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Management of field sowthistle (*Sonchus oleraceus* L.): an emerging threat in winter crops

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ABSTRACT

In central India, most of the arable and disturbed non-arable lands are vulnerable to invasions of field sowthistle (*Sonchus oleraceus* L.) during winter and summer. Its infestation has threatened the resident biodiversity and has also posed the possibility of spread to adjoining areas. The present study was conducted to know the biology of *S. oleraceus*, its impact and suggest suitable management strategies to restrict its further spread. In wheat, pendimethalin *fb* metsulfuron-methyl (678 *fb* 4 g/ha) recorded the lowest density and biomass of *S. oleraceus* (2 no./m^2 and 0.5 g/m^2, respectively) with 92.3% weed control efficiency (WCE) followed by clodinafop + metsulfuron (60+4 g/ha), which were statistically comparable. Similarly, in chickpea, pendimethalin + imazethapyr (900+60 g/ha) recorded the lowest density and biomass of *S. oleraceus* (3 no./m^2 and 1.1 g/m^2, respectively) with 86.9% WCE, where density was comparable to propaquizafop + imazethapyr (50+75 g/ha). The lower density of *S. arvesnsis* recorded with higher grain yield of wheat (5.10 t/ha) and seed yield of chickpea (2.25 t/ha). The highest density and least yield recorded in control plots.

INTRODUCTION

Crop productivity is severely influenced by biotic and abiotic stresses. Among biotic factors, weeds are major yield reducers and may cause yield penalty up to 33-37% (Choudhary and Dixit 2018). In recent past, it has experienced that most of the arable and non-arable lands are vulnerable to invasions of field sowthistle (*Sonchus oleraceus* L.) (Andreasen and Stryhn 2008, Suryawanshi *et al.* 2018) and threatened the resident biodiversity. *S. oleraceus* is a plant of Asteraceae family, and originated from Europe and Western Asia. This is a dicotyledonous winter annual plant and considered an invasive species in several parts of the world. In India, it is being present in North-Eastern states, Himachal Pradesh, Jammu and Kashmir, Uttarakhand and West Bengal and also considered invasive (Chandra 2012). Leaves are thin, soft, dark green with a purple vein with dimension of 10-22 × 3-10 cm with extremely variable upper leaves (Global Invasive Species Database 2019). It can grow up to 25-160 cm height and prefers solar radiation. It can grow fast and come into early flowering and produce enormous seeds. The seeds can germinate from September to March at optimum soil temperature and moisture (CISRO 2010). The longevity of *S. oleraceus* recorded up to 10 years under laboratory condition, whereas only 3.4-5.0% seeds were viable after 5 years in the soil. The seeds remain viable for 8 months when retained in top 2 cm, while seeds buried deeper can remain viable up to 30 months (Chauhan *et al.* 2006). Only 12% of seeds could survive after 30 months buried 10 cm deep (Widderick *et al.* 2010). At early stages up to 30 days, it does not offer serious competition; however, at 45 days onwards, it poses a serious threat. It can cause substantial yield loss to the tune of 12-45% in various crops such as chickpea, wheat, pea, *etc.* (personal observations). The major problem occurs particularly with open space field and vegetable crops. *S. oleraceus* is also an important alternate host of pest and diseases of crops *i.e.* watermelon mosaic virus, tomato spotted wilt virus and alfalfa mosaic virus, host for caster whitefly (*Trialeuro desricini*), *Bemisia* whiteflies, cotton bollworm (*Helicoverpa armigera*) (Gu *et al.* 2003) and nematode *Radopholus similis* (Schippers 2004).

It can grow in the cultivated land, field bunds, gardens, roadsides, construction sites or burned areas and degraded lands. In recent times, density of *S. oleraceus* is rapidly increasing, and it is becoming a major threat in Conservation Agriculture (CA). An urgent attention is required to develop management strategies, so that its further dissemination and losses could be minimized. Therefore, present study was conducted to understand the biology of *S. oleraceus,* assess its impact and suggest suitable management strategies to restrict its further spread in wheat and chickpea.

MATERIALS AND METHODS

Field experiments were conducted at the ICAR-Directorate of Weed Research, Jabalpur (23°132'N, 79°592'E, and 388 m above mean sea level) during 2017-18 and 2018-19 with a sub-tropical climate. The temperature ranges from 4°C in January to 45°C in May and the experimental site had a clay loam texture (Typic chromusterts) with 7.2 pH, 0.21 dS/m electrical conductivity, 0.58% organic carbon, low in available nitrogen (248 kg/ha), phosphorus (16.7 kg/ha) and exchangeable potassium 348 kg/ha) in the 0-20 cm. In a net house experiment, the seedling emergence of *S. oleraceus* from different burial depths was studied. In these, 50 counted seeds of *S. oleraceus* were placed at 0, 2, 5, 10, 15 and 20 cm burial depths and replicated thrice. In these, 0-15 cm burial depths were managed in the pots with 17 x 17 cm dimension and 30 x 28 cm dimension pots were used for 20 cm burial depths. The pots were filled with autoclaved soils of above mentioned properties. Pots were irrigated as and when required. The seedling emerged at 30 DAS were considered as final seedling emergence.

Field experiments were executed in a randomized block design with three replications, where wheat cv '*GW 273*' and chickpea cv '*JG 130*' were sown in gross plot of 5 x 5 m plot size with recommended package of practice except weed management. Pendimethalin *fb* metsulfuron 678 *fb* 4 g/ha, metribuzin + clodinafop 210 +60 g/ha, clodinafop + metsulfuron 60+4 g/ha, mesosulfuron + iodosulfuron 12+2.4 g/ha, metsulfuron-methyl 4 g/ha, control in wheat; Pendimethalin 678 g/ha, pendimethalin + imazethapyr 900+60 g/ha, imazethapyr 30 g/ha, propaquizafop + imazethapyr 50+75 g/ha, topramezone 30 g/ha, sodium acifluorfen+ clodinafop 41.25+20 g/ha, control in chickpea. The herbicides were applied as per the schedule using flat fan nozzle using 500 L/ha spray volume for pre-emergence herbicides and 375 L/ha for post-emergence herbicides. Density and biomass of *S. oleraceus* were recorded at 60 days after sowing (DAS) with standard protocol (Choudhary and Dixit 2018). The rest of the weeds emerged with crops under experiments were neither removed nor considered for the interpretation, as the densities were fewer. Observations were made on various stage of *S. oleraceus* plants *i.e.* seedling (a), leaf orientation (b) and variability in leaves (c), flower (d), puffball (e) and seeds (f) (**Figure 1a-f**). Analysis of variance was performed to determine treatment effect using SAS 9.2 (SAS Institute, Cary, NC) and significance of the treatment was determined by the *F*-test. The difference between means of two treatments was tested using least significant difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Emergence from soil burial depths

Data presented in figure 2 clearly illustrated that 33 seeds could emerged from soil surface (0 cm) followed by 7 seedlings at 2 cm depth. Further, at deeper depths (5 cm onwards), no emergence has been recorded (**Figure 1g**). It was visualized that freshly shed seeds display no dormancy and thus readily germinated at optimum soil moisture content. In CA, due to zero-till system, a large number of seeds remain on the soil surface resulting in higher seedling emergence and heavy infestation in field but at the same time it was killed by the post-emergence herbicide (clodinafop + metsulfuron 60+4 g/ha) in wheat (**Figure h-j**). These plants are well established and compete with crops for available resources in wider row spacing (Johnson and Hovestad 2002). Availability of moisture flourishes its growth and development, whereas dry condition suppresses. Light is most essential for germination, thus mulching or seeds buried in deeper soil profile inhibits seed germination and also causes high seedling mortality (Choudhary 2019).

Wheat

The lowest density (2 no/m^2) and biomass (0.5 g/m^2) of *S. oleraceus* were recorded with the application of pendimethalin *fb* metsulfuron (678 *fb* 4 g/ha) followed by clodinafop + metsulfuron (60+4 g/ ha); however, both were statistically comparable. The highest density and biomass (12 no./m^2 and 6.5 g/m^2, respectively) of *S. oleraceus* were recorded in control plots. Fewer density and lighter biomass helped in achieving significantly higher weed control efficiency (WCE) in pendimethalin *fb* metsulfuron by 92.3% followed by clodinafop + metsulfuron (87.9%) (**Table 1**). Rest of the treatments recorded a significant reduction in density and biomass of *S. oleraceus* with better WCE, yet their performance was less pronounced as compared to pendimethalin *fb* metsulfuron and clodinafop + metsulfuron. The highest grain yield of wheat (4.88-5.32 t/ha) was obtained with clodinafop + metsulfuron followed by pendimethalin *fb* metsulfuron (4.87-5.22 t/ha). The lowest grain yield (3.24-3.46 t/ha) was recorded in control. The rest of weed control treatments also recorded considerably higher yield than control but were less of clodinafop + metsulfuron. In general, the density and biomass of *S. oleraceus* was more in 2018-19 then 2017-18.

Figure 1. ***Sonchus oleraceus*** **a) seedling, b) leaf orientation, c) leaves (bottom to top), d) flower, e) pappus (puffball), f) seeds, g) emergence from different burial depth , h) effect of herbicide, i) heavy infestation in wheat and j) comparison of treated and infested wheat plots**

Table 1. Effect of herbicides on density, biomass and control efficiency of *S. oleraceus* in wheat (mean of two years)

Treatment	Dose (g/ha)	Application time (DAS)	*S. oleraceus* density (no./m^2)	*S. oleraceus* biomass (g/m^2)	*Sonchus* control efficiency (%)	Wheat grain yield (t/ha)	
						2017-18	2018-19
Pendimethalin *fb* metsulfuron	678 *fb* 4	1 and 25	2	0.5	92.3	5.22	4.87
Metribuzin + clodinafop	210 +60	25	6	2.2	66.2	4.70	4.34
Clodinafop + metsulfuron	60+4	25	2	0.7	87.9	5.32	4.88
Mesosulfuron + iodosulfuron	12+2.4	25	5	2.0	69.2	4.94	4.58
Metsulfuron-methyl	4	25	4	1.3	80.0	4.79	4.35
Control	-	-	12	6.5	-	3.46	3.24
LSD (p=0.05)			2.2	0.7		0.19	0.15

Table 2. Effect of herbicides on density, biomass and control efficiency of *S. oleraceus* in chickpea (mean of two years)

Treatment	Dose (g/ha)	Application time (DAS)	*S. oleraceus* density (no./m^2)	*S. oleraceus* biomass (g/m^2)	*Sonchus* control efficiency (%)	Chickpea seed yield (t/ha)	
						2017-18	2018-19
Pendimethalin	678	1	5	2.4	71.4	2.12	1.74
Pendimethalin + imazethapyr	900+60	1	3	1.1	86.9	2.45	2.05
Imazethapyr	30	20	10	5.4	35.7	1.52	1.32
Propaquizafop + imazethapyr	50+75	20	3	1.8	78.6	2.15	1.81
Topramezone	30	20	5	3.1	63.1	2.32	2.04
Sodium acifluorfen+ clodinafop	41.25+20	20	8	4.8	42.9	1.98	1.62
Control			16	8.4	-	1.01	0.65
LSD (p=0.05)			2.5	0.8		0.12	0.09

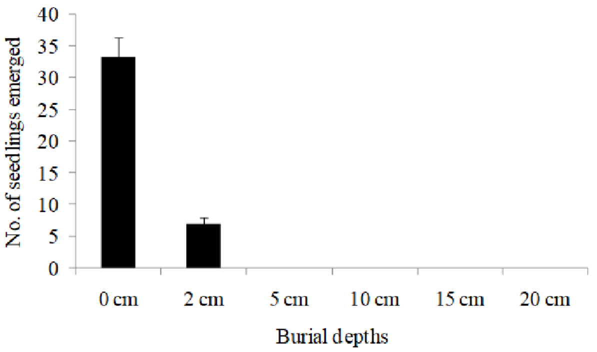

Figure 2. *Sonchus oleraceus* seedling emergence at various burial depths of soil

Chickpea

The lowest density (3 no./m^2) and biomass (1.1 no./m^2) of *S. oleraceus* was recorded with pendimethalin + imazethapyr (900+60 g/ha), whereas density was on par to propaquizafop + imazethapyr (50+75 g/ha) but biomass was considerably lower. The lesser accumulation of biomass led to achieving the highest WCE 86.9 and 78.6%, respectively (**Table 2**). Other management practices like pendimethalin, imazethapyr, topramezone, sodium acifluorfen + clodinafop also considerably reduced the density and biomass of *S. oleraceus* resulting in improved WCE, yet their response was less in relation to pendimethalin + imazethapyr. The highest seed yield (2.05-2.45 t/ha) recorded in pendimethalin + imazethapyr followed by topramezone (2.04-2.32 t/ha). The lowest seed yield (0.65-1.01 t/ha) of chickpea recorded in control. Rest of the weed management practices also provided considerably good yield than control but were less of pendimethalin + imazethapyr.

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