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Possible Controlling Effects of Cover Crops on Weeds in Subsequent Cultivation (Corn) under Different Tillage Methods

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Abstract: In order to investigation of possible controlling effects of cover crops on weeds in subsequent cultivation (Corn) under Different Tillage Methods, two factorial experiment based on randomized complete block design were carried out in Karaj, Iran, in 2006, in two separate parts of a farmland considering great variations in growth and diversity of weeds. The main factor was cover crops including control (without crop cover), hairy vetch, Persian clover and rye and the second factor was planting date of cover crops under surface or disk tillage and common or moldboard tillage. One experiment was done before corn cultivation according to initial plot plan under disk tillage and another one was carried out under moldboard tillage with cultivation of corn SCK108. Results showed that inhibition potential of these two crops is higher due to higher N content of their aerial and root system (residue) that lead to increase in mean mineral and organic N content under disk tillage. It is possible that released inhibitors with higher remained N in soil had toxicity effects on weed germination, so that weed plant number and density decreased with the increase in N content of vetch and clover residue. The plant number of these weeds significantly decreased through planting vetch, Persian clover or rye as cover crop under surface tillage compared to control. Their TDW in the presence of vetch and Persian clover was significantly lower than that in the rye and control treatments under same tillage method. Similarly, soil mineral N content in the depth of 20-40 cm aggregately in three planting date under disk tillage in vetch and clover treatments was significantly higher than that in rye treatment that corresponds to the status of weeds. The amount of mineral N content was highest in rye treatment among all treatments under moldboard tillage. Among two kinds of tillage, surface or disk tillage had better results compared to common or moldboard tillage. It seems that nowadays surface tillage by different implements was extensively used in the cultivation of different crops under different conditions.

Key words: Cover crops, corn, planting date, tillage method and weed control

INTRODUCTION

Integrating reduced tillage with cover crop cultivation minimizes weed populations at subsequent cultivation. The management of this system respecting tillage and factors relating to cover crop cultivation including species, growth period, planting and harvest date, chilling resistance, growth rate, competitiveness with weeds and primary crop (subsequent cultivation), allelopatic effects, application

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method as fresh or dead mulch, harvest and mixing with soil etc., is laborious and needs to be investigated in order to select the best method and integrate foregoing factors to reach the maximum controlling effect on weeds. The growth inhibition of some weeds through application of extracts produced by residue of clover-crimson and hairy vetch was reported by Kafi *et al*. (2005), so that if legume residue is not mixed with soil, their controlling effect on some weeds will reduce. There are some evidences denoting the allelopatic effect of leaf extracts and clover residue as well as the reduction of weeds biomass due to rye dead mulch accompanied by tillage in corn cultivation (Blevins *et al*., 1990). Emam and Niknejhad (2004) found that rye dead mulch can properly control broad-leafed weeds in some cereals under non-tillage method. They showed that application of root residue and mulch of rye at early growth stages lead to more than 90% decrease in the growth of lambs quarters. In another study, they reported that rye plants have 20-60% inhibition effect on lambs quarters, redroot pigweed and palmer amaranth. Allelopathy is the harmful effect of supreme plants on germination and growth of other crop species. The effects of materials produced by narrow-leafed plants or grasses on the growth of plants are lower than the effects of legumes, Application of chemical fertilizers neutralizes the effects of cover plants because it satisfies the shortage in crop growth (Alizadeh, 2002). Inhibition effects have been observed around decomposing materials. If the decomposition of alive plant materials or crop residue prolongs e.g., under a cold and humid condition, they will stay in soil for longer time and therefore, their harmful effects will be greater. Phytotoxin production rate increases in higher temperature and lower pH (Koochaki and Mohassed, 2001). The decomposition of residue in saturated (non-aerobic) soil has greater inhibition effect than that in soil with lower moisture. In another experiment about the effect of age on various stages of plant growth, two fresh plants including corn and alfalfa, as well as dried oat and soybean were studied. Higher N content in fresh plant extracts had a higher toxicity effect on corn germination. The study of decomposed extracts of these plants showed that N content of soybean, oat, corn and alfalfa were 162, 136, 283 and 612 mg L^{-1}, respectively. Therefore, N content of corn and alfalfa was 1.9 and 4.1 times greater than that of soybean and oat, respectively (Koochaki and Mohassed, 2001). In another research, it was concluded that higher organic N content of wheat stem during decomposition stimulates microbus activity and increases the inhibition effect on weed germination and growth (Kafi *et al*., 2005). Plant age and growth stage influence the decomposition, decay, phytotoxin production and consequently, toxicity effects on the growth of the subsequent plant. Therefore, both age and growth stage affect the production of inhibitors and N whose abundance can have toxicity effects on plant germination and growth. In a study, it was revealed that the phytotoxin effects of wheat and oat had been decreased with time but the decomposed corn residue had still had toxicity signs after 22 weeks. It was found that fresh residue of maize had more inhibition effect on plant root and aerial system growth than aged one (Koochaki and Mohassed, 2001). Many studies have been carried out about the winter cover crops in which different kinds of tillage have been integrated together in order to find their relations with weed population (density) and biomass reduction. In addition to the physical effects of cover crops on weed growth and development (for example, rapid growth of rye and its effect on weed smothering), these crops may have allelochemical compounds. These compounds limit the weed growth in subsequent cultivation. Most studies have been focused on small-grains such as rye, wheat, oat and barley and legumes such as vetch, crimson clover, clover-sub and other cultivars of clover. These studies mostly prove the considerable capability of cover crops in controlling weeds and in most studies, it was revealed that cover crops not only physically affect weed but also they have allelopatic effects on them (Khajehpour, 2004). The root exudations of navy bean and corn inhibit the growth of lambs quarters, redroot pigweed and palmer amaranth (Emam and Niknejhad, 2004). In the cultivation of soybean and sunflower, with the return of rye, the population density of lambs quarters and celosia was decreased by 99 and 96%, respectively (Hashemidez *et al*., 1998). In the case of using disk tillage for preparing soil in spring, cover crops such

