Indian Journal of Weed Science **47**(2): 131–135, 2015

Allelopathic potential of canola and sugarbeet to control weeds in chickpea

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Received: 17 January 2015; Revised: 5 March 2015

ABSTRACT

Filed experiment was done to evaluate the allelopathic potential of sugarbeet and canola residues on weeds of chickpea field. Five treatments, *viz.* 1: Chopped residues of canola, 2: Chopped residues of sugarbeet both were separately incorporated to 25 cm depth soil, 20 days before sowing, 3: Shoot aqueous extract of canola, 4: Shoot aqueous extract of sugarbeet which were separately sprayed at post emergence stage and 5: Without any residues and spraying as control. The weed control treatments reduced the total weed cover, weed density and total dry weigh of weed. The reduction in weed density with canola and sugarbeet residues incorporated with soil were up to 42.7 and 57% respectively, at 45 days after sowing and 41% and 52.4%, respectively, at 90 days after sowing, compared to control. However, post emergence spraying of shoot aqueous extract of canola and sugarbeet, suppressed weed density up to 37.2 and 35.6% at 40 days after sowing and 56.7% and 49.2% at 90 days after sowing respectively, compared to control. Weed control treatments reduced weed cover (%), weed biomass and weeds stem length. Incorporation of canola and sugarbeet residues in soil reduced weed cover (%) by 47.9% and 57.6%, respectively, while spraying of shoot water extract of canola and sugarbeet suppressed weed cover (%) by 31.7% and 42%, respectively at 90 days after sowing. Application of canola residues and spraying shoot aqueous extract of canola increased chickpea yield by 25.4% and 39.5% respectively, while application of sugarbeet residues and shoot aqueous extract of sugarbeet decreased chickpea yield by 22% and 29.8% respectively compared to control. All nutrient elements analyzed in the leaves of weed generally were lower than control for all treatments. Incorporation of crop residue of canola and sugarbeet on weeds were more effective than spraying water extract of these plants.

Key words: Allelopathy, *Beta vulgaris*, Bio-herbicide, *Brassica napus*, Plant residues

The weeds have significant negative effects on agricultural ecosystems (Singh *et al.* 2003), and may decrease crop yield up to as 24% then 16.4% and 11.2% for diseases and insects, respectively (Hegab *et al.* 2008). Since 1980s, dependence on chemical weed controls worldwide has become less ubiquitous because of public concerns over safety, risks for the environment (Dayan *et al.* 1999) and the development of resistance to chemical herbicides by weeds. This necessitated the research for alternative strategies.

Allelopathy is defined as the inhibitory/ stimulatory effect(s) of one plant on other plants through the release of chemical compounds into the surrounding environment (Rice 1984). Allelopathy is characterized by a reduction in plant emergence or growth, reducing their performance in the association (Florentine *et al.* 2006). It provides a relatively cheaper and eco-friendly weed control strategies (Cheema *et al.* 2000).

Various *Brassica* species possess allelopathic potential and suppresses the certain weed species. Allelopathic effects of *Brassica* species are due to glucosinolates (GSLs) that are not biologically active. When the plant tissue is disrupted, the GSLs are hydrolyzed to a number of products. The mean breakdown products are isothiocianates (ITCs) which are phytotoxic (Fenwick *et al.* 1983).

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Sugarbeet (*Beta vulgaris* L.) is known to be allelopathic against weeds. The allelopathic activity of sugarbeet has been attributed to phenolic acids and related compounds. Hegab *et al.* (Hegab *et al.* 2008) identified and quantified 8-phenolic compounds (shikimic acid, camphor, hydroxybenzoic, p-coumaric, vanilic acids, coumarin and porotocatechuic acids) in water extract of *Beta vulgaris*. Dadkhah (2012) has demonstrated that sugarbeet allelopathic varietes can be used to reduce weed populations below the threshold level to minimize the applications of herbicides.

The present study was done to develop management practices to reduce the use of agro-chemicals for sustainable agriculture. Therefore, the effects of allelopathic potential of canola and sugarbeet residues on suppression of some weeds of chickpea farm were studied.

