Identification and distribution of ALS resistant *Sorghum halepense* populations in Serbia

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INTRODUCTION

Sorghum halepense (L.) Pers. is one of the most troublesome weeds in Serbian field crops production. Recently, resistance of *S. halepense* to some sulfonylurea herbicides has been confirmed in Italy and Hungary (Panozzo, 2012). Continuous application and the poor efficiency of some sulfonylurea herbicides applied in maize, indicate that the same phenomenon exists in some regions of Serbia.

The aim of this study was to determine if and where resistance of *S. halepense* to the acetolactate synthase (ALS)-inhibiting herbicides occurred in Serbia.

MATERIALS AND METHODS

In 2013 and 2014 a total of 25 *S. halepense* populations suspected for resistance to ALS-inhibiting herbicides were sampled from maize fields in Southern Banat, Mačva, Stig and Northern Bačka region of Serbia. Suspected resistant population from S. Banat (R) and susceptible population from vicinity of Novi Sad (S) were used for herbicide dose response trials. Whole plant bioassays were carried out in greenhouse conditions (28/22±3°C day/night temperatures with a 16-h photoperiod) designed as a randomized complete block design with 4 replications (8 plants per pot and replication) and repeated. Herbicides nicosulfuron (0.23 - 7680 g a.i. ha^{-1}), rimsulfuron (0.16-2560 g a.i. ha^{-1}), imazamox (0.63-2560 g a.i. ha^{-1}), pyroxsulam (1.5-12000 g a.i. ha^{-1}), propoxycarbazone-sodium (0.33-5400 g a.i. ha^{-1}) and cycloxydim (0.78-200 g a.i. ha^{-1}) were applied at two-three leaves growth stage of *S. halepense* seedlings, with portable sprayer, flat fan nozzle XR11002 and 280 L/ha of water. Shoot fresh and dry weight per pot and visual growth reduction in relation to the untreated control were recorded 14 days after the herbicides' applications, respectively. Using the "R" software and *drc* package, GR_{50} and resistance index (RI) were determined for the susceptible and suspected resistant populations. For testing of populations from other locations to confirm ALS-resistance, we used a nicosulfuron at recommended rates (60 g a.i. ha^{-1}) and 10-fold increased rate (600 g a.i. ha^{-1}).

RESULTS

Results from whole plant bioassays confirmed that tested populations from South Banat (close to Romanian border), Mačva (near to river Drina), Stig and North Bačka region (close to Hungarian border) are resistant to nicosulfuron (Fig. 3), and R population from S. Banat (001-13) was highly cross-resistant to all tested ALS inhibitors from four different chemical groups: sulfonylureas, imidazolinones, triazolopyrimidines and sulfonylaminocarbonyl-triazolinones (Fig. 1 and 2). The results showed a high level of resistance of the population from S. Banat on whole plant level (fresh shoot weight) to nicosulfuron, rimsulfuron, imazamox, pyroxsulam and propoxycarbazone-sodium (RI = 985, 2198, 849, 220 and 321). In contrast to this, ALS-resistant populations were susceptible to cycloxydim (RI=0.88), which could be very important chemical option in the management of ALS-resistant *S. halepense* from rhizome in cycloxydim-tolerant maize. We estimate that the ALS-resistant populations of *S. halepense* are infesting at least 50,000 ha of crop fields in Serbia, and suggest it is necessary to implement urgently the measures for resistance management.

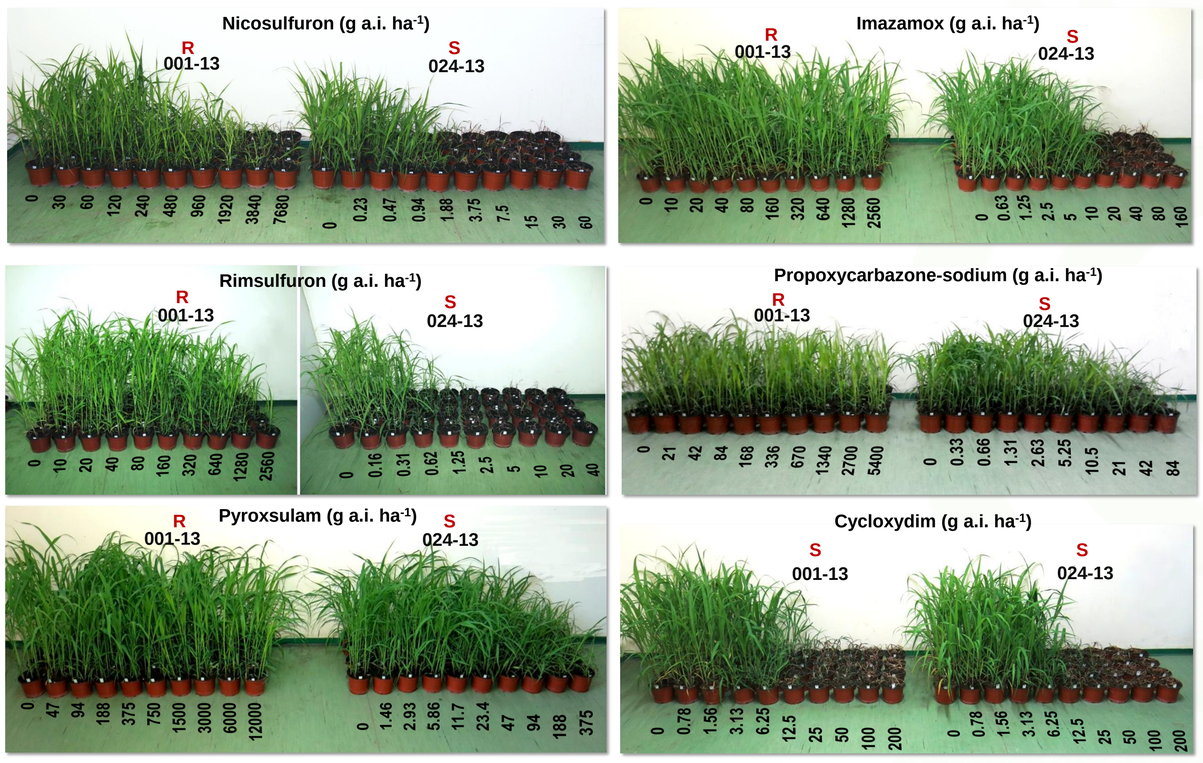

Fig. 1 - Effect of increasing rates of nicosulfuron, rimsulfuron, imazamox, pyroxsulam (d) propoxycarbazone-sodium, and cycloxydim on plants of the resistant (R, 001-13) and susceptible (S, 024-13) populations of *S. halepense* to ALS inhibitors (14 days after application).

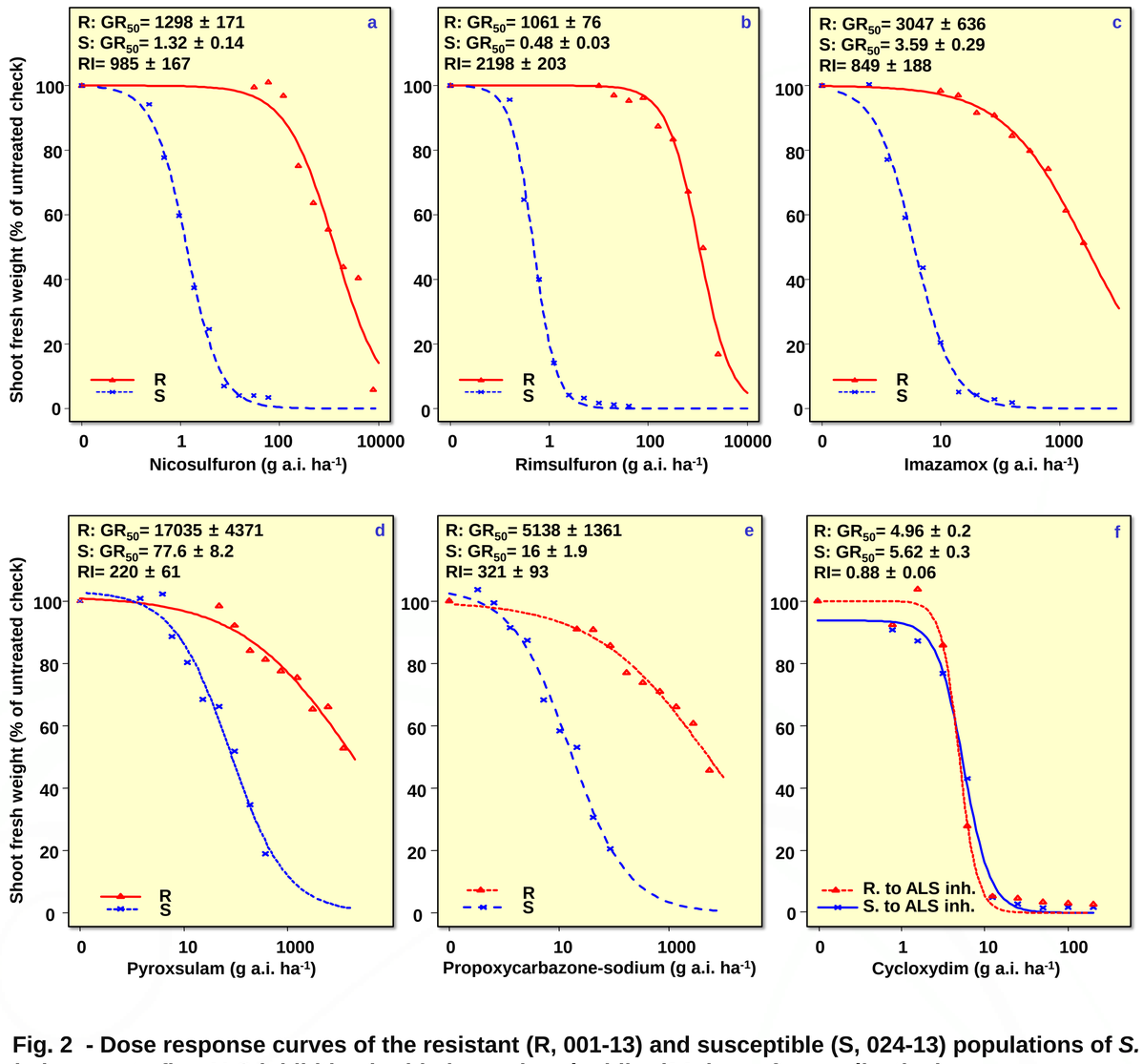

Fig. 2 - Dose response curves of the resistant (R, 001-13) and susceptible (S, 024-13) populations of *S. halepense* to five ALS-inhibiting herbicdes and cycloxidim (14 days after application).

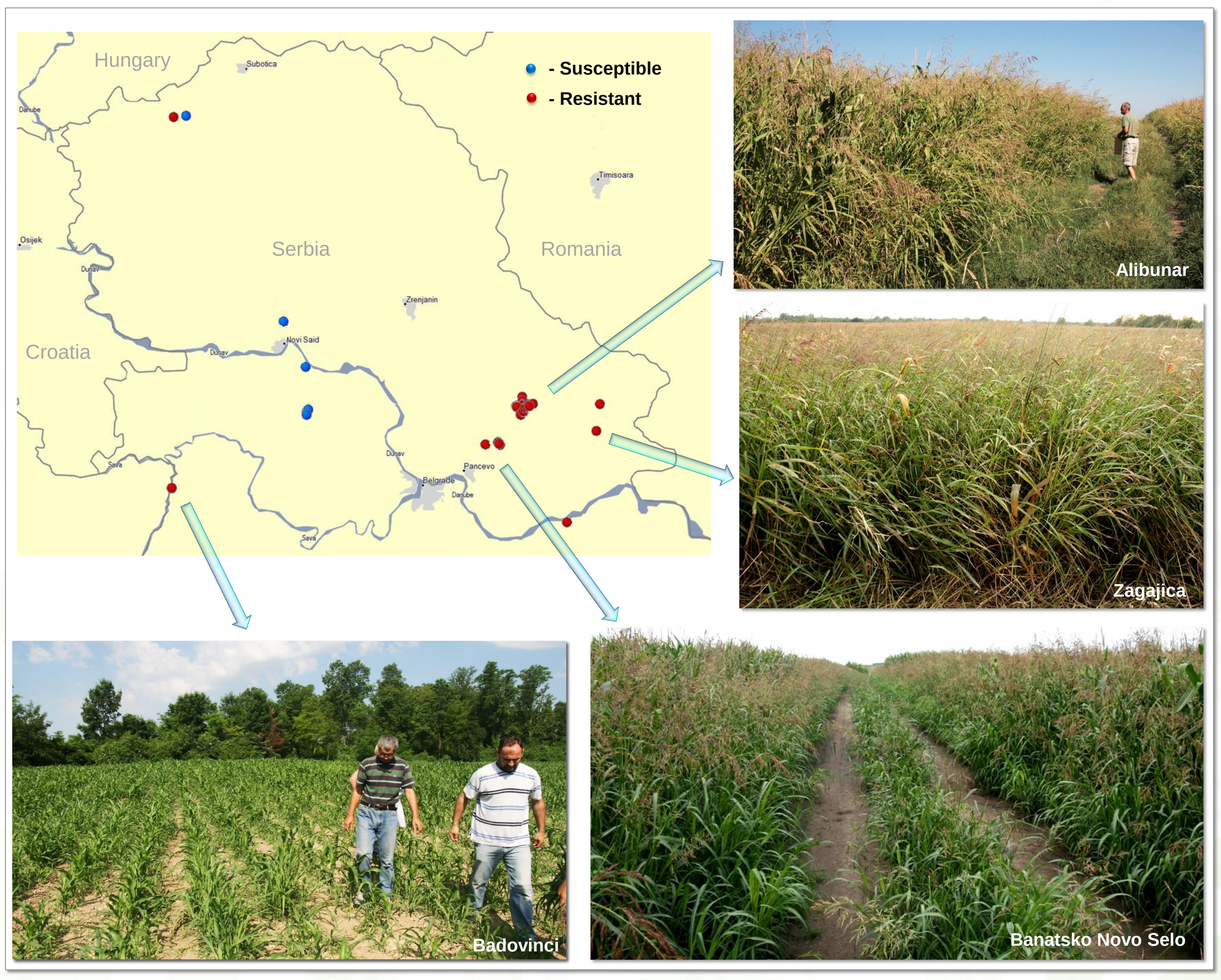

Fig. 3 - Locations with confirmed resistance of *S.halepense* to ALS-inhibiting herbicides in Serbia

CONCLUSIONS

Based on the results it can be concluded that in some regions of Serbia populations of *S. halepense* are resistant to herbicides that inhibit acetolactate synthase (ALS). This study showed that the resistant population from location Alibunar was cross-resistant to rimsulfuron, nicosulfuron and imazamox. Also, a high level of resistance to nicosulfuron was confirmed in populations from North Bačka (Bajmok), South Banat (Banatsko Novo Selo, Kačarevo, Zagajica, Vlajkovac), Stig (Ostrovo) and Mačva (Badovinci). These are the first confirmed cases of herbicide-resistant *S. halepense* in Serbia, which will have significant consequences for resistance management. Resistant populations are susceptible to cycloxydim, which will be unique tool in the resistance management in cycloxydim-tolerant maize.