as rye are used for competing with weeds, covering the soil during winter and improving it (Khajehpour, 2004).

This study was carried out to determine the inhibition effects of various cover crop residue on weed growth in corn cultivation, the effect of cover crops, common tillage (moldboard) and surface tillage on the weed weight in different stages of weeding and some other controlling effects of cover crops on weeds in subsequent cultivation (corn) in the case of harvesting the cover crops in spring and using two kind of tillage including moldboard and disk tillage in order to plant corn. In the second year, different planting dates of cover crops whose effects had been recognized as a main factor was replaced by corn cultivars.

MATERIALS AND METHODS

This study has been done in 2006 in investigative field research of Karaj, Iran, in which two investigations carried out factorial experiment based on randomized complete block design. Disk tillage and moldboard tillage were applied in the first and second experiments, respectively. In both experiments, various cover crops including normal (without cover crops), hairy vetch, Persian clover and rye as well as three different planting dates including late September, early October and late October were studied in 4 replications. Sampling included the followings:

(1) Sampling weeds from areas of 1.5 m^2 experimental plot, (2) Counting important weeds involving potulaca, redroot pigweed, palmer amaranth, lambs quarters, cocklebur, convolvulus, jimson weed and purple-nutsedge (*Cyperus rotundus*) separately in order to determine their population density, (3) Determining the Total Dry Weight (TDW) of weeds in each sampling through putting in an oven with a temperature of 70°C for 48 h and (4) Regarding the reports stating the toxicity effects of released N from roots and residue of cover crops on subsequent cultivation (like corn) under special conditions, roots and residue of these crops inside and outside the soil were randomly sampled in every 1.5 m along planted lines after their harvest and after washing, they were naturally dried by sun light. Then the samples relative to each cover crop were powdered by Miller-6000 and then, the powder was tested by Kejeldal method to determine the N content. Other measurements, which were useful in the test concerning inhibition effect potential (allelopatic, toxicity and allelochemical) and/or other soil N effect on weed plant density and dry weight, were done as following and (5) Determining mineral N content separately involving nitrate and ammonium N, organic carbon (matters) and soil moisture content percentage.

