USE OF SUNFLOWER RESIDUES IN COMBINATION WITH SUB RECOMMENDED DOSE OF HERBICIDES FOR WEEDS CONTROL IN BARLEY FIELD*

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ABTRACT

Sunflower residues at rates of 0, 600 and 1400 g per m^2 were incorporated in field soil to evaluate their herbicidal potential alone and in combination with 0, 50, 75 and 100% of recommended doses of 2, 4-D and Topic herbicides against weeds of barley crop. All treatments received equal amounts of irrigation water and recommended doses of nitrogen and phosphorus fertilizers. Combination of recommended dose of herbicides with sunflower residue at 1400 g m^{-2} produced minimum above ground weed biomass(122 g m^{-2}) and weeds number (155.5 weeds per m^2), which were 35 and 50% less than recommended herbicide dose applied alone, respectively. Meanwhile, integration of herbicides and sunflower residue appeared superior in enhancing number of spikes, weight of 100 grains and yield per unit area than herbicide alone. Application of 50% dose of herbicides on plants growing in plots containing sunflower residue at 1400 g m^{-2} resulted in similar yield advantage as was noticed with 100% herbicide dose. Chromatographic analysis revealed the presence of several phenolic compounds in the soil containing sunflower residues and none of these appeared in soil without sunflower residues. Concentration of total phenolic compounds appeared to be increased at two weeks of decomposition, reached its maximum at the 4th week of decomposition and started to decline thereafter until vanished at the 8th week of decomposition. Weeds population started to increase after 6 weeks of residues decomposition when the phytotoxins concentration was sharply reduced in the soil. The possible advantage of this approach in reducing reliance on herbicides for weeds control is briefly discussed.

INTRODUCTION

Weeds are one of the major problems that limit crop production in the world through competition and allelopathy mechanisms (26, 28). Farmers are generally trending toward controlling of weeds with herbicides which comes with increased awareness about health, environment concern and other issues (5, 32). Thus attention is focused on reducing reliance on using synthetic herbicides by finding alternative strategy for weed management. Allelopathy can offer appropriate potential tool for weed management by leaving residues of allelopathic crops in their field alone or in combination with sub recommended dose of herbicides (9, 17).

Sunflower allelopathy against weeds has been studied and well documented by several investigators appeared to be cultivar dependent (11, 21, 23). In an earlier work (2), it was found that root exudates and residues of several sunflower genotypes caused substantial reduction to population and biomass of companion weeds and weeds of wheat crop respectively. Although the reduction was feasible and environment friendly, it was generally less than herbicides. It may be possible to increase the efficacy of sunflower residues by combining it with low rates of herbicides. Several investigators have found that integration of water extract of allelopathic grain sorghum with sub recommended doses of herbicides suppressed weeds biomass as the recommended dose of herbicides (10, 17).

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With this in minds, the present study was conducted to test suppressive effect of sunflower residues in combination with sub recommended doses of herbicides on weeds of barley crop.

MATERIALS AND METHODS

Field study

The experiment was conducted in Kute province which is 180 km south of Baghdad. The site was located at 328340N, 458500E. The field is characterized by calcareous and loamy sand soil of with pH 7.2 and electrical conductivity 3.5 dS m^{-1}. Field plots (1×1m) were selected randomly in field in heavily infested with weeds in November 8. The plots were plowed by spade to the depth of 30 cm and received N as urea (46% N) at 200 kg/ ha and P as triple superphosphate (46% P_2O_5) at 200 $kgha^{-1}$. All phosphorus and half of the nitrogen were applied at sowing time while the remaining half of nitrogen was applied at tillering stage. The experiment comprised of sunflower residue incorporated at rates of 0, 600 and 1400 g m^{-2} and different doses (0, 50, 75 and 100%) of 2,4-D (720 mg/liter a. i.) and Topic (100 mg/liter a.i.) herbicides. 2, 4-D was applied at the 4^{th} leaf stage to control broad leaves weeds while Topic was sprayed two weeks after 2,4-D application to control narrow leaves weeds. The doses of herbicides were applied using a Knapsack hand sprayer fitted with T-Jet nozzle at a pressure of 207 k Pa. The treatments were used either alone or in combination with each other. The rates of sunflower residues were incorporated in the soil of their respective plots prior to sowing. Seeds of barley cv Samir were sown manually in the plots in rows with a distance of 20 cm between rows and at a density of 120 kg/h. The experiment was conducted in split plot design with four replications for each treatment. The herbicide rates were kept in the sub plot while sunflower residue rates were assigned as main plot. The data were analyzed by analysis of variance technique. The least significant differences test was used to compare the means of treatments (29).