MATERIALS AND METHODS

A field experiment based on a randomized complete blocks design with four replications was carried out in a naturally weeds infested land to investigate the allelopatic effects of canola (*Brassica napus*) and sugarbeet (*Beta vulgaris*) residues on weeds and yield of chickpea (*Cicer arietinum*) at research center of Shirvan Agricultural College (37° 23′ north latitude and 57° 54′ east longitude and altitude of 1060 meters), North Khorasan Province, Iran. Arial parts of canola and sugarbeet were collected from farm of Shirvan Agricultural College, at harvesting stage. Arial parts were spread on a clean plastic sheet in the shade at room temperature for 3 weeks until they were completely dried and chopped into 5 cm pieces and stored until needed. The experimental site was ploughed, followed by a disc-harrow and smoothing with land leveler. Fertilizer was applied prior to planting at the rate of 100 kg/ha ammonium nitrate (33% N) and 80 kg/ha calcium superphosphate (15.5% P_2O_5). Plot size was 9 m^2 (3 × 3 m). Five treatments, *viz.* 1: Chopped residues of canola (1.5 kg/m^2), 2: Chopped residues of sugarbeet (1.5 kg/m^2) both were separately incorporated to 25 cm depth soil uniformly 20 days before sowing, 3: Shoot aqueous extract of canola, 4: Shoot aqueous extract of sugarbeet which were separately sprayed at post-emergence stage (at 7 and 14 days after sowing) and 5: Without any residues and spraying as control. Chickpea seeds were planted on April 25th in 2013. For preparation of aqueous extract, chopped shade dried residues of canola and sugarbeet were separately ground into fine powder (using an electric mill). One hundred gram of ground tissue of each of the tested species was placed in a 2 L Erlenmeyer flask and 1 L distilled water was added and left for 48 h at room temperature. The mixtures were then filtered through a double layer of cheese cloth followed by Whatman No.1 filter paper using a vacuum pump. Water extracts were applied between rows at the rate of 100 ml per square meter twice at 7 and 14 days after sowing (DAS) using a knapsack hand-sprayer fitted with a flat fan nozzle maintaining a pressure of 207 kpa.

Leaves nutrient content (N, P, K, Ca, Mg, Fe and Mn) of two main weeds of chickpea farm (*Solanum nigrum* and *Echinochloa crusgalli*) were determined at 90 DAS. Nitrogen was determined by Micro-kjeldahl. Phosphors by spectrophotometer and K, Ca, Mg, Fe and Mn were determined by atomic absorption spectrometry after mineralization through wet combustion (AOAC 1970).

Data for individual and total weed density and biomass in a unit area was recorded 40 and 90 days after sowing (DAS) using a 0.5 × 0. 5 m quadrat randomly placed at two places in each experimental unit. Weeds were oven dried at 70^0 C for 72 hours for the dry weight. Chickpea crops was harvested and threshed manually in fourth week of August, 2013 from individual treatment plots; grain yield was weighed in kilograms and expressed as kilo gram per hectare (kg/ha).

RESULTS AND DISCUSSION

Statistical analysis of the data showed that there were significant differences among the weed control treatments. Results showed that incorporation of crop residues had greatly affected the total weeds cover, weeds density and weeds dry weight, while post application of water extract of crop showed comparatively lesser controlling ability. There was significant difference on weed cover and weed dry weight between two test spices.

The reduction in weed density with canola and sugarbeet residues incorporation were up to 42.7 and 57.2%, respectively at 45 days after sowing and 41 and 52.6% at 90 days after sowing compared to control (Fig. 1). However, post-emergence spraying of shoot aqueous extract of canola and sugarbeet suppressed weed density up to 37.2 and 35.6% at 45 days after sowing and 56.7 and 49.2% at 90 DAS, respectively, compared to control (Fig. 1).

Weed control treatments also reduced weed cover (%). Incorporation of canola and sugarbeet residues in soil, reduced weed cover by 48 and 58.6% respectively, while spraying water extract of canola and sugarbeet lowered weed cover by 31.6 and 42.5% respectively at 90 DAS (Fig. 2).

Total weeds dry weight decreased significantly by weed control treatments. Incorporation of canola and sugarbeet residues in soil reduced total weeds dry weight by 57.6 and 78.2%, respectively, compared to control. However, spraying water extract of canola and sugarbeet decreased total weeds dry weight by 56.3 and 70.7%, respectively, compared to control at 45 DAS (Fig. 3). The reduction of total weeds dry weight for canola and sugarbeet residues were 82.3 and 90.9% respectively, at 90 DAS (Fig. 3). Such suppressive actions are believed to originate through the release of phytotoxin allelochemicals from incorporated crop residues by leaching or decomposition.

Leaves nutrient elements content of weeds was significantly decreased by treatments compared to control. The N content of *Solanum nigrum* leaves

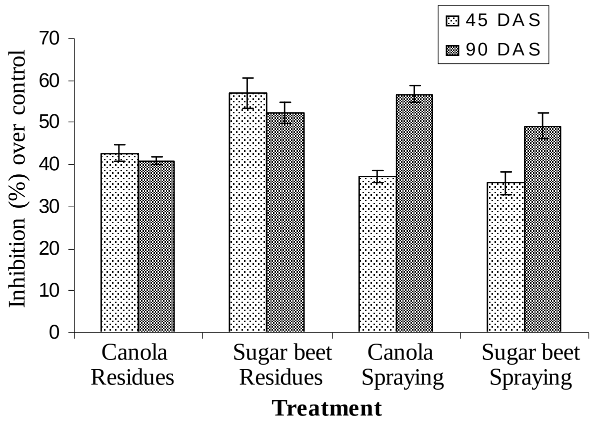

Fig. 1. Inhibitory effects of canola, wheat residues and spraying aqueous extracts of canola and sugarbeet on weed density of chickpea farm (vertical lines are standard deviation of means)

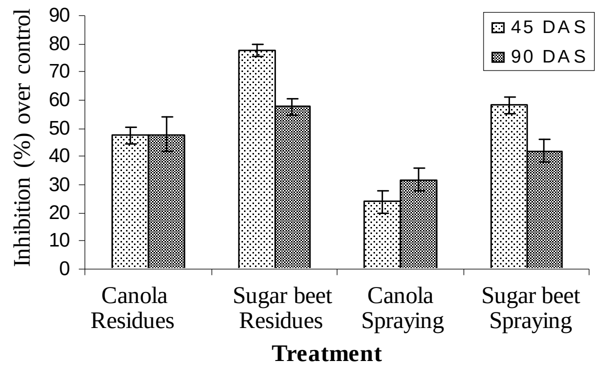

Fig. 2. Inhibitory effects of canola, wheat residues and spraying aqueous extracts of canola and sugarbeet on weed cover of chickpea farm (vertical lines are standard deviation of means)

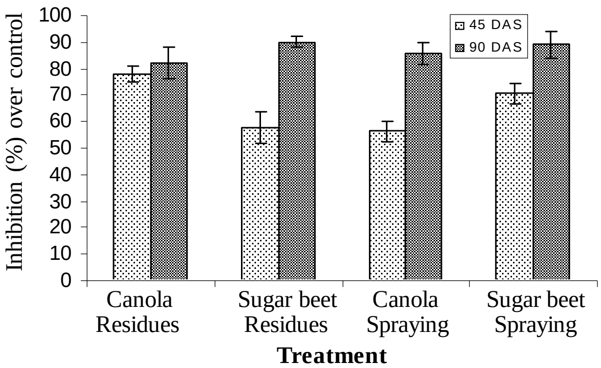

Fig. 3. Inhibitory effects of canola, wheat residues and spraying aqueous extracts of canola and sugarbeet on total weeds dry weight of chickpea farm (vertical lines are standard deviation of means)

decreased from 3.68% (at control) to 1.95% (at canola residues treatment), 1.78 (at sugarbeet residues treatment), 2.48 (at canola extract spraying) and 2.59 (at sugarbeet extract spraying).

