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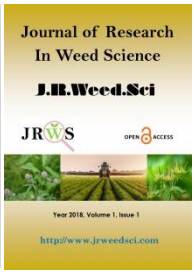

Effects of Cover crop residue management on corn yield and weed control

Rasoul Fakhari[1,*], Ahmad Tobeh[1], Parviz Sharifi Ziveh[2], Ghorban Didehbaz Moghanlo[2], Behrouz Khalil Tahmasbi[1]

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Abstract

The use of cover crops can be considered as an effective method in sustainable agriculture through reducing herbicide use, improving soil and increasing crop yield. An experiment was conducted using randomized complete block design with three replications in Agricultural and natural resources research center of Ardabil (Moghan) in 2015-2016. Cover crops was considered as the main factor (mixed wheat + crimson clover, monoculture wheat and mixed (rye + wheat)) and mulch management as subplots and control (no cover crop use post-emergence herbicide Maister (Foramsulfuron + Idosulfuron 3.1% OD)). The results showed no significant difference between treatments in terms biomass production, the lowest weed biomass was related mixed of rye + wheat in both crop management methods. In wheat and wheat+ rye a significant decrease was observed in crop yield components possibly due to the release of allelopathic materials and soil properties, But the crimson clover mix of wheat + maize yield satisfactory beside weed control a good yield was obtained after the treatment with herbicide. The results showed that the effect of cover crop, crop management and their interaction except grain weight, were significant for ear dry weight, biological yield, number of rows per ear and number of kernels per ear. The highest values of grain yield, ear dry weight, biological yield, number of grains per ear was achieved in treatments clover + wheat and the least amount of yield and yield components of treated wheat were obtained in residues removed management.

Keywords: Crimson clover, grain yield, maister, maize, rye

1- Faculty of Agricultural and Natural Resources, Department of Agronomy and Plant Breeding, University of Mohaghegh Ardabili. Ardabil. Iran. 2- Plant Protection Research Department, Ardabil Agricultural and Natural Resources Research and Education Centre, AREEO, Ardabil, Iran

* Corresponding author r.fakhari@uma.ac.ir

1. Introduction

In recent years, the adverse effects of chemical fertilizers and pesticides on environment have been greatly concerned (Mehdizadeh et al. 2017) and led to more attention about negative impacts on ecosystems such as pollution of soil and water sources and phytotoxic effects on rotational crops (Mehdizadeh et al. 2016). So, ecological approaches are considered for modify these problems and achievement the sustainability in agriculture. One of the effective ways to achieve this objective is planting cover crops and turning in to the soil. Winter cover crops with proper management can be a desirable alternative to conventional methods of weed control which ultimately will increase productivity and reach the goals of established sustainable agriculture. Cover crops influence physical, chemical and biological soil properties, the circulation of nutrients and organic carbon, reduce weed growth and crop yield (Blanco-Canqui et al. 2015). Prevention of the growth of weeds by the remains of several Crimson clover and hairy vetch was reported (White et al. 1989). One of the benefits of cover crops is controlling weeds and preventing light from reaching to photoblastic weed seeds so that it will prevent germination and growth. In an experiment on the effects of cover crop on weed growth, it was shown that a pure culture of cover crop of rye and mixed rye + chickpea (*Cicer arietinum* L.) were greater impact on the growth of weeds than cultivate pure pea (Mary et al. 2000). Also, in their test the ground covered by weeds in wheat and pea mix treatment was less than 2 percent while this covering was more than 73 percent in pure pea treatment. Mulch cover crops, due to lower light levels in the soil and reduce photosynthesis, prevents emergence and growth of weed seeds as a physical barrier of germination and thereby suppresses weed growth (Teasdale et al. 2007). An experiment showed that the light of canopy cover crop of rye, rye + hairy vetch (*Vicia villosa* L.) were 2.5 and 2.3 percent respectively and 7.3 percent in net vetch (Samedani et al. 2007). Cover crops with high biomass production cause faster canopy closure and overcome the weeds (Tokasi et al. 2008; Linars et al. 2008). Cover crops affect soil nutrients by fixing nitrogen in the atmosphere (in the legume family), turnover, and reduced leaching of nutrients (Blanco-Canqui et al. 2015). Also through the cover crop residues in soil, inorganic nitrogen remains accessible for the next crop cultivation through which the use of industrial nitrogen fertilizers is reduced. Shurley (1987) found that by cultivating annual alfalfa and barley nitrogen fixation was done by 66 to 140 kg and weed biomass decreased 65% as well. In another experiment the sowing of different types of cover crops (rye, clover and hairy vetch) with the use of nitrogen fertilizer on maize caused a further rise in yields compared to maize nitrogen fertilizer use alone (Frye et al. 1985). If cover crops are not managed properly they can also prevent the growth of main crop therefore live coverage is essential due to the interference with the necessary sources. The most important subject for successful use of cover crops is to prevent it from competing with the crop by drying or converting them to the residues. To end the growth of cover crops herbicides or mechanical equipment can be used (Fakhari and Tobeh, 2013). A

mechanical method of removing cover crops includes topping up, rolling, rolling on the floor and splitting (Teasdale et al. 2007). The success of these methods depends on the area, cover crop species and stage of development (De Bruin et al. 2005). Cover crops which are managed at flowering time better disappear (De Bruin et al. 2005). Rolling on the floor of cover crops can provide surface mulch to suppress weeds for a longer period of time. The existence of crops residues on the soil surface stimulates the crop growth by keeping moisture in the soil and keeps the soil cooler in environments with warm seasons (Hutchinson and Mc Giffen, 2000). This experiment was done to evaluate cover crops and how to manage them on the yield and yield components of maize as well as the weed control in this crop.

2. Materials and Methods

The experiment was conducted at the Research Station of Agriculture and Natural Resources of Ardabil Province (Moghan) with the altitude 39 degrees 23 minutes to 42 degrees and 39 minutes and longitude 47 ° 25 'to 48 degrees 23 minutes and a height of 72 meters above sea level and semiarid temperate weather conditions in crop year 2015-2016. Physical and chemical properties of soil are shown in Table 1. The experiment was done using a split plot design with randomized complete block in three replications. Where the plant cover was applied as the main factor in three levels (mixed wheat (*Triticum aestivum* L.) + crimson clover (*Trifolium incarnatum* L), monoculture of wheat, mixed rye (*Secale cereal* L.) + wheat. This was replaced in the main plot and crop management factor (residues left on soil surface and residues removing from the plots), was placed in sub plots. Control treatment (without cover crop) by applying the post-emergence Maister (Foramsulfuron + Idosulfuron 3.1% OD) herbicide (1.5 liters per hectare for 4-3 leaf stage of maize) was conducted with three replications beside the main experiment. After preparing the ground operations including a plow, disc and leveling, the seeds of cover crops were cultivated by drill coverage.

The amount of seed for wheat monoculture and mix was 120 kg/ha and 60/ha kg respectively. The amount of seed for clover monoculture was 15 kg/ha. Also, the amount of rye seed in mix was 70 kg/ha. For subplot an area of 15 square meters was considered and the rows were created with the distance of 75 cm from each other. Cover crops were planted in the furrow and each sub-plot had 4 rows of 5 m long. On 29 April, 2016 and 10 days before maize planting, the cover crops had been managed by following methods:

a) Mowing and leaving the residue on surface of plots

b) Mowing and removing them from the plots (simulated grazing).

On May 20, late ripen maize seeds were cultivated manually on the soil with a distance of 75 cm between row, 20 cm on row and depth of 5 cm. For the control, herbicides Maister 3.1% OD with the proportion of 1.5 liters per hectare for post-emergence at 3-4 leaf stage of maize by Matabi backpack sprayer equipped with nozzle sag with the pressure of 2 to

2.5 bar was applied. The first irrigation was done after planting and the next was done based on watering weather conditions between 5 and 8 days later. To investigate the effect of cover crops on density, weed biomass natural populations of weeds, the sampling was done of the 6-8 leaf stage of maize by using a quadrat 50 cm × 50 cm (0.25 m^2). All weeds of each treatment were counted and were sent to the laboratory. The samples were dried for 48 hours in an oven at 75 °C and then weighed. The harvest of maize was done manually on 12 October from the two middle lines of each plot after removing side effect of 0.5 m from the top and down and the components of yield, cob number of rows, number of kernels per ear of maize and maize seed were weighed and measured. Analysis of variance and statistical analysis were performed using SAS software and LSD mean comparison test was performed at the probability level of 5%. Mean comparisons of traits in a control experiment and T-test was also performed.

Table1- Physical and chemical properties of field soil.

Organic carbon (%)	soil Texture	Salinity (ds/m^{-1})	K (ppm)	P (ppm)	N (%)	Clay (%)	Silt (%)	Sand (%)
0.2	Clay Lom	0.81	448.8	11.2	0.1	41	42	17

3. Results and Discussion

3.1. The effect of cover crop and weed management on the dry weight

Weed species were including red root pigweed (*Amaranthus retroflexus* L.), common lambsquarters (*Chenopodium album* L.), common purslane (*Portulaca oleracea* L.), johnson grass (*Sorghum halepense* Pers.) and field bindweed (*Convolvulus arvensis* L.). The results showed that the dry weight of cover crops were not significantly different from each other (Figure 1). Looking at the results reveals that the lowest weed dry weight was in mixture of rye + wheat in the management of the leaving the residue and the highest weed dry weight were obtained in wheat residues removing management (figure 1). The reasons for high allopathic potential of rye is that although its dry weight was almost same to other treatments, at the same time it has greater impact as a result of decay and decomposition (the rye plant tissues because woody and hard of late rotten) and has the greatest impact in terms of production of allopathic. In general, the total biomass of weeds in the residues left on soil surface was less than residues removing from the plots (Figure 1). We can say that probably in the residues removing treatments, due to the removal of canopy cover, weeds have better conditions for growth and biomass production. The placement of mulch as a result of more lasting residue on the soil surface and thereby producing allopathic more likely to create unfavorable conditions for the weeds. Bilalis et al. (2009) showed that the lowest weed dry weight and density were obtained in red clover and hairy vetch cover crops. The researchers said that this was due to the decline transmitted light to the lower parts of the canopy cover crops compared to the control treatment which results in

reduction in photosynthetic activity and thus reduce weed density and weed biomass. Sadeghpour et al. (2014) found that rye reduced weed biomass (76%) compared to the control and 71 percent compared to oat (*Avena sativa*). The reason for the higher biomass control of rye is its allelopathic property. Samedani et al. (2007) Reported that controls weed better rye due to its high biomass. Hasannejad and Alizadeh (2005) reported that rye significantly controls pigweed, lambsquarters, salsola spp. and bindweed compared with the control (without cover crop). The density and biomass of field bindweed in living rye treatment reduced 100% (Samadani and Montazeri, 2009). Elmore (1980) observed that rye residue has remains a large potential to reduce the biomass of weeds, especially in annual plants. In an experiment, the cultivation of rye with a density of 157 kg per hectare in early fall, had an optimal weeds control (Smeda and Weller, 1996).

3.2. Comparison the effect of cover crops to control (herbicide use) on weeds total dry weight

The evaluation of cover crop revealed their effects and how to manage them compared to the control without cover crop (herbicide) on total dry weight of weeds indicated a significant difference between treatments for cover crops and control treatment (Table 3). In other words, the lowest weeds total dry weight was for the application of herbicide Maister 3.1% OD and then mulch treatments rye + wheat management (Figure 1). Samdani et al. (2005) showed that mulch rye, wheat, vetch and glyphosate, reduced biomass of bindweed 100 100, 100, 56 percent respectively. DE Haan et al. (1993) introduced the use of cover crops between rows of crop and herbicide option to replace conventional tillage and stated that as spring planting alfalfa (*Medicago sativa*), without reducing crop yield, reduced weed density up to 80 percent.

Table 2- Analysis of variance based on the mean squared affected by different cover crops.

S.O.V.	df	Mean squares	
		Cover crop biomass	Total weed biomass
Replication	2	4266.67 ^{ns}	6.05^{ns}
Cover crop (A)	2	466.67 ^{ns}	286.22*
Main Error	4	933.33	572.43
Management (B)	1	612.04 ^{ns}	647.01**
A*B	2	538.09 ^{ns}	263.36**
Sub Error	17	59.32	54.18
CV (%)		21.13	25.42

ns,* and ** represent non-significant and significant at 5 and 1% level of probability

Table3- Comparison of the average biomass of weed control (no cover crop with herbicide application) and using cover crops treatments (T-test).

Treatments	Total weed biomass
Control (With Herbicide)	9.5
Clover+ Wheat (residues removing from the plots)	35.98 **
Clover+ Wheat (left on soil surface)	32.58 **
Wheat (residues removing from the plots)	45.4**
Wheat (left on soil surface)	20.78 **
Rye+ Wheat (residues removing from the plots)	23.82*
Rye+ Wheat (left on soil surface)	18.47*

The means with similar letter did not show significant differences. ns, * and ** represent non-significant, significant at 5 and 1% level of probability.

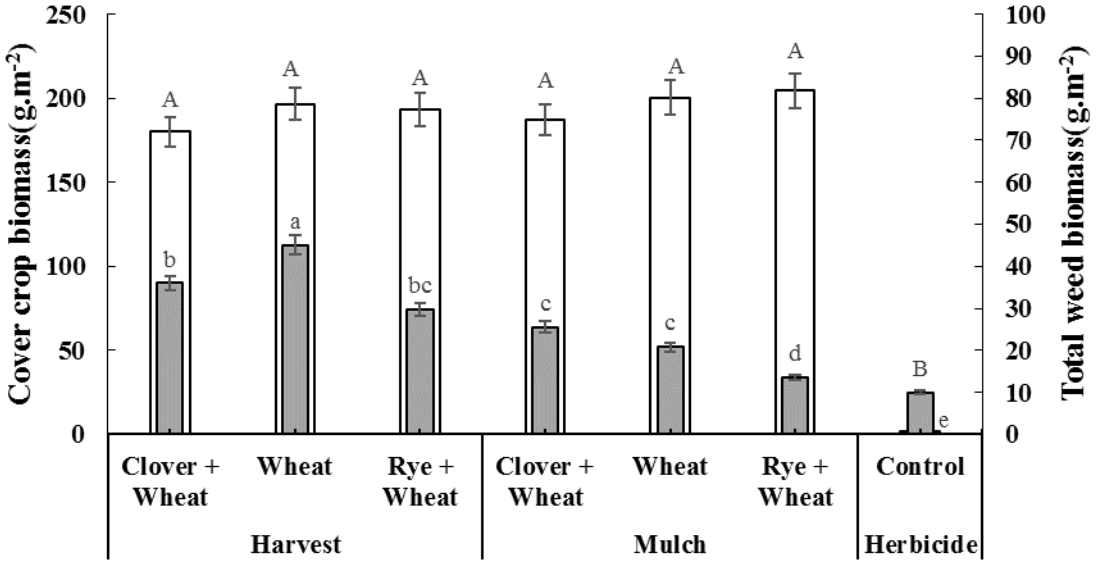

Figure 1- Effect of cover crop on total weeds biomass (Colorless columns (with large Latin letters) and shaded column (with a small Latin letters) represent the total dry weight biomass and dry weight of total cover crops respectively).

3.3. The effect of cover crop on maize yield and yield components

The results showed significant effect of cover crop, mulch management and their interaction on grain weight, ear dry weight, biological yield, number of rows per ear and number of kernels per ear were significant (Table 4) however the effects on grain yield was not significant. The highest values of grain yield, dry matter ear, biological yield, number of rows per ear and number of kernels per ear obtained for the treatment clover + wheat

residues removing management and the least amount of yield and yield components were obtained from treated wheat residues removing management (Table 5). Wortman et al. (2012) showed that planting cover crops and their management by the methods of mixed with soil and mowing, in rotation, sunflower, maize and soybeans, it became clear that management of undercutting cover crops increased the yield of maize and soybeans.

The results of the effect of cover crops and their management showed that although cover crop treatments were in the same group considering one hundred seed weight, seed weight treated with the mixture of clover + wheat were less in both managed (table5). Given that the test treatment crimson clover + mixture produced less biomass due to clover slow growth plants and nutrients (especially nitrogen) were absorbed less from the soil during its growth. Therefore the remaining nitrogen and more moisture had stored in the soil which could be used by the next season ultimately increasing the yield of maize (Table 5).

3.4. Comparison of the effect of cover crops to control (herbicide) on the yield of maize

The comparison of yield and yield components of maize between different treatments and control showed that there was no significant difference between the control and treatment clover + wheat residues removing management for grain yield, ear weight row and number (Table 6). Because of the roots and residues added by cover crops to the soil, and the presence of nitrogen by clover and thus change of the C/N ratio, probably microorganisms cause further decomposition of organic matter and increasing organic carbon and nitrogen mineral which improves maize yield is accessible by the main crop. Soil microbial activity is associated with the amount of organic matter and nutrient availability for crop (Blanco-Canqui et al. 2015). Therefore, it can be said that the cultivation of winter crops to control weeds can be effective for maize plant regarding its quality components. For biological yield, grain weight per ear and seed treatments there was no significant difference and the control (table 4). In other words, for these attributes control without cover crop with herbicide application is more favorable a reason for the possible decrease in maize trails in the treatments of wheat and rye wheat can the effect of the plants romans on maize. Because the reaction of cover crops is similar to weeds in many cases. Cover crops can behave like weeds if not managed well, by depleting inherent moisture and nutrient reserves and reducing yield of the following crop as noted by (Salako and Tian, 2003). Reductions of cover crops residue, especially small grains, is related to reduced nitrogen availability, free of toxins and reduce soil temperature (Norsworthy, 2004; Westgate et al. 2005). Blanco-Canqui et al. (2013) reported that cover crops did not increase crop yield, but they reduces wind and water erosion, improve physical, chemical and biological properties of soil (Blanco-Canqui et al. 2013).

Table 4- Analysis of variance based on the mean square of maize affected by different cover crops.

S.O.V	df	Mean Squares					
		grain yield	ear dry weight	biological yield	number of rows per ear	number of kernels per ear	100 kernels weight
Replication	2	99.55**	42.89^{ns}	1151.05^{ns}	0.39^{ns}	1.50*	34.19^{ns}
Cover crop (A)	2	3610.39**	768.05**	38149.39**	1.05*	45.17**	71.28^{ns}
Main Error	4	7220.78	1536.11	76298.78	2.11	90.33	142.57
Management (B)	1	2862.72**	23762.00**	93456.06**	2.00**	26.89**	3.87^{ns}
A*B	2	80.55**	10134.50**	24376.39**	1.171*	/1.72*	26.43^{ns}
Sub Error	17	8.22	17.16	562.44	0.11	0.28	32.42
CV (%)		14.89	21.50	19.73	22.67	21.51	23.18

ns,* and ** represent non-significant and significant at 5 and 1% level of probability.

Table 5- Comparison of interaction effects and management of cover crops on maize traits

Treatments	Mean comparison					
	grain yield ($k.ha^{-1}$)	ear dry weight ($k.ha^{-1}$)	biological yield ($k.ha^{-1}$)	number of rows per ear	number of kernels per ear	100 kernels weight (gr)
Control (With Herbicide)	372.27 a	355.67 a	1475.04 a	13.67 a	26.32 a	24.98 a
Clover+ Wheat (residues removing from the plots)	324.11 b	325.44 b	1433.33 ab	12.31 bc	22.33 b	23.98 a
Clover+ Wheat (left on soil surface)	294.47 c	207.67 f	1148.33 d	12.15 c	20.25 c	22.15 a
Wheat (residues removing from the plots)	305.10 c	270.66 c	1405.62 c	12.19 c	18.67 d	25.81 a
Wheat (left on soil surface)	320.73 b	240.31 e	1305.17 c	12.67 b	20.43 c	19.11 a
Rye+ Wheat (residues removing from the plots)	303.33 c	255.32 d	1427.67 b	12.82 c	18.13 d	22.33 a

The means with similar letter did not show significant differences.

Table 6- Comparison of the average maize yield in control (no cover crop with herbicide application) and using cover crops treatments using T-test.

Treatments	Mean comparison					
	grain yield ($k.ha^{-1}$)	ear dry weight ($k.ha^{-1}$)	biological yield ($k.ha^{-1}$)	number of rows per ear (No)	number of kernels per ear (No)	100 kernels weight (gr)
Control (With Herbicide)	386.67	410.25	1810.32	14.70	29.33	27.24
Clover+ Wheat (residues removing from the plots)	372.27 ^{ns}	355.67 ^{ns}	1475.04*	13.67^{ns}	26.32*	24.98*
Clover+ Wheat (left on soil surface)	324.11*	325.44*	1433.33*	12.31*	22.33*	23.98*
Wheat (residues removing from the plots)	294.47 **	207.67*	1148.33*	12.15*	20.25*	22.15*
Wheat (left on soil surface)	305.10*	270.66*	1405.62*	12.19*	18.67**	25.81*
Rye+ Wheat (residues removing from the plots)	320.73*	240.31*	1305.17*	12.67*	20.43*	19.11**
Control (Herbicide)	303.33*	255.32*	1427.67*	12.82*	18.13**	22.33*

The means with similar letter did not show significant differences.
ns,* and ** represent non-significant and significant at 5 and 1% level of probability.

Conflict of interest

No conflicts of interest have been declared.

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