RESULTS AND DISCUSSION

Effects of Cover Crops and Their Planting Dates on Weeds

The results of variance analysis of weed TDWs under disk tillage condition and means comparison indicated the significant effect of cover crops in both weedings and sum of two weedings (Table 1). Hairy vetch and Persian clover treatments faced significantly lower weed TDWs than rye and control treatments in both weeding, specially first one that coincided with the initial stages of corn growth. Corn plants are highly sensitive to weeds in this stage which is of importance in disk tillage for early cultivar 108. The reason is seemingly the relative limitation of weed growth due to fertilizer used at the first stages of corn growth and remaining N from these two crops. This increases the growth role of corn on the one hand and toxicity or production of inhibitors on the other hand whose final implication is limited growth of weeds. In the second weeding, the lowest weed biomass was observed in hairy vetch treatment and the differences between other treatments were not statistically significant.

The reduction of clover effect in second weeding may be due to fast decay of Persian clover. Therefore, its maximum effect on weed biomass was achieved in first weeding. On the other hand,

Table 1: Means comparison of Weed Dry Weight (WDW) in corn cultivation under minimum tillage

Treatment	WDW in first weeding	WDW in second weeding	Total WDW
	----------(g)----------		
Cover crop			
Control (C0)	105.2ab	116.9a	222.1a
Hairy vetch (C1)	94.1c	88.8b	182.9c
Persian clover (C2)	96.0bc	98.4ab	194.4bc
Rye (C3)	110.2a	101.9ab	212.1ab
Planting date			
Late Sept. (D1)	105.9a	106.5a	212.4a
Early Oct. (D2)	103.6a	97.4a	200.9a
Mid-Oct. (D3)	94.6a	100.6a	195.6a
Cover crop×Planting date			
C0×D1	105.1b	116.9a	222.1ab
C0×D2	104.1b	116.4a	222.1ab
C0×D3	105.3b	116.7a	222.2ab
C1×D1	93.1bc	106.8ab	199.9abc
C1×D2	94.5b	78.5b	173.1c
C1×D3	94.6b	81.0ab	175.6c
C2×D1	88.5bc	101.17ab	190.2bc
C2×D2	123.2a	91.5ab	214.7abc
C2×D3	76.5c	101.9ab	178.4c
C3×D1	137.0a	100.5ab	237.5a
C3×D2	91.5bc	102.5ab	194.0bc
C3×D3	102.1b	102.7ab	204.8abc

Mean differences with same letter(s) in columns are not statistically significant based on Duncan test in probability level of 5%

Table 2: Means comparison of weed number in first weeding in corn cultivation under minimum tillage

Treatment	TWN	Common purslane	Redroot piweed	Lambs quarters	Johnsongrass	Palmer amaranth	Convolvulus	Cocklebur	Purple nutsedge
Cover crops									
Control (C0)	77.67a	13.03a	11.75a	14.67a	3.87a	10.75a	2.12a	14.45a	0.00a
Hairy vetch (C1)	53.46b	14.75a	12.13a	9.46b	0.78b	5.09b	1.98a	1.34b	1.02a
Persian clover (C2)	47.24b	12.64a	10.11a	10.42ab	1.40b	3.55b	1.65a	0.22b	0.38a
Rye (C3)	60.30ab	19.26a	16.45a	7.78b	2.34ab	5.48b	1.52a	2.56b	0.00a
Planting date									
Late September (D1)	55.70a	14.66a	14.29a	9.44a	2.85a	6.45a	2.10a	3.19a	0.00a
Early October (D2)	64.91a	14.71a	15.54a	11.51a	1.91a	5.73a	1.54a	4.38a	0.00a
Mid-October (D3)	56.12a	15.00a	8.35a	10.40a	1.42a	5.87a	1.82a	3.67a	1.30a

Mean differences with same letter(s) in columns are not statistically significantbased on Duncan test in probability level of 5%