Soil incorporated canola residues decreased the P, K. Ca, Mg, Fe and Mn from 0.78% to 0.42%, 2.19% to 1.3%, 2.45% to 1.8%, 0.62% to 0.48%, 95 ppm to 49 ppm and 73 to 50 ppm respectively, compared to control (Table 1).

The nitrogen content of *Echinochloa crusgalli* leaves decreased from 2.83% (at control) to 1.5% (at canola residue treatment), 1.32% (at sugarbeet residue treatment), 1.9% (at canola extract spraying) and 2.1% (at sugarbeet extract spraying) (Table 2). The results showed that soil incorporation of crop residues of canola and sugarbeet were more effective than water extract spraying of these plants.

The results showed that the treatments were more effective on weeds dry weight than weed density. It indicates that growth of weeds was more suppression by phytotoxic effects of test plants than weed seed germination. In other words, inhibition in weeds dry weight was more pronounced than in weed seed germination. Smith (1991) and Ben-Hammouda *et al.* (1995) found that allelochemicals of several species suppressed the seedling growth in target plants more than seed germination.

Some researchers reported that allelochemicals inhibits the physiological processes that leads to reduced growth (Jefferson and Pennacchio 2003, Dadkhah 2012). The effects of allelochemicals on growth of plants may occur through various mechanisms. Like reduced mitotic activity, suppressed hormone activity, reduced rate of nutrients uptake, inhibited photosynthesis and respiration, inhibition of protein formation, reduction in permeability of cell membranes and inhibition of enzyme action (Rice 1984, Wu *et al.* 2000, Xuan *et al.* 2004). Under stress conditions, growth decreases due to decrease in cell number and cell size (De-Herralde *et al.* 1998). A possible reason for reduction in dry matter in weeds under allelochemical stress could be owing to the drastic reduction in uptake and assimilation of mineral nutrients. Akemo *et al.* (2000) reported that reduction in both macro and micronutrients uptake under allelopathy stress could be one of the effective parameters for growth reduction. Another possibility for dry matter reduction may be due to reduction in photosynthetic area or assimilation rate per unit leaf area (Dadkhah 2012). He also reported that dry matter accumulation of *Amaranthus retroflexus* significantly decreased by increasing allelochemical concentration. He mentioned that this reduction accompanied with reduction in leaf area and leaf photosynthesis per unit leaf area.

Table 1. Nutrient elements content of *Solanum nigrum* weed and percentage of reduction at different treatments condition at 90 DAS

Nutrient	Control		Canola residue		Wheat residue		Canola spraying		Wheat spraying	
	Actual	%	Actual	%	Actual	%	Actual	%	Actual	%
N (%)	3.68a	0.0	1.95b	47.01	1.78b	51.63	2.48a	32.61	2.59a	29.62
P (%)	0.78a	0.0	0.42d	46.15	0.53c	32.05	0.61b	21.79	0.53c	32.05
K (%)	2.19a	0.0	1.3c	40.63	1.49c	31.96	1.82b	16.89	1.73b	21.01
Ca (%)	2.45a	0.0	1.8b	26.53	1.89b	22.86	2.31ab	5.714	2.10b	14.29
Mg (%)	0.62a	0.0	0.48b	22.58	0.48b	22.58	0.52b	16.13	0.50b	19.36
Fe (ppm)	95.0a	0.0	49.0c	48.42	56.0c	41.05	67.0b	29.47	59.0bc	37.90
Mn (ppm)	73.0a	0.0	50.0c	31.50	53.0bc	27.40	65.0b	10.95	62.0b	15.07

Each number is the mean of four replications. Numbers followed by the same letter in rows are not significantly (P³0.05) different by Duncan's multiple range test.

