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Scientific paper

The Effect of Field Dodder (*Cuscuta campestris* Yunck.) on Morphological and Fluorescence Parameters of Giant Ragweed (*Ambrosia trifida* L.)

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SUMMARY

The effect of the parasitic flowering plant known as field dodder (*Cuscuta campestris* Yunck.) on morphological and fluorescence parameters of infested giant ragweed (*Ambrosia trifida* L.) plants was examined under controlled conditions. The parameters of chlorophyll fluorescence (Fo, Fv/Fm, Φ_{PSII}, Fv, Fm, ETR and IF) were measured on infested (I) and non-infested (N) *A. trifida* plants over a period of seven days, beginning with the day of infestation. Morphological parameters (plant height, dry and fresh weight) were measured on the last day of fluorescence measurements. *C. campestris* was found to affect the height, fresh and dry weight of the infested *A. trifida* plants, causing significant reduction in plant height and dry weight. Field dodder also affected several parameters of chlorophyll fluorescence (Fo, Fv/Fm, Φ_{PSII} and Fv) in infested *A. trifida* plants.

Keywords: *Cuscuta campestris*; *Ambrosia trifida;* Morphology; Fluorescence

INTRODUCTION

Cuscuta campestris Yunck. is considered the most widespread plant species of the *Cuscuta* genus. Although North America is assumed to be its place of origin, the species is Cosmopolitan and distributed throughout South America, Europe, Asia, Africa and Australia (Holm et al., 1997). The genus *Cuscuta* includes predominantly annual and some perennial nonherbaceous plants with threadlike and twining stems, and leaves reduced to inconspicuous scales. As an obligatory stem parasite, *C. campestris* has only a rudimentary root while its haustoria get attached to the host plant (Swift, 1996); an appressorium is formed at first and then haustoria that penetrate vascular bundles of the host.

Serious damage that field dodder can cause results primarily from the fact that parasitism is the most severe form of negative interaction between vascular plants in which one of the partners moves to heterotrophic nutrition and gets nutrients from the host plant. Dodder-infested plants gradually become weak, lush growth declines and their vegetative and generative yields decrease (Koskela et al., 2001; Fathoulla and Duhoky, 2008). Damage can ultimately lead to total destruction and death of the host. Field dodder causes most damage during massive infestation of recently established leguminous crops (alfalfa or clover) when it challenges the very feasibility of crop production. Problems with field dodder also occur in vegetable nurseries (e.g. tomato, pepper or cabbage), plastic greenhouses, crops such as sugar beet or potato, while hosts of various other species of the *Cuscuta* genus are often weed species, such as *Polygonum aviculare*, *P. persicaria*, *Amaranthus retroflexus*, *Urtica dioica*, *Chenopodium album*, *Cirsium arvense*, *Convolvulus arvensis*, *Ambrosia artemisiifolia*, *Xanthium strumarium*, etc. (Kojić and Vrbničanin, 2000; Rančić and Božić, 2004). The genus *Ambrosia* is a group of invasive weeds and allergenic plants that are widespread across the globe. Species of this genus (e.g. *Ambrosia artemisiifolia*) appeared in this country some 50 years ago and have become a major problem both regarding agricultural purposes and human health as a result of strong allergic reactions that their pollen is able to cause. *Ambrosia trifida* L. is an allochthonous invasive neotophyte, found sporadically in the territory of Serbia (Službeni glasnik R. Srbije, 2010, List IA part II). The latest data have located its foci in central parts of the Bačka region around Kucura, Savino Selo, Ravno Selo and Despotovo, on roadsides in and between villages, as well as around fields and in sunflower, maize, soybean and sugar beet crops (Malidža and Vrbničanin, 2006). During a survey and mapping of allochthonous invasive weeds in Serbia in 2006, the species was not found in the environs of Čoka where Šajinović and Koljadzinski had first detected it in 1982.

As most other *Ambrosia* species, *A. trifida* is also originating in North America (Taramarcaz et al., 2005). It is an annual species exceptionally large in size (exceeding 4 m in height), with branching shoot, large leaf area and weight, allometric sex distribution and high production of large seeds (around 5000 achenes per plant). Considering the damage that *A. trifida* is able to cause, it is necessary to study various measures and develop a strategy for its control. Herbicides and mechanical control (digging, cutting, ploughing or burning) are the most adequate and most frequently chosen forms of control of this invasive species, as well as some other. However, eradication of invasive weeds by herbicide treatments on non-agricultural areas is too costly, while concern for preserving the surrounding vegetation does not provide much opportunity for herbicide treatments. Besides, chemical control is not acceptable on sites close to water sources, and in gardens and yards around housing facilities. Therefore, a strategy of sustainable control of invasive weeds requires methods for their long-term suppression, including biological control. Biological control has so far included the use of insects, mites, microorganisms, nematodes, herbivorous fish, etc. (Petanović et al., 2000). Using *Cuscuta* species to control invasive plants is a new approach that has been developing in China over the past years (Yu et al., 2009; Shen et al., 2011). It has been confirmed that the species *C. campestris* is fit to be used as an agent of control of the exotic species *Mikania micrantha* (Yu et al., 2009; Shen et al., 2011), which is listed as one of the world's 100 most invasive species (Lowe et al., 2001). Yu et al. (2009) based their conclusions about possibilities for its biological control using *C. campestris* on data for coverage and weight of *M. micrantha* infested by this parasite, and on their analysis of N, P and K contents in infested plants. In a similar study monitoring the same parameters, Shen et al. (2011) also included the effect of *C. campestris* on photosynthesis, stomatal conductance, transpiration, chlorophyll content and content of soluble proteins.

In the present study, we focused on examining the effect of *C. campestris* on the invasive weed species *A. trifida* in order to assess its potentials for biological control of *A. trifida*.

MATERIAL AND METHODS

The effect of *C. campestris* on morphological and chlorophyll fluorescence parameters was monitored on infested and non-infested *A. trifida* plants. The latter were grown in plastic pots of 10 cm diameter, each containing two *A. trifida* plants. Several parameters of chlorophyll fluorescence were measured over a period of seven days beginning with the first day of infestation (DI) of host plants. Fluorometer PAM-2100 (Heinz Walz, GmbH, Effeltrich, Germany) was used for all measurements, which were taken at 24 h intervals, and the plants were kept for 2 h in the dark before them. The following parameters were measured directly:

minimal fluorescence (Fo – fluorescence yield in the absence of actinic (photosynthetic) light, i.e. in its basic, non-excited state); maximal fluorescence of darkness-adapted leaf (Fm); ratio of variable and maximal fluorescence (Fv/Fm – maximal fluorescence emitted by photosystem II after absorbing a quantum of light); electron transport rate (ETR); effective fluorescence yield emitted by photosystem II after absorbing a quantum of light (Φ_{PSII}). Two other parameters were computed: intensity of fluorescence (IF) and variable fluorescence (Fv). IF was calculated as a ratio of Ft/Fo, the Ft being the fluorescence yield under light at stable state and Fv a calculated difference between the maximal and minimal fluorescence (Fv=Fm-Fo). On the last day of fluorescence measurements, the height and fresh weight of plants were also measured. Dry weight was measured after keeping the plants in a drying chamber for 72 h at 60°C. All parameters were measured in four replications and the trial was repeated twice.

Data were processed by the STATISTICA® 8.0 software package and average and standard deviation (SD) values were calculated for each parameter. T-test was used to determine significant differences between the infested and non-infested plants for each of the analysed parameters.

RESULTS AND DISCUSSION

The effect of *Cuscuta campestris* on morphological parameters of infested *Ambrosia trifida* plants

C. campestris has been shown in earlier studies to have a significant effect on weight, flower production and yield of host plants, as well as on their general physiological state (Deng et al., 2003; Zan et al., 2003). Also, some researchers have concluded that parasitic flowering plants of the genus *Cuscuta*, most especially *C. campestris* Yunck., *C. chinensis* Lam. and *C. australis* R. Br., can significantly reduce their host's growth (Liao et al., 2002; Zan et al., 2003; Zhang et al., 2004). Similar data emerged in our own research as *C. campestris* was found to change the height, fresh weight and dry weight of above-ground stems of *A. trifida* (Table 1). All three morphological parameters (plant height, and fresh and dry weight) had higher values in non-infested (14.23±2.80 cm; 2.15±0.51 g; 0.68±0.20 g) than in infested plants (8.85±1.38 cm; 1.80±0.48 g; 0.47±0.11 g). Statistical analysis of these data detected significant differences (p<0.05) in height and dry weight between non-infested and infested *A. trifida* plants, while the effect of *C. campestris* on fresh weight was not statistically significant (p>0.05) (Table 2). Jeschke et al. (1994, 1997) had found that *Coleus blumei* and *Lupinus albus* parasitized by *Cuscuta reflexa* had much lower weights than non-infested plants. Similar results were later reported by Shen et al. (2005), who measured for 40-50 days the stem/root weight ratio in *Mickania micrantha* plants non-infested and infested by *C. campestris*, and detected significant differences. Other comparable data had been reported by Watling and Press (1997) after investigating the effect of *Striga hermonthica* and *S. asiatica* on *Sorghum bicolor*.

Table 1. The effect of *C. campestris* on morphological parameters of *A. trifida* plants

Parameter	Non-infested *A. trifida* plants	Infested *A. trifida* plants
Plant height (cm)	14.23±2.80	8.85±1.38
Plant fresh weight (g)	2.15±0.51	1.80±0.48
Plant dry weight (g)	0.68±0.20	0.47±0.11

Table 2. Significant differences in morphological parameters between non-infested and infested *A. trifida* plants

Parameter	Non-infested : Infested
Plant height (cm)	0.001756 **
Plant fresh weight (g)	0.250267 NZ
Plant dry weight (g)	0.042742 *

NZ- not statistically significant (p>0.05); (0.01<p<0.05)*; (p<0.01)**; t-test

The effect of *Cuscuta campestris* on fluorescence parameters of infested *Ambrosia trifida* plants

Many researchers have used methods based on chlorophyll fluorescence to monitor the effect of various stress factors on plants, such as water deficit (Duraes et al., 2001), extreme temperatures (Francheboud et al., 1999), high salt concentrations (Moradi and Ismail, 2007) or nitrogen deficit (Duraes et al., 2001), to study changes in photosynthetic processes caused by herbicides (Abbaspoor et al., 2006; Pavlović et al., 2007; Bozic et al., 2010), or to examine the resistance of weeds to photosynthesis-inhibiting herbicides (Korres et al., 2003; Pavlovic et al., 2008) or pathogen infection

(Duraes et al., 2001). However, we have discovered no studies that used chlorophyll fluorescence as an indicator of stress in host plants parasitized by *C. campestris*, and our data (Figures 1-4) show that this parasitic flowering plant has a significant ($p<0.05$) effect on some fluorescence parameters (Table 3). Our analysis of data on the effect of *C. campestris* on parameters of chlorophyll *a* fluorescence in *A. trifida* plants showed that Fo Fv/Fm, Φ_{PSII} and Fv were parameters sensitive to parasitic effect. The other fluorescence parameters (Fm, ETR and IF) were unaffected by *C. campestris*, and were consequently excluded from further study.

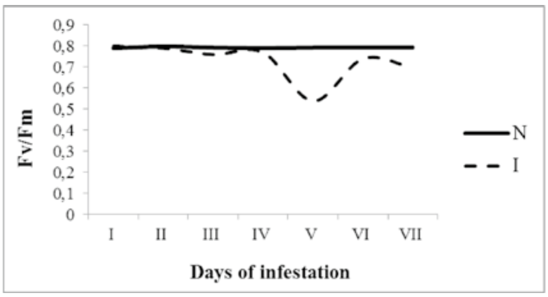

Figure 1. Parameter Fv/Fm in non-infested (N) and infested (I) *A. trifida* plants

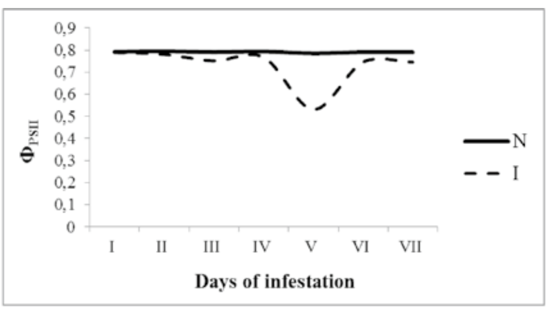

Figure 2. Parameter Φ_{PSII} in non-infested (N) and infested (I) *A. trifida* plants

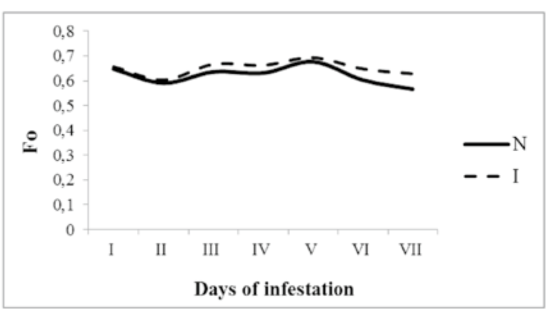

Figure 3. Parameter Fo in non-infested (N) and infested (I) *A. trifida* plants

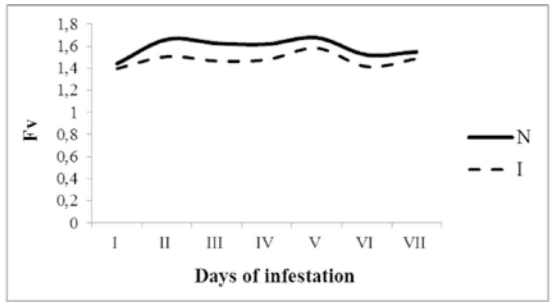

Figure 4. Parameter Fv in non-infested (N) and infested (I) *A. trifida* plants

Table 3. Significant differences for fluorescence parameters in non-infested and infested *A. trifida* plants

Parameter	Non-infested/Infested plants
Fv/Fm	0.043902*
Φ_{PSII}	0.003399**
Fo	0.144719^{NZ}
Fv	0.804431^{NZ}

^{NZ}- not statistically significant ($p>0.05$); ($0.01<p<0.05$)*; ($p<0.01$)**; t-test

The stressful influence of *C. campestris* on *A. trifida* led to reductions in the parameters Fv, Fv/Fm and Φ_{PSII}, which is consistent with reports from other studies (Abbaspoor et al., 2006; Riethmuller-Haage et al., 2006) that confirmed lower values of these parameters in plants exposed to stress caused by various factors. Contrarily, *C. campestris* was found to increase Fo values in host plants, compared to non-infested plants, which is consistent with data showing that Fo values also increased after stressful activity of herbicides in sunflower plants (Božić, 2010). An analysis of all parameters of fluorescence in *A. trifida* plants (Fv/Fm, Φ_{PSII}, Fo, Fv) recorded during the seven-day trial indicates that Fv is a more sensitive indicator of stress caused by parasitism of *C. campestris* than Fv/Fm, Fo or Φ_{PSII}. Decreasing Fv values in infested *A. trifida* plants were recorded as early as on the first day of trial. These values were lower than control values throughout the seven-day period, reaching their lowest points on the 3rd and 6th days of infestation (Figure 4). On the other hand, values of the parameter Fo in infested plants were higher than control values during the seven days of measurement (Figure 3). The parameters Fv/Fm and Φ_{PSII} had nearly identical values in infested and control plants during the initial two days of measurement, but they decreased in infested plants on the 3rd day of infestation and reached the lowest point on the fifth day (Figures 1 and 2). A number of studies (Klem et al., 2002; Abbaspoor and Streibig, 2005; Abbaspoor et al., 2006) have shown that fluorescence parameters reacted to stress at different speed, depending on a number of factors.

CONCLUSION

C. campestris affects the morphological parameters (height, fresh and dry weight) of infested *A. trifida* plants, reducing significantly their height and dry weight. Also, this parasitic plant affects several parameters of chlorophyll fluorescence [minimal fluorescence (Fo), variable/maximal fluorescence ratio (Fv/Fm), effective fluorescence yield (Φ_{PSII}) and variable fluorescence (Fv)], showing that these parameters can be used as indicators of *C. campestris* effect on host plants. The results provide a basis for further testing of *C. campestris* as a potential agent of biological control of the invasive weed species *A. trifida*.

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Uticaj viline kosice (*Cuscuta campestris* Yunck.) na morfološke i parametre fluorescencije kod ambrozije trolisne (*Ambrosia trifida* L.)

REZIME

Ispitivan je uticaj parazitske cvetnice viline kosice (*Cuscuta campestris* Yunck.) na morfološke i parametre fluorescencije kod zaraženih biljaka ambrozije trolisne (*Ambrosia trifida* L.) u kontrolisanim uslovima. Parametri fluorescencije (Fo, Fv/Fm, ΦPSII, Fv, Fm, ETR i IF) kod zaraženih (Z) i nezaraženih (N) biljaka *A. trifida* su mereni sedam dana, počev od prvog dana nakon zaražavanja. Morfološki parametri (visina biljaka, suva i sveža masa biljaka) su mereni poslednjeg dana merenja fluorescencije. *C. campestris* je uticala na visinu, svežu i suvu masu zaraženih biljaka *A. trifida*, pri čemu je dovela do značajne redukcije visine i suve mase biljaka. Takođe, vilina kosica je uticala na veći broj parametara fluorescencije hlorofila (Fo, Fv/Fm, ΦPSII i Fv) kod zaraženih biljaka *A. trifida*.

Ključne reči: *Cuscuta campestris*; *Ambrosia trifida*; morfologija; fluorescencija