considering this point that rye residue decay and decompose slowly, mean effect of rye residue in second weeding was greater than that in first weeding. According to the sum of both weedings, it is concluded that the effect of hairy vetch and Persian clover on the decrease in weed biomass dry weight has been greater versus control and rye treatments. Planting dates of cover crops did not have a major effect on weeds (Table 1). But the interaction between cover crop species and planting date significantly affected weed biomass in the first weeding. The lowest weed biomass was achieved in clover and hairy vetch treatments particularly at first planting date, which was considerably lower than that in control treatment. As the reason of decline in weed dry weight and population after cover clover and vetch in disk tillage system versus control and rye, it can be argued that according to the measurement of N after cover crops harvest, mineral nitrogen (particularly nitrate) and moisture content percentage was greater in disk tillage for these two crops. On the other hand, since clover and vetch organs and their residue are soft and fragile, they immediately decay in the presence of adequate nitrogen and release inhibitors. Finally, weed TDWs were significantly decreased in cover clover and vetch treatments under disk tillage versus other treatments. Application of cover crops significantly affected the total plant number of johnsongrass, palmer amaranth, cocklebur and lambs quarters. According to Table 2, the trend of cover crops effect on weed plant number was similar to that of weed dry biomass. In other words, Persian clover and hairy vetch had higher controlling effect on weeds than

Table 3: Mean comparison of weed dry weight and number in first weeding in corn cultivation under common tillage

Treatment	Weed TDW	Weed No.	Number of common purslane	Redroot pigweed	Lambs quarters	Johnsongrass	Palmer amaranth	Convolvulus	Cocklebur	Purple Nutsedge
Cover crops										
Control (C0)	282.3a	246.88a	9.21ab	99.25a	33.53a	2.69a	21.92a	5.73a	0.49a	7.32a
Hairy vetch (C1)	131.8b	184.76ab	7.91b	88.21a	15.96b	3.42a	4.09b	3.21a	0.88a	4.16a
Persian clover (C2)	142.5b	139.38b	17.63a	70.52a	7.17b	6.17a	7.67b	2.57a	0.45a	2.75a
Rye (C3)	123.8b	114.29b	9.52ab	53.65a	8.28b	3.96a	7.27b	2.03a	1.75a	3.80a
Planting date										
Late September (D1)	175.3a	178.47a	11.89a	78.20a	14.56a	2.07b	7.58a	2.78a	0.84a	5.86a
Early October (D2)	157.4a	143.20a	10.75a	77.54a	11.23a	3.06b	10.84a	2.42a	0.97a	2.26a
Mid-October (D3)	177.6a	174.28a	9.68a	72.70a	17.88a	7.43a	9.46a	4.86a	0.82a	5.39a

Mean differences with same letter(s) in columns are not statistically significantbased on Duncan test in probability level of 5%

control and rye treatments. Other studies have shown that the density of lambs quarters was significantly decreased in vetch and rye treatments (Blevins *et al*., 1990).

Since celosia, lambs quarters and Johnsongrass are dominant weeds in the region in which the study has been done, according to the results of this study, application of vetch and Persian clover as cover crops led to a significant decrease in density of these weed species. The effect of planting dates of cover crops and their interactions with cover crop species on total plant number and density of weed was not statistically significant. Table 3 is clear that the effect of cover crops on weed dry weight and total density was significant. According to Table 3 indicating means comparison of weed dry weight, the highest weed biomass has been gained in control treatment. So all three cover crops considerably control weeds. The order of controlling effect of cover crop treatments was rye, hairy vetch and Persian clover from highest to lowest (the lowest mean weight and plant number of weed were observed under rye treatment). Under deep tillage as well as the decay and decomposition of crop residue and roots, inhibitors are released and consequently, the growth of weed especially small-grain ones are inhibited (Emam and Niknejhad, 2004).

However, in some studies it has been concluded that the decay of crop residue may reduce the inhibition effect (Munawar *et al*., 1990). Rye, which had the highest effect on reducing weed weight under deep tillage, may be influenced by other factors than forgoing factors. Rye plants had the highest growth during fall and winter and produced an extended root system. According to the experiment, probably the inhibition effect of rye on weeds is due to material exuded from the roots and gathered in soil so that probably the inhibition effect of fresh rye would be higher than dead one or its residue. It is important to point that since the tillage methods were different in two separate experiments and statistical comparison between them was not carried out from the viewpoint of experiment fields, but it is necessary to consider the data concerning disk tillage and moldboard tillage in all cases including mean main effects of cover crops, planting dates and interaction between different studied characteristics, dry weight and weed number particularly in the first weeding, mean data comparison in Table 1-3. For example, weed weight in the first weeding for control, hairy vetch, Persian clover and rye treatments were 105, 94, 96 and 110 g, respectively under surface or disk tillage. But the same characteristic was 282.3, 131.8, 142.5 and 123.8 g, respectively under moldboard and common tillage. At least, observation shows a considerable difference between them so that weed weight under common tillage was far greater than that under surface tillage. The same trend was observed in weed plant number, too. As another example, according to Table 4 and 5, mineral and organic N in the depth of 0-20 and 20-40 cm had considerable differences under these two tillage methods. Totally, surface tillage causes a considerable increase in organic and mineral N that leads to a drop of weed weight and number. For example, soil mineral N content in the depth of 0-20 cm under surface tillage for control, hairy vetch, Persian clover and rye treatments was 20.02, 14.83, 13.62 and 14.32 ppm, respectively, while the same characteristics under common tillage was 15.08, 11.9, 9.96 and 11.56 ppm, respectively. This (observational) comparison kept this trend in all characteristics and showed that surface tillage is much better than moldboard tillage.

