering plant, which rarely destroys them totally but the weakness caused by parasitism creates threats from other harmful organisms, primarily insects and various pathogens. Significant damage has been reported lately on *Capsicum frutescens* (hot pepper) in Pakistan, where the crop has high economic value because it is used both for diet and medical purposes (Mukhtar et al., 2011).

CONTROL OPTIONS

Based on the importance of field dodder and damage that it is able to cause, it has been categorized as a quarantine plant parasite in many countries, and in Serbia too (IA List, 2010), making its suppression mandatory throughout the country. Attention should primarily focus on field crops. Control of field dodder should commence as soon as initial points of infestation have been observed, and completed before dodder plants begin to flower and set seeds. Once its seeds have fallen on the ground the species becomes a permanent threat to crops. Various options for control of field dodder are available, beginning with preventive steps (by using pure seeding material or tolerant cultivars), to physical removal (by mowing or hand weeding) to herbicide treatements.

PREVENTIVE CONTROL OF FIELD DODDER

Preventive control is one of the most important and fundamental activities in any field dodder control strategy, which focuses primarily on prevention of plot infestation by: (1) cleaning all nearby plots; (2) cleaning field margins; (3) cleaning waste grounds;

(4) destroying weeds parasitized by field dodder; (5) maintaining irrigation canals dodder-free; (6) spreading rotted manure; (7) hand weeding dodder plants in small areas, taking good care of the removed plants because dodder seedlings are able to survive only a few days without a host, while fully developed plants removed with their hosts are able to retain freshness up to a couple of weeks; (8) checking on potentially infestable crops at 15 days intervals to detect infestation in an early stage and take adequate control measures; (9) long-term crop rotation; once the presence of field dodder seeds in soil has been detected, such plots should not be used for cultivation of known dodder hosts for a minimum of 4-5 years. Crop rotation is an important preventive measure even though it may be difficult to find an adequate replacement for some crops and so avoid dodder parasitism in that new crop (Parker, 1991). Cereals are considered suitable rotation crops as they have not been observed to host *Cuscuta* species (Dawson, 1987; Dawson et al., 1994).

Postponement of sawing or replanting is also considered an important preventive measure. Lanini (2004) found that later replanting of older tomato plantlets made it difficult for dodder plants to attach to them because stalk tissue of such plants had already lignified. However, this measure is often considered a poor choice because it delays yield. Also, early crop sowing in combination with irrigation enables faster development of the cultivated plants, while field dodders will not germinate at low temperatures. Fast crop growth and its greater density make dodder germination more difficult because it requires high temperatures, as well as good irradiation (Dawson et al., 1994).

Differences in the tolerance of host plants to various *Cuscuta* species have been reported but they have not been studied in detail. Al-Menoufi and Ashton, (1991) detected different levels of tolerance of four wild *Lycopersicon* species to *C. pentagona*. Similar data were collected by Löffler et al. (1995) in a study of relationships between *Cuscuta reflexa* and as many as 30 varieties of tomato, which showed their significant level of tolerance to the parasite. The examined tomato cultivars were found to undergo changes in epidermis, hypodermis and collenchyma, forming necrotic tissue around points of haustoria penetration and thus preventing its further progress. Ihl and Miersch (1996) observed a similar level of tolerance of 22 tomato cultivars to four *Cuscuta* species: *C. reflexa*, *C. japonica*, *C. odorata* and *C. europaea*. All those tomato cultivars reacted with hypersensitiveness of epidermal cells on their stalks and tissue necrotization, which stopped haustoria penetration. Necrosis of the upper cell layer was accompanied by increased peroxidase activity, which was a further obstacle to haustoria penetration into the conducting tissue of the host. However, different levels of tolerance of some tomato cultivars greatly depend on the virulence of different *Cuscuta* populations. Goldwasser et al. (2001) and Lanini (2004) confirmed different tolerance levels of 33 commercial tomato cultivars to a highly virulent population of *C. pentagona*. So far, six commercial tomato cultivars (Heinz 9492, Heinz 9553, Heinz 9992, Heinz 9888, Heinz 1100 and Campbells CXD 233) have been confirmed tolerant to several species of the genus *Cuscuta*. Some of the species manage to survive on their tomato hosts without causing them significant damage. The cultivars had been created to be primarily tolerant to bacterial cancer (*Clavibacter michiganensis subs. michiganesis*), which may have also created their tolerance to field dodder (Goldwasser et al., 2001; Lanini, 2004).

BIOLOGICAL CONTROL OF FIELD DODDER

Parker (1991) tried to use certain phytopathogenic fungi, bacteria and insects for biological control of several *Cuscuta* species. Bewick et al. (1987) found several phytopathogenic fungi, including *Fusarium tricinctum* and *Alternaria* spp., to cause some damage to *C. gronovii*, while *A. alternata* and *Geotrichum candidum* were harmful to *C. pentagona*. Besides, Li (1987) reported that a conidial suspension of *Colletotrichum gloeosporioides* could be used for selective control of the species *C. chinensis* and *C. australis* in soybean crops. Bewick et al., (2000) used *Alternaria destruens* to control *C. gronovii* in fields of cranberry (*Vaccinium macrocarpon*) and carrot (*Daucus carota*), and reduced it up to 90%. However, the results of similar efforts to control *C. pentagona* in the same crops were not nearly as successful in the warm and dry climate of California (Lanini, 2004). Sarić and Božić (2009) and Sarić et al. (2009) tested the influence of soil microorganisms (PGPR- Planth Growth Promoting Rhizobacteria) on the germination of field dodder (*Cuscuta campestris* Yunk.) and used the bacterial cultures of: *B. licheniformis*, *B. pumilus* and *B. amyloliquefaciens* isolated from manure; *B. megatherium* ZP6 isolated from maize rhizosphere; and *A. chroococcum* Ps1 from wheat rhizosphere. The results inferred that bacterial cultures of the genus *Bacillus* had different degrees of inhibitory effects on field dodder germination.

Conversely, the bacterial culture *A. chroococcum* Ps1 had a stimulating effect on seed germination of that flowering parasite.

CHEMICAL CONTROL OF FIELD DODDER

As a result of haustoria penetration and the formation of a closed host-parasite association it is believed that only strongly selective herbicides are effective enough in destroying the parasite without hurting the host (Fer, 1984). Studies have mostly been focused on chemical methods of field dodder control (Dawson, 1984, 1987; Parker, 1991; Parker & Riches, 1993). Some researchers have reported better results of herbicide treatments before the parasite has attached to its hosts (Cudney et al., 1992; Dawson, 1990a; Orloff & Cudney, 1987). Herbicide treatments prior to dodder attachment are conducted to avoid such attachment and so prevent even the least damage (Parker, 1991). Dinitroaniline herbicides have been used for preventive control of field dodder in alfalfa crops (Orloff & Cudney, 1987). Pendimethalin, one of such herbicides, has been found far more effective than trifluralin because its effect is more durable. But trifluralin may also be used as a selective herbicide for control of *C. indecora* and *C. pentagona* in alfalfa crops. It is used in granular formulation that stays close to soil surface in which dodder seeds are expected to germinate. Liquid formulation of trifluralin has not produced such good results in controlling these species in tomato. Pendimenthalin may also be used for selective control of field dodder in carrot, onion and alfalfa (Orloff & Cudney, 1987). Pendimenthalin is less transportable than trifluralin but rainfall and irrigation certainly facilitate its faster incorporation and activity in soil (Parker & Riches, 1993). Foschi and Rapparini (1977) used ethofumesate to control field dodder in sugar beet. As the selection of herbicides available for control of field dodder in sugar beet is very restricted, soil herbicides are often used, but practice has revealed their rather poor effects on field dodder. Conversely, propyzamide has been identified as a sound solution for field dodder control in sugar beet, depending on infestation intensity (Sarić-Krsmanović & Dobriković, 2012). Orloff and Cudney (1987) conducted similar research and both studies showed rather weak effects of that herbicide. The low water potential of field dodder is assumed to restrict movement of herbicides through the xylem, which is another reason why soil herbicides are less effective against this parasitic plant (Fer, 1984). Fer (1984) found that xylem-conducted compounds move and become accumulated mostly in organs of the host plants with higher water potential (transpiration) and may so harm the host plant more than the parasite. Liu and Fer (1990) found that the weakly transportable pendimenthalin herbicide applied in beans was not moving fast enough along transpiration pathway to control field dodder plants, while its foliar application resulted in its nearly 60%accumulation in parasite tissue.

Treatments with post-emergence herbicides, which are translocated through the host phloem, enable their selective uptake by dodder plants owing to the parasite's ability to draw nourishment from the host phloem by transfers of solutions that occur as a result of different water potentials of cell sap in the host and the parasite (Fer, 1984; Nir et al., 1996; Shlevin & Golan, 1982). Herbicides conducted through the phloem should selectively accumulate in the parasite plant because of its stronger uptake (Nir et al., 1996). Liu and Fer (1990) reported that foliar application of glyphosate led to its 26-fold higher accumulation in the apical part of field dodder plants than in the root and young leaves of their hosts. Bewick et al. (1991) used ^{14}C-labelled glyphosate in carrot infested with *C. pentagona* and found that significantly greater amounts were accumulated in the parasite tissue than in any part of the host plant. Dawson (1990b) reported similar good results after applying glyphosate in alfalfa, and Mishra et al. (2004) after treatment of black gram [*Vigna mungo* (L.) Hepper]. Besides, glyphosate has been found effective in controlling *Cuscuta monogyna* Vahl. on the woody species *Punica granatum* L. (Bewick et al., 1988). Sarić-Krsmanović et al. (2015) found that glyphosate applied at the rates of 288 and 360 g a.i. ha significantly reduced field dodder in alfalfa crop. Shawn et al. (2008) conducted a two-year study in which all application rates (140-1,120 g a.i. ha) had high effectiveness of >84% in controlling field dodder on ornamental plants. In some other crops, however, even low amounts of glyphosate are able to harm the host (Orloff & Cudney, 1987), which prevents adequate control of the parasite (Frolisek, 1987).

Several herbicides classified as ALS inhibitors have proved themselves effective in controlling field dodder. Post-emergence treatment with imazethapyr is able to reduce significantly the number of dodder seedlings in alfalfa (Cudney & Lanini, 2000). Rimsulfuron applied in tomato crops also controls field dodder (Mullen et al., 1998). Furthermore, imazethapyr treatment in an infested carrot crop has been found to cause less damage than its application in non-infested crop, which again points at the potentials of exploiting the low translocation rates of non-selective herbicides for selective control of parasite weeds (Nir et al., 1996). However, Sarić-Krsmanović et al. (2015) found imazethapyr to have a weak effect on field dodder heavily infesting alfalfa as 78-95% of dodder plants remained after treatment (imazethapyr, 150 g a.i. ha).

The fact that carotenoid pigment lends field dodder stalks their orange colour and its role as an auxiliary pigment is to absorb light and transfer it to chlorophyll, thus protecting it from oxidation, was used by Weinberg et al. (2003) in studying the effect of herbicides that prevent carotenoid biosynthesis in *C. campestris*. β-carotene is considered to have a significant role in maintaining membrane amyloplasts, and its decrease therefore results in amyloplast destruction and decrease in starch contents (Weinberg et al., 2003). Flurochloridone caused bleeching effects merely two days after application but failed to inhibit stem elongation, and a full pigment recovery from the application of this herbicide occurred after six days. In contrast, sulcotrione and mesotrione slowed down the recovery (Weinberg et al., 2003) but it occurred nevertheless.

Introduction of transgenic crops that are tolerant to phloem-transported broad-spectrum herbicides has inspired some researchers (Nadler-Hasser & Rubin, 2003; Nadler-Hasser et al., 2004) to try to use them for control of field dodder. However, Nadler-Hasser and Rubin (2003) found that field dodder was not reduced by glyphosate when it was applied to a transgenic sugar beet crop. Sulfometuron had the same effect in a tomato crop tolerant to that herbicide. Similar data have been reported after control trials of *C. campestris* in glyphosate-tolerant tobacco (Nadler-Hasser et al., 2004).

Cudney et al. (1992), Cudney and Lanini (2000), and Sarić-Krsmanović et al. (2015) also examined the effects of non-selective contact herbicides, such as paraquat and diquat, in controlling field dodder in alfalfa and red clover. Control results were good but the host crops were also greatly affected, so that their use is meaningful only in small areas of infestation.

CONCLUSION

Successful control of field dodder requires a systematic approach of the integrated protection program that begins with dodder monitoring in crops, as well as ruderal areas, and includes adequate crop rotation, planned growing of crops that are not suitable hosts to field dodder, a variety of preventive measures and physical removal, the use of tolerant cultivars and biological agents, as well as treatments with herbicides when the problem cannot be solved any other way.

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REFERENCES

Al-Menoufi, O. A., & Ashton, F.M. (1991). Susceptibility and resistance of some Lycopersicon species to *Cuscuta pentagona* infection (p. 293-297). In J.K. Ransom, L.J. Musselman, A.D. Worsham and C. Parker (eds.) *Proceedings of the 5th International Symposium of Parasitic Weeds "Studies on the parasitism of Cuscuta spp."* (Series 8). Nairobi, Kenya: CIMMYT.

Babović, M.V. (2003). *Osnovi patologije biljaka*. Beograd: Poljoprivredni fakultet.

Belyaeva, A.V., Cherkasova, A.P, Shapnova, L.G., & Alfomova, R.A. (1978). Maleic hydrazide aganist dodder. *Sakharnaya Svekla*, *23*, 37-39.

Benvenuti S, Dinelli G, Bonetti A, & Catizone P. (2005). Germination ecology, emergence and host detection in *Cuscuta campestris*. *Weed Research*, *45,* 270-278.

Bewick, T.A., Binning, L.K., & Balke, N.E. (1991). Absorption and translocation of glyphosate by carrot infected by swamp dodder. *Journal of the American Society for Horticultural Science*, *116*(6), 1035-1039.

Bewick, T.A., Binning, L.K., & Dana, M.N. (1988). Postattachment control of swamp dodder (*Cuscuta gronovii*) in cranberry (*Vaccinium macrocarpon*) and carrot (*Daucus carota*). *Weed Technology*, *2*, 166-169.

Bewick, T.A., Binning, L.K., Stevenson, W.R., & Stewart, J. (1987). A mycoherbicide for control of swamp dodder (*Cuscuta gronovii* Willd) Cuscutaceae. In H.C. Weber & W. Forstreuter (eds.), *Proceedings of 4th International Symosium on Parasitic Flowering Plants* (pp. 93-104). Marburg, Germany: Phillips Universitat.

Bewick, T.A., Porter, J.C., & Ostrowski, R.C. (2000). Field trial results with Smolder: a bioherbicide for dodder control. In *Proceedings of Northeastern Weed Science Society*, (p. 66). Woodstown, NJ: NEWSS.

Cudney, D.W., & Lanini, W.T. (2000). Dodder. In O.C. Maloy and T.D. Murray (eds.), *Encyclopedia of Plant Pathology,* Volume I (pp. 376-379.). New York, NY: John Wiley & Sons, Inc.

Cudney, D.W., Orloff, S.B., & Reints, J.S. (1992). An integrated weed management for the control of dodder (*Cuscuta indecora*) in alfalfa (*Medicago sativa*). *Weed Technology*, *6*, 603-606.

Dawson, J.H. (1984). Control of *Cuscuta* in alfalfa - a review. In C. Parker, L.J., Musselman, R.M., Polhill and A.K., Wilson (eds.), *Proceedings of the 3rd International Symposium on Parasitic Weeds* (pp. 188-199). Aleppo, Syria: International Center for Agricultural Research in Dry Areas (ICARDA).

Dawson, J.H. (1987). *Cuscuta* (Convolvulaceae) and its control. In H.C. Weber & W. Forstreuter (eds.), *Proceedings of 4th International Symposium on Parasitic Flowering Plants* (pp. 137-149). Marburg, Germany: Phillips Universitat.

Dawson, J.H. (1989). Dodder (*Cuscuta* spp.) control in established alfalfa (*Medicago sativa*) with glyphosate and SC-0224. *Weed Technology*, *3*, 552-559.

Dawson, J.H. (1990a). Dodder (*Cuscuta* spp.) control with dinitroaniline herbicides in alfalfa (*Medicago sativa*). *Weed Technology*, *4*, 341-348.

Dawson, J.H. (1990b). Dodder (*Cuscuta* spp.) control in newly seeded alfalfa (*Medicago sativa*) with glyphosate. *Weed Technology*, *4*, 880-885.

Dawson, J.H., Musselman, L.J., Wolswinkel, P., & Dörr, I. (1994). Biology and control of *Cuscuta*. *Reviews of Weed Science*, *6*, 265-317.

Fathoulla, C.N., & Duhoky, M.M.S. (2008). Biological and anatomical study of different *Cuscuta* species (Kurdistan 1st Conference on Biological Sciences). *Journal of Dohuk University, 11*(1), 22-39.

Fer, A. (1984). Physiological approach to the chemical control of *Cuscuta*: experiments with l C-labelled herbicides. In C. Parker, L.J. Musselman, R.M. Polhill and A.K. Wilson (eds.), *Proceedings of the 3rd International Symposium on Parasitic Weeds* (pp. 164-174). Aleppo, Syria: International Center for Agricultural Research in Dry Areas (ICARDA).

Foschi, S., & Rapparini, G. (1977). The control of *Cuscuta campestris* L.Yunck. and *Cuscuta europaea* L. In *Proceedings of the European Weed Research Society symposium „The different methods of weed control and their integration"* (pp. 129-137). Uppsala, Sweden: EWRS.

Frolisek, M. (1987). Results of our studies on dodder (*Cuscuta* spp.) control in lucerne (*Medicago sativa* L.) in Czechoslovakia. In H.C. Weber & W. Forstreuter (eds.), *Proceedings of 4th International Symposium on Parasitic Flowering Plants* (pp.231-240), Marburg, Germany: Phillips Universitat.

Goldwasser, Y., Lanini, W.T., & Wrobel, R.L., (2001). Tolerance of tomato varieties to lespedeza dodder. *Weed Science*, *49*, 520-523.

Hibberd, J.M., & Jeschke, W.D. (2001). Solute flux into parasitic plants. *Journal of Experimental Botany*, *52*, 2043-2049.

Holm, L., Doll, J., Holm, E., Pancho, J.V., & Herberger, J.P. (1997). *World weeds: Natural histories and distribution*. New York, NY: John Wiley.

IA List, part II (2010). Retreived from *Official Gazette of the Republic of Serbia* at http://www.mpzzs.gov.rs [In Serbian].

Ihl, B., & Miersch, I. (1996). Susceptibility and resistance of *Lycopersicon* to infection by *Cuscuta*. In M. T. Moreno, J. I. Cubero, D. Berner, D. Joel, L. J. Musselman and C. Parker (eds), *Advances in parasitic plant research* (pp. 600-605). Cordoba, Spain: Direccion General de Investigation Agraria.

Jeschke, W.D., Baumel, P., Rath, N., Czygan, F., & Proksch, P. (1994). Modelling of the flows and partitioning of carbon and nitrogen in the holoparasite *Cuscuta reflexa* Roxb. and its host *Lupinus albus* L. II. Flows between host parasite and within the parasitized host. *Journal of Experimental Botany*, *45*(6), 801-812.

Kojić, M., & Vrbničanin, S. (2000). Parazitski korovi - Osnovne karakteristike, taksonomija, biodiverzitet i rasprostranjenje, I: Vilina kosica (*Cuscuta* L.). *Acta herbologica*, *9*(1), 21-27.

Koskela, T., Salonen, V., & Mutikainen, P. (2001). Interaction of a host plant and its holoparasite: effects of previous selection by the parasite. *Journal of Evolutionary Biology*, *14*(6), 910-917.

Kujit, J. (1969). *The biology of parasitic flowering plants*. Barkeley, CA: University of California Press.

Lanini, T. (2004). Economical methods of controlling dodder in tomatoes. *Proceedings of the California Weed Science Society*, *56*, 57-59.

Li, Y. (1987). Parasitism and integrated control of dodder on soybean. In H.C. Weber & W. Forstreuter (eds.), *Proceedings of 4th International Symposium on Parasitic Flowering Plants* (pp. 497-500). Marburg, Germany: Phillips Universitat.

Liu, Z.O., & Fer, A. (1990). Influence d'un parasite (*Cuscuta lupuliformis* Krock.) sur la redistribution de deux herbicides systemiques appliques sur une Legumineuse (*Phaseolus aureus* Roxb.). *Comptes Rendus de l'Academie des Sciences. Paris*, *311,* 333-339.

Liu, Z.O., Fer, A., & Lecoco, F.M. (1991): L'imazaquine: un herbicide prometteur pour la lutte curative contre la cuscute (*Cuscuta* spp.) dans les cultures de soja (*Glycine max*). *Weed Research*, *31*, 33-40.

Löffler, C., Sahm, A., Wray, V., Czygan, F.C., & Proksch, P. (1995). Soluble phenolic constituents from *Cuscuta reflexa* and *Cuscuta platyloba*. *Biochemical Systatics and Ecology*, *23*, 121-128.

Losner-Goshen, D., Portnoy, V.H., Mayer, A.M., & Joel, D.M. (1998). Pectolytic activity by the haustorium of the parasitic plant *Orobanche* L. (Orobanchaceae) in host roots. *Annals of Botany*, *81*(2), 319-326.

Marcone, C., Hergenhahn, F., Ragozzino, A., & Seemüller, E. (1999). Dodder transmission of pear decline, European stone fruit yellows, Rubus stunt, Picris echioides yellows and cotton phyllody phytoplasmas to periwinkle. *Journal of Phytopathology*, *147*(3), 187-192.

Matković, A., Božić, D., Radošević, R., & Sarić-Krsmanović, M. (2012). Uticaj viline kosice (*Cuscuta campestris* Yunck.) na anatomsku građu stabla lucerke (*Medicago sativa* L.) u uslovima sa i bez primene herbicida. In *Zbornik rezimea radova XIV simpozijum o zaštiti bilja i IX kongres o korovima*, Zlatibor (str. 150). Beograd, Srbija: Društvo za zaštitu bilja Srbije.

Mishra, J.S. (2009). Biology and management of *Cuscuta* species. *Indian Journal of Weed Science*, *41*, 1-11.

Mishra, J.S., Bhan, M., Moorthy, B.T.S., & Yaduraju, N.T. (2004). Bio-efficacy of herbicides against *Cuscuta* in blackgram (*Vigna mungo* (L.) Hepper). *Indian Journal of Weed Science*, *36*, 278-279.

Movsesyan, T.B., & Azaryan, K.A. (1974). Poisoning produced by feeding dodder (*Cuscuta campestris*) to animals. *Veterinariya* (Moscow), *6*, 92.

Mukhtar, I., Khokhar, I., & Mushtaq, S. (2011). *Cuscuta campestris* Yunk., a new pest of *Capsicum frutescens* L. (hot chilli) in Lahore-Pakistan. *Pakistan Journal of Weed Science Research*, *17*(1), 103-110.

Mullen, R.J., Orr, J.P., Viss, T.C., & Whiteley, S.W. (1998). A three year study on dodder management with rimsulfuron in processing tomato. *Proceedings of the Western Society of Weed Science*, *51*, 76-78.

Nadler-Hassar, T., Goldshmidt, A., Rubin, B., & Wolf, S. (2004). Glyphosate inhibits the translocation of green fluorescent protein and sucrose from a transgenic tobacco host to *Cuscuta campestris* Yunk. *Planta*, *219*, 790-796.

Nadler-Hassar, T., & Rubin, B. (2003). Natural tolerance of *Cuscuta campestris* to herbicides inhibiting amino acid biosynthesis. *Weed Research*, *43*(5), 341-347.

Nickrent, D.L. (2002). Plantas parásitas en el mundo. Part 2, In J.A. López-Sáez, P. Catalán and L. Sáez (eds.), *Plantas Parásitas de la Península Ibérica e Islas Baleares* (pp. 7-27). Madrid, Spain: Mundi-Prensa Libros, S.A.

Nir, E., Rubin, B., & Zharasov, S.W. (1996). On the biology and selective control of field dodder (*Cuscuta campestris*). In M. T. Moreno, J. I. Cuberu, D. Berner, D. Joel, L.J. Musselman and C. Parker (eds.) *Advances in Parasitic Plant Research* (pp. 809-816). Cordoba, Spain: Direccion General de Investigation Agraria.

Orloff, S. B., & Cudney, D.W. (1987). Control of dodder in alfalfa with dinitroaniline herbicides. *Proceedings of the Western Society of Weed Science*, *40*, 98-103.

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

Parker, C., & Riches, C.R. (1993). *Parasitic weeds of the world: Biology and control*. Wallingford, UK: Cab International.

Rančić, D., & Božić, D. (2004). Uticaj viline kosice (*Cuscuta* sp.) na troskot (*Polygonum aviculare* L.). *Acta herbologica*, *13,* 167-172.

Rao, P. N., & Reddy, A. R. S. (1987). Effect of china dodder on two pulses: green gram and cluster bean - the latter a possible trap crop to manage china dodder. In H.C. Weber & W. Forstreuter (eds.), *Proceedings of 4th International Symposium on Parasitic Flowering Plants* (pp. 665-674). Marburg, Germany: Phillips Universitat.

Rubin, B. (1990). Weed competition and weed control in *Allium* crops. In H.D. Rabinowitch and J.L. Brewster (eds.), *Onions and Allied Crops* (Vol. II, p. 63-84). Boca Raton, FL: CRC Press Inc.

Sarić, M., & Bozić, D. (2009). Uticaj zemljišnih bakterija na klijanje semena viline kosice (*Cuscuta campestris* Yunck.) i lucerke. *Zaštita bilja*, *60*, 227-236.

Sarić, M., Vrbničanin, S., Božić, D., & Raičević, V. (2009). Effect of plant growth-promoting rhizobacteria on the germination of *Cuscuta campestris* Yunck. In *Proceedings of 10th World Congress of Parasitic Plants,* Kusadasi (p. 73). Kusadasi, Turkey: IPPS and Ege University.

Sarić-Krsmanović, M., Božić, D., Kresović, M., Radivojević, Lj., & Vrbničanin, S. (2013a). Effect of *Cuscuta campestris* on the nitrogen, phosphorus and potassium content in alfalfa and sugar beet. In *Programme and Abstracts of the 1st International Conference on Plant Biology, 20th Symposium of the Serbian Plant Physiology Society,* Subotica (p 83). Belgrade, Serbia: SPPS.

Sarić-Krsmanović, M., Božić, D., Malidža, G., Radivojević, Lj., Gajić Umiljendić, J., & Vrbničanin, S. (2015). Chemical control of field dodder in alfalfa. *Pesticides and Phytomedicine, 30*(2), 107-114.

Sarić-Krsmanović, M., Božić, D., Pavlović, D., Radivojević, Lj, & Vrbničanin, S. (2013b). Temperature effects on *Cuscuta campestris* Yunk. seed germination. *Pesticides and Phytomedicine*, *28(3),* 187-193.

Sarić-Krsmanović, M., & Dobriković, D. (2012): Vilina kosica i mogućnosti suzbijanja u usevu šećerne repe. *Biljni lekar*, *40*(5), 400-406.

Sarić-Krsmanović, M., Rančić, D., Radivojević, Lj. (2012): Morfološke, anatomske i fiziološke promene na lucerki i šećernoj repi napadnutim vilinom kosicom (*Cuscuta campestris* Yunck.). In *Zbornik rezimea radova XIV simpozijum o zaštiti bilja i IX kongres o korovima,* Zlatibor (pp. 130-131). Beograd, Srbija: Društvo za zaštitu bilja Srbije.

Shawn, M.H., Wiecko, G., & Knezevic, Z.S. (2008). Glyphosate dose affected control of field dodder (*Cuscuta campestris*) in the tropics. *Weed Technology*, *22*(1), 151-155.

Shlevin, E., & Golan, D. (1982). Selective control of dodder in carrots. *Phytoparasitica*, *10*(4), 267.

Stojanović, D., & Mijatović, K. (1973). Distribution, biology and control of *Cuscuta* spp. in Yugoslavia. In *Proceedings of EWRC Symposium on Parasitic Weeds*, Malta (pp. 269-279). Wageningen, Netherlands: EWRC.

Stojšin, V., Marić, A., & Jocić, B. (1992). Harmfulness of *Cuscuta campestris* Yunck. on sugar beet under varying mineral nutrition. *Zaštita bilja*, *42*(4), 357-363.

Swift, C. (1996). *Cuscuta* and Gramica species - dodder a plant parasite. Fort Collins, CO: Colorado State University Cooperative Extension.

Tóth, P., Tancik, J.J., & Cagáň, L. (2006). Distribution and harmfulness of field dodder (*Cuscuta campestris* Yuncker) at sugar beet fields in Slovakia. *Zbornik Matice srpske za prirodne nauke*, *110*, 179-185.

Tsivion, Y (1981). Suppression of axillary buds of its host by parasitizing *Cuscuta* I. Competition among sinks and indirect inhibition. *New Phytologist*, *87*(1): 91-99.

Vrbničanin, S., Malidža, G., Stefanović, L., Elezović, I., Stanković-Kalezić, R., Marisavljević, D., & Gavrić, M. (2008). Distribucija nekih ekonomski štetnih, invazivnih i karantinskih korovskih vrsta na području Srbije, II deo: Prostorna distribucija i zastupljenost devet korovskih vrsta. *Biljni lekar*, 36(6), 408-418.

Vrbničanin, S., Sarić-Krsmanović, M., & Božić, D. (2013): The effect od field dodder (*Cuscuta campestris* Yunck.) on morphological and fluorescence parameters of giant ragweed (*Ambrosia trifida* L.). *Pesticides and Phytomedicine*, *28*(1), 57-62.

Weinberg, T., Lalazar, A., & Rubin, B. (2003). Effects of bleaching herbicides on field dodder (*Cuscuta campestris*). *Weed Science*, *51*(5), 663–670.

Wolswinkel, P. (1974). Complete inhibition of setting and growth of fruits of *Vicia faba* L. resulting from the draining of the phloem system by *Cuscuta* species. *Acta Botanica Neerlandica*, *23*(1), 48-60.

Vilina kosica i mogućnosti njenog suzbijanja

REZIME

Široka geografska rasprostranjenost, kao i širok krug domaćina vilinu kosicu čini jednom od najrasprostranjenijih i najvećih štetočina među parazitskim cvetnicama. Problemi sa vilinom kosicom se javljaju pri proizvodnji rasada povrtarskih biljaka (npr. paradajz, paprika, kupus), kao i u plasteničkoj proizvodnji, usevu krompira, itd. Najveće štete vilina kosica pravi kada se u velikim infestacijama javi na tek zasnovanim višegodišnjim leguminozama (luceništima, deteliništima), koji ujedno spadaju u najčešće parazitirane useve od strane ove parazitske cvetnice. Poslednjih godina primećena je ekspanzija viline kosice, pored lucerke i deteline i u usevu šećerne repe.

Postoje različite mere koje se mogu preduzeti za suzbijanje viline kosice, počev od preventivnih (čist semenski materijal, otporne sorte), preko mehaničkog uklanjanja (košenje, ručno uklanjanje) do korišćenja herbicida. Nijedna od ovih metoda pojedinačno nije stopostotno efikasna, ali se njihovim integrisnjem mogu postići dobri rezultati.

Ključne reči: Vilina kosica; Herbicidi; Suzbijanje