At the end of crop maturity (May 5, 2010), weeds density was counted in each plot before and after herbicides application. Total weeds were clipped, brought to laboratory, oven-dried at 70°C for 72 days and their weights were recorded.

For crop measurements, barley plant height and biomass (oven dry weight at 70°C for 48 h) were recorded. Number of spikes and tillers per plant, number spikes per m^2, number of grains per spike, weight of 100 grains and yield of grain per m^2 were also recorded using standard procedure.

Isolation and quantification of phytotoxins in the decomposing sunflower residues in soil:

Experiment set up of residues decomposition in soil and extraction of phytotoxins:

Soil minus litters was taken from different sites of barley field. The soil samples were mixed thoroughly and air dried under sun. Air dried materials of sunflower plants cv Coupan were chopped into pieces of 2-3 cm length and incorporated in to the soil at a rate of 7g/kg soil (4). The mixture was packed in plastic pot of 10 kg capacity, irrigated with water to field capacity, covered with perforated plastic cover to avoid evaporation and placed in the field at the beginning of growing season of barley. Biweekly soil samples were taken from the pot using metal soil borer and stored in deep freeze until use

For extraction of phenolic acids, the stored soil samples were taken from the deep freeze and air dried mixed thoroughly. One gram of soil was extracted with 100ml of distilled water using a method of Harborne (14). The water extract was acidified with one milliliter of acetic acid. The mixture was heated gently, mixed thoroughly by ultrasonic apparatus to exclude air bubbles from the residues and allowed to stand for 4 h. The mixture of each sample was filtered by filter paper under vacuum condition and kept in refrigerator until use.

Separation, identification and quantification of phytotoxines

For identification, 50 µl of the extract was injected in Reversed Phase Liquid Chromatogram (RVLC Shimadzu-C-6A) using procedure and condition outlined by Hartley and Buchan (15) and Alsaadawi *et al.* (2). The peaks were detected by UV detector. Standards of suspected phytotoxins were run similarly for identification and quantification. Concentration of each isolated compound was determined using standard procedure.

RESULTS

Effects on weeds of barley crop

Weed flora appeared in barley field comprised mainly of *Avena fatua*, *Melilotus indicus*, *Beta vugaris cicla* and *Centaurea bruguierana* with other minor species such *Cynodon dactylon* and *Lolium rigidum*. Both rates of herbicides and sunflower residues caused significant reduction to total number of these weeds (Table 1). Residues incorporation at 600 and 1400 g m^2significantly suppressed weed density by 23 and 40% of control respectively. The reduction in weeds density increased with the increased rates of herbicides application. However, weeds density suppressed to greater extent when herbicides applied in plots where sunflower residues were incorporated. Herbicides and sunflower residues showed complementary interaction and recorded 19 to 50% more suppression to weeds density than recommended dose. Reduced herbicide dose (50%) in combination with sunflower residue at 1400 g per m^2 scored weed suppression similar to that realized with recommended dose used alone, while reduced dose (75%) in combination with residues at 600 and 1400 g per m^2suppressed weeds density by 30 % over the recommended dose of herbicide alone.

Table 1: Effects of different rates of herbicides (H) and residues (R) of sunflower cv. Coupan on total weeds density in barley field

Herbicide rates* (% of recommended doses)	Residues rates (g m^{-2})**			
	0	600	1400	Average
0 (Control)	365.0	282.0	220.0	289.0
50	239.0	213.5	183.5	212.0
75	217.0	170.0	128.0	171.7
100	182.5	148.0	90.5	140.3
Average	250.9	203.4	155.5	
LSD = 0.05	H = 13.7	R = 7.8	H × R= 21.4	

*Recommended doses of 2, 4- D and Topic are 1.5 liters ha^{-1} and 750 ml ha^{-1} respectively. ** Each number is an average of 4 replicates.

Weeds biomass was significantly inhibited by the herbicides and sunflower residues treatments. The inhibition was significantly increased with increasing rates of herbicide and residues incorporated into the soil (Table 2). Recommended dose of herbicide when applied to plots amended with sunflower residues at 1400 g m^{-2} scored 2.85 times more weeds biomass suppression than recommended herbicide dose used alone (Table 2). Reduced herbicides rates used in plots where sunflower residues were applied gave even higher reduction in weed dry matter accumulation as compared with plots where such doses were

used alone. Use of 50% of recommended dose of herbicide coupled with 1400 g. m^{-2} sunflower residues scored statistically similar suppression of weeds biomass compared to that achieved with the same herbicide dose applied alone. Treatment of 1400 g. m^2 sunflower residues + 75% of recommended dose of herbicides caused greater weed biomass suppression than recommended dose of herbicide alone.

Table 2: Effects of different rates of herbicides (H) and residues (R) of sunflower cv. Coupan on total weeds biomass in barley field

Herbicide rates * (% of recommended doses)	Residues rates (g m^{-2})**			
	0	600	1400	Average
0 (Control)	1136.5	634.5	451.0	740.7
50	569.5	448.0	318.0	445.2
75	459.0	317.5	190.5	322.3
100	348.0	265.0	122.0	245.0
Average	628.3	416.3	270.4	
LSD = 0.05	H = 69.1	R = 92.3	H × R =129.3	

*Recommended doses of 2, 4- D and Topic are 1.5 liters ha^{-1} and 750 ml ha^{-1} respectively. ** Each number is an average of 4 replicates.

Effects on barley crop

All test agronomic traits of barley was significantly affected by treatments of herbicides and sunflower residues and their interaction (Table 3). Combination of recommended dose of herbicides with sunflower residues at 1400 g m^{-2} produced maximum above ground biomass and minimum plant height compared to recommended herbicide dose applied alone. Use 50% of recommended dose of herbicides in combination with 1400 g m^2 gave straw biomass similar to the recommended dose of herbicide alone but increased number of tillers per plant by 37% over recommended dose alone respectively, while the use of 75% of recommended dose of herbicides accompanied with sunflower residues at 1400 g m^{-2} reduced straw biomass by over the recommended herbicide dose only.

Table 3: Effects of different rates of herbicide (H) and residues (R) of sunflower cv. Coupan on some agronomic traits of barley

Herbicide rates *	Residues rates (g m^{-2})**			
	0	600	1400	Average
		Plant height (cm)		
0 (Control)	77.6	69.5	74.3	73.8
50	68.3	66.5	72.3	69.0
75	67.3	63.3	68.7	66.4
100	65.8	75.1	63.0	67.9
Average	69.8	68.6	69.6	
LSD = 0.05	H = 2.0	R = NS	H × R= 3.3	
		Straw biomass (g m^{-2})		
0 (Control)	167.5	199.0	223.5	196.7
50	212.3	232.5	284.8	243.2
75	233.0	274.3	330.0	279.1
100	282.3	307.0	379.5	322.9
Average	223.8	253.2	304.5	
LSD = 0.05	H = 6.4	R =9.4	H ×R= 12.5	
		Number of tillers per plant		
0 (Control)	2.9	3.0	3.2	3.0
50	3.2	2.7	3.5	3.1
75	2.7	2.9	3.7	3.1
100	2.7	3.2	3.7	3.2
Average	2.9	3.0	3.5	
LSD = 0.05	H= 0.22	R= 0.31	H×R= 0.43	

Recommended doses 2, 4- D and Topic are 1.5 liters ha^{-1} and 750 ml ha^{-1} respectively.** Each number is an average of 4 replicates.

More number of spikes m^{-2} and greater yield over control was observed for most of the treatments (Table 4). Combination of herbicide and sunflower residue at 1400 g m^{-2} appeared superior in enhancing number of spikes, weight of 100 grains and yield per unit area than herbicide alone. Application of 50% dose of herbicides in plots amended with sunflower residue resulted in statistically similar yield as was noticed at 100% herbicide dose. Maximum yield (1045 g m^{-2}) was harvested from plots applied with recommended dose of herbicides + sunflower residue at 1400 g m^{-2}.

Table 4: Effects of different rates of herbicide (H) and residues (R) of sunflower cv. Coupan on yield and yield component of barley

Herbicide rates *	Residues rates (g m^{-2})**			
	0	600	1400	Average
		Number of spikes m^{-2}		
0 (Control)	78.9	96.8	92.5	89.4
50	88.2	106.5	106.5	100.4
75	98.0	102.1	120.5	106.9
100	104.3	104.6	128.3	112.4
Average	92.4	102.5	112.0	
LSD = 0.05	H = 6.1	R = 5.3	H×R=10.0	
		Number of grains per spike		
0 (Control)	51.8	51.0	50.8	51.2
50	52.0	50.0	51.3	51.1
75	53.0	52.0	51.8	52.3
100	54.0	53.0	52.5	53.2
Average	52.7	51.5	51.6	
LSD = 0.05	H = NS	R = NS	H×R = NS	
		Weight of 100 grain (g)		
0 (Control)	2.16	2.22	2.62	2.33
50	2.35	3.21	3.23	2.93
75	2.62	3.63	3.87	3.34
100	3.24	3.7	3.93	3.62
Average	2.59	3.19	3.41	
LSD = 0.05	H=0.242	R=0.236	H×R=0.411	
		Yield (g m^{-2})		
0 (Control)	88.4	109.5	123.8	107.2
50	107.9	172.4	179.3	153.2
75	137.1	194.0	241.6	190.9
100	182.6	204..7	264.8	217.4
Average	129.0	170.2	202.4	
LSD = 0.05	H =19.2	R =22.4	H×R =34.2	

*Recommended doses of 2, 4- D and Topic are 1.5 liters ha^{-1} and 750 ml ha^{-1} respectively. ** Each number is an average of 4 replicates.

Phytotoxins isolation, identification and quantification

Chromatographic analysis revealed the presence of chlorogenic, isochlorogenic, caffeic, gallic, syrinigic, hydroxyl benzoic, p-coumaric, ferulic and vanillic acids in the residues of sunflower (Table 5). Catechol was also observed. An appreciable amount of these phytotoxins was recorded in residue incorporated soil. Hydroxy benzoic acid was found to be the predominant constituent (6624 ppm) of residue decomposition products right from beginning. Considerable amounts of caffeic, gallic, syrinigic, ferulic and vanillic acid were also observed. Dynamics of release, decomposition and degradation of phytotoxins into the soil was quite interesting as different phytotoxins showed differential behavior for these processes. Phytotoxins released into the soil, increased with time and reached their peak values at 4 weeks after incorporation of residues. During this period, maximum quantities of chlorogenic, isochlorogenic, caffeic, hydroxyl benzoic, ferulic and vanillic acids as well as catechol were recorded. Afterwards, a sharp decline in the quantities of these phytotoxins was observed at 6 weeks that reached to almost negligible values at 8 weeks. Gallic and syrinigic acid continued to increase up to 6 weeks and thereafter showed a decline. P-coumaric acid was maximum (522 ppm) at 2 weeks, and was not detected after 4 weeks as did ferulic acid.

Table 5: Isolation, identification and quantification of phytotoxins of decomposed sunflower residues in soil at different periods of decomposition

Phenolic acids	Concentration (PPM)*				
	Decomposition periods (week)				
	0	2	4	6	8
Chlorogenic acid	93.23	48.8	76.23	37.46	0.59
Isochlorogenic acid	29.26	85.30	112.06	1.19	0.02
Caffeic acid	164.58	316.28	553.15	265.09	3.93
Gallic acid	126.23	349.16	458.73	665.07	0.26
Syrinigic acid	91.51	314.40	236.52	756.36	3.97
Hydroxy benzoic acid	394.68	386.02	6624.27	179.55	5.46
P- coumaric acid	110.95	521.77	213.41	0.00	0.00
Ferulic acid	84.59	311.50	441.69	0.00	0.00
Vanillic acid	120.33	342.40	494.35	238.52	13.44
Catechol	85.13	206.82	289.20	0.00	3.52
Total	1300.49	2882.15	9499.61	2143.24	31.37

*Average of two replicates

DISCUSSION

Results indicated that Incorporation of sunflower residues into the soil caused substantial weed suppression. This suggests that sunflower residues contain phytotoxic allelochemicals which may release during their decomposition into the soil and affect the receiver species (6). Chromatographic analyses indicated that the residues contain several phytotoxins of phenolic in nature (Table 5). These phytotoxins reached maximum concentration 4 weeks after incorporation of residues in soil then sharply declined at 6 weeks of decomposition in soil. The isolated compounds proved to exert adverse effects on ion uptake (24), chlorophyll biosynthesis (30), cell membrane stability and cellular metabolism (8,18), protein and hormone biosynthesis (16, 26), cell division and ultra structural components of cells (27). Phytotoxic compounds other than phenolic acids have also been isolated from sunflower residues (22). Some of these compounds have been reported to have selective effects on broad leaved weeds (20,19, 3). Most of these allelochemicals are water soluble and when imbibed by the germinating weed seeds, hampered their germination and subsequent seedling growth, thus contributing to overall decline in the density, vigor and stand establishment of the weed community (13).

It is interesting to mention that period indicating maximum quantities of these phytotoxins (first 4 weeks) in soil coincided with the period in which maximum suppressive activity against weeds was noticed in the field, suggesting that these phytotoxins are probably the major cause of weed suppression. After 5 weeks, weeds appeared to emerge and grow but could not compete with barley plants efficiently. Dynamics of release of phytotoxins revealed periodic rise in their level that eventually start declining after 4 weeks. It seems that allelochemicals release into rhizosphere through residue decomposition is a function of time as well as concentration. Decline in the levels of these phytotoxins is due to variety of physico-chemical and biological transformations upon entering into the soil phase as proposed by Blum *et al.*, (7).

Treatment of barley plants with 2, 4-D and Topic significantly suppressed weeds density and biomass. The suppression magnitude was obvious at higher application rates than at lower rates *i.e.* 50 and 75 % of the recommended dose. However, when herbicide application whether at low or recommended dose was applied on plants grown in plots amended with sunflower residues showed greater weeds biomass suppression than sole application of herbicide was achieved (Table 2). Maximum weeds biomass suppression was obtained by integrating 75% of recommended dose of herbicides with sunflower residues at 1400 g m^2. Also, it seems that a reduced level of herbicide (50% of recommended dose) may be feasible for providing weeds control as the recommended dose of herbicides when it works simultaneously with allelopathic conditions. It is possible that the residues inhibited seedling growth and them more susceptible to the even low level of herbicides.

The increase in growth and yield of barley crop by efficient control treatments might be attributed to suppression of weeds in these treatments by residues and thus eliminating the competition with wheat crop (Tables 3, 4). Higher shoot biomass and number of tillers and spikes over control might be attributed to the greater availability of growth factors to barley plants. Allelopathic crops including sunflower can be used as potential means to control weeds and enhancing crop production using different strategies such as using plant extract, plant residues as a cover and mulch, crop rotation, crop mixture and inter cropping practices (3, 24, 12, 11, 1).

Thus it appears those sunflowers residues not only suppress weeds by allelopathic and probably by smothering mechanisms but also improve physical and biological characteristics and nutritional status of the soil. More work needs to be done on other herbicides and crops and under environmental conditions before definite conclusion can be made. However such approach would provide a useful tool for weeds control.

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استخدام مخلفات زهرة الشمس مع جرع منخفضة من المبيدات للسيطرة على ادغال محصول الشعير

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الملخص

تم في تجربة حقلية دراسة تاثير خلط مخلفات زهرة الشمس من الاوراق والسيقان بتربة الحقل بمعدل 700 و 1400 غم مخلفات/م^2 في نمو والتاجية محصول الشعير وادغاله بصورة منفردة او مع استخدام 50، 75 و100% من الجرعة الموصى بها من المبيدين 2,4-D وTopic المستخدمين للادغال عريضة ورفيعة الاوراق على التوالي. سمدت جميع المعاملات بالجرعة الموصى بها من السماد النيتروجيني والفوسفاتي وسقيت عند الحاجة بكميات متساوية من مياه الري. وقد نفذت التجربة وفق تصميم القطاعات العشوائية وبترتيب الالواح المنشقة، اذ مثلت مخلفات الذرة البيضاء الألواح الرئيسة وتراكيز المبيدات الالواح الثانوية و بواقع ثلاثة مكررات لكل معاملة.

سجلت معاملة الجرعة الموصى بها من المبيدين بوجود مخلفات زهرة الشمس بتركيز 1400 غم/م2 اقل وزن جاف (122 غم/م^2) وكثافة للادغال (155.5 دغل/م^2)، وهي اقل من مما سجلته الجرعة الموصى من المبيد لوحدها بنسبة 35 و50% على التوالي. وقد اعطت هذه المعاملة زيادة عالية في عدد السنابل ووزن 1000 حبة وحاصل النبات في وحدة المساحة مقارنة بمعاملة المبيد لوحده. وسجلت معاملة المبيد بالجرعة 50% وبوجود مخلفات زهرة الشمس بالتركيز 1400 غم/م^2 حاصلا مساويا لما اعطته معاملة المبيد لوحده.

واظهرت التحليلات بجهاز الكروموتغرافي السائل وجود العديد من المركبات الفينولية المعروفة بجهدها الاليلوباثي المثبط في التربة الحاوية على مخلفات زهرة الشمس وعدم وجودها في التربة غير الحاوية على تلك المخلفات. ولوحظ ان تراكيز تلك المركبات ازداد بعد اسبوعين من تحلل المخلفات في التربة ووصل الى اعلى مستوى له في الاسبوع الرابع من التحلل، ثم بدأ بالانخفاض الى ان تلاشى في الاسبوع الثامن. وبالمقابل لوحظ ان عدد الادغال ازداد بعد ستة اسابيع وهي الفترة التي شهدت انخفاظا كبيرا للمركبات الفينولية في التربة. وقد ناقش البحث بشيء من الايجاز الابعاد الايجابية لهذه الطريقة في تقليل الاعتماد على المبيدات لمكافحة الادغال.

جزء من رسالة ماجستير للباحث الثاني.
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