Table 4: Means comparison of organic and mineral N content of soil after harvesting cover crops in spring disk tillage

	Mineral N		Organic N	
Treatment	Depth of 0-20 cm (ppm)	Depth of 20-40 cm (ppm)	Depth of 0-20 cm (ppm)	Depth of 20-40 cm (ppm)
Cover crop				
Control (C0)	20.02a	22.63a	0.540a	0.470a
Hairy vetch (C1)	14.83b	14.26b	0.526a	0.449a
Persian clover (C2)	13.62b	11.65c	0.536a	0.503a
Rye (C3)	14.32b	10.52d	0.543a	0.457a
Planting date				
Late September (D1)	16.13a	12.92c	0.519a	0.458a
Early October (D2)	14.16b	14.67b	0.531a	0.463a
Mid-October (D3)	16.80a	16.70a	0.558a	0.489a
Cover crop×Planting date				
C0×D1	20.02a	22.45a	0.540a	0.470b
C0×D2	19.95a	22.98a	0.53a	0.475b
C0×D3	19.80a	22.45a	0.54a	0.471b
C1×D1	13.12bc	10.91de	0.530a	0.462b
C1×D2	12.21c	14.87c	0.525a	0.462b
C1×D3	19.15a	17.00b	0.523a	0.422b
C2×D1	12.72bc	9.45e	0.470a	0.460b
C2×D2	11.73c	10.33de	0.565a	0.455b
C2×D3	16.40ab	15.18bc	0.572a	0.595a
C3×D1	18.65a	8.88e	0.538a	0.440b
C3×D2	12.69bc	10.50de	0.493a	0.462b
C3×D3	11.63c	12.17d	0.597a	0.470b

Mean differences with same letter(s) in columns are not statistically significantbased on Duncan test in probability level of 5%

Table 5: Means comparison of organic and mineral N content of soil after harvesting in common tillage

	Mineral N		Organic N	
Treatment	Depth of 0-20 cm (ppm)	Depth of 20-40 cm (ppm)	Depth of 0-20 cm (ppm)	Depth of 20-40 cm (ppm)
Cover crop				
Control (C0)	15.08a	19.03a	0.448ab	0.377a
Hairy vetch (C1)	11.90b	9.84c	0.407b	0.364a
Persian clover (C2)	9.96c	9.63c	0.448ab	0.382a
Rye (C3)	11.56b	11.48b	0.534a	0.437a
Planting date				
Late September (D1)	12.19a	12.39b	0.483a	0.406a
Early October (D2)	11.70a	11.49b	0.463a	0.382a
Mid-October (D3)	12.48a	13.60a	0.431a	0.378a
Cover crop×Planting date				
C0×D1	15.08a	18.95a	0.448b	0.377a
C0×D2	15.03a	19.20a	0.451b	0.375a
C0×D3	15.07a	18.95a	0.444b	0.381a
C1×D1	12.95ab	10.03cd	0.420b	0.363a
C1×D2	11.20bcd	7.32e	0.422b	0.360a
C1×D3	11.55bc	12.17bc	0.377b	0.370a
C2×D1	9.65cd	9.15de	0.445b	0.390a
C2×D2	9.03d	9.34de	0.468ab	0.395a
C2×D3	11.19bcd	10.42cd	0.430b	0.363a
C3×D1	11.10bcd	11.45bcd	0.620a	0.495a
C3×D2	11.48bc	10.10cd	0.513ab	0.415a
C3×D3	12.10b	12.88b	0.470ab	0.403a