Table 2. Nutrient elements content of *Echinochloa crusgalli* weed and percentage of reduction at different treatments condition at 90 DAS

Nutrient	Control		Canola residue		Wheat residue		Canola spraying		Wheat spraying	
	Actual	%	Actual	%	Actual	%	Actual	%	Actual	%
N (%)	2.83a	0.0	1.50c	47.00	1.32c	53.36	1.90b	32.86	2.1b	25.80
P (%)	0.86a	0.0	0.40c	53.49	0.46c	46.51	0.71b	17.44	0.61b	29.07
K (%)	2.00a	0.0	1.15c	42.50	1.23c	38.50	1.72ab	14.00	1.56b	22.22
Ca (%)	2.50a	0.0	1.72b	31.20	1.63b	34.80	2.10ab	16.00	1.82b	27.20
Mg (%)	0.50a	0.0	0.56a	-12.00	0.46ab	8.00	0.40b	20.00	0.39b	22.00
Fe (ppm)	70.0a	0.0	53.0b	24.29	61.0b	12.86	68.00a	2.86	55.0b	21.43
Mn (ppm)	61.0a	0.0	48.0b	21.31	52.0b	14.75	65.00a	-6.56	51.0b	16.39

Each number is the mean of four replications. Numbers followed by the same letter in rows are not significantly different by Duncan's multiple range test.

Incorporation of crop residues of canola and sugarbeet to control weeds were more effective than spraying water extract of these plants. The main reason for this can be attributed to higher concentration of allelochemicals or release gradually of allelochemicals by the residues of test plants that remained in the soil during growth period. Elijarrat and Barcelo (2001) reported that weeds can be controlled better by incorporating plant residues that release a greater fraction of allelochemicals in the soil. Higher concentration of allelochemicals inhibits the amylase activity in wheat seedlings and decreases the protein content in wheat seedlings (Hegab *et al.* 2008). On the other hand, application of sugarbeet residues and sugarbeet water extract had more inhibitory effect on weeds than canola application. Therefore, more inhibitory effects of *Beta vulgaris* might be due to the presence of more active phenolic compounds in it (Dadkhah 2012). Chung *et al.* (2002) demonstrated that p-hydroxybenzoic, p-coumaric acids were the most active compounds in rice hull extract, which inhibited the growth of barnyardgrass. The nature of inhibitory effects of allelochemicals on weed seed germination and weed growth could be attributed to the inhibition in water absorption (Oyun 2006).

The result of this experiment also showed that application of canola treatments increased chickpea yield (Fig. 4). Application of canola residues incorporated in soil and canola extract spraying increased chickpea yield by 25.4 and 39.5% compared to control plants. However, application sugarbeet residues and spraying water extract of sugarbeet decreased chickpea yield by 29.8 and 21%, compared to control. The increased chickpea yield by application canola residues and canola water extract might be due to suppression of weeds, soil and moisture conservation and improved nutrient cycling. While, chickpea yield reduction due to application of sugarbeet could be due to negative effect of sugarbeet allelochemicals on vegetative and reproductive growth of chickpea.

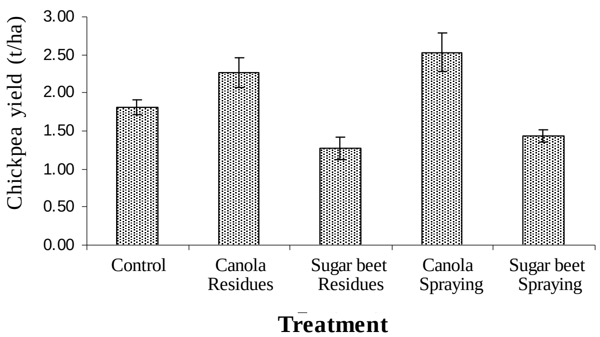

Fig. 4. Effect of different treatments on yield of chickpea. Vertical lines are standard deviation of means

These studies conclude that integrating canola and sugarbeet residues has the potential to suppress weeds germination and growth. These residues can be used as an eco-friendly approach to manage weeds in chickpea fields.

ACKNOWLEDGEMENTS

The author thanks the Complex Higher Education of Shirvan, Ferdowsi University of Mashhad for financial support and use of laboratory facilities to conduct this study.

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