Mean differences with same letter(s) in columns are not statistically significant based on Duncan test in probability level of 5%

Nitrogen Content Percentage

According to Table 6, N content of cover crop organs was significant in both first and second study. Among all cover crops in all three studies, hairy vetch and rye had significantly the highest and lowest N content, respectively. In total, hairy vetch, persian clover and red clover had higher N content

than control and rye treatments. Thus hairy vetch with a higher N-uptake potential and even with biological fixation of nitrogen under appropriate conditions, is a suitable cover crop in current or subsequent cultivation. In the second study, N content of cover crop root system has been measured. The root system of hairy vetch and persian clover had significantly higher N content than that of other studied crops. Higher N content of root system may lead to an increase in the soil N content, the reduction of C/N ratio, the reduction of soil pH and specially the possibility of toxicity effects on weed germination and growth (Sarmadnia and Koocheki, 1997; Kafi *et al*., 2005). Deep-root plants have better capability in uptake and use of N from the depth of soil than short-root or taproot plants (Alizadeh, 2002). It should be noted that higher N content in a crop does not mean the uptake and reservation of a higher deal of N unless the crop produces greater biomass.

Nitrogen in Plant Root and Residue

After harvesting cover crops, N content of root systems and residue of these crops and weeds in control treatment was measured (Table 6). Then cover crop N-uptake was compared with weed dry weight and total density in first weeding, second weeding and sum of two weedings under surface tillage condition. Hairy vetch with the highest N content in root and aerial system led to the lowest weed dry weight and total density. Following hairy vetch, persian clover had the highest N content in root and aerial system and accordingly had a negative effect on weed weight and density in subsequent cultivation (Corn). On the other hand, rye treatment with lower N content in root and aerial system led to higher weed weight and density than two other crops. In control treatment, N content in root and aerial system was lower than that in hairy vetch and persian clover but higher than that in rye, because the production of plant matter in control treatment was lower than that of rye and other treatments (because of far lower root and residue production). The comparison between plant matters of all treatments is shown in Table 6. In control treatment, the produced plant matter (fresh or dry) was far lower than that in other treatments.

Therefore, the added N or other compositions compromising N to soil in control treatment were negligible. But in rye treatment, despite of low N content in root and aerial system (residue), a great deal of plant matter was produced and accordingly the added N to soil was higher than that in control treatment. Hence, the highest weed weight and total density in control treatment among all treatments prove that a cover crop, specially crops with higher N content in their root and aerial system (residue), can decrease weed weight and total density. It is important to mention a point about the effect of rye on weeds. Rye as a cover crop has various inhibitors in controlling weeds that can affect the weeds under a certain condition. The foregoing results were achieved in surface tillage (disk tillage) in silt loam soil with 20% content of clay (fine-texture). In all studies with surface tillage, persian clover and hairy vetch have had the highest effect on controlling and reducing weeds versus other treatments, but in common deep tillage, it has been rye that played considerable role in reducing weeds. In other words, the inhibition effect of cover crop is under the influence of tillage method and soil bed condition. Another important point is about soil N content that was measured in two different depths after harvest of cover crops. The amount of soil N content in both form (nitrate and ammonium) as well as organic matters and soil moisture content are the factors determining the status of soil N content (Table 4, 5).

One of the important effects of two studied tillage method is their capability in influencing the condition of releasing existing materials in crop root system and residue. Some other effects are as following: changing the N content in tillage depth via rooting the soil and exuding from cover crop roots during fall and winter in soil depth whose amount alongside the effects of such factors as temperature, pH, organic matters, density variation and nutrient content required by plant in depth of soil, moisture, structure and C/N variation ratio can change the activity of microorganisms (Lopez-Fando and Almendros, 1995; Khajehpour, 2006). As an advantage of disk tillage, it is worth adding that

the tissue of hairy vetch and persian clover is smooth and aqueous which was chipped and mixed in disk tillage and after a short time, the materials in its tissue were released. On the other hand, the tissue of rye is hard and vigorous. Therefore, the surface tillage can not provide appropriate condition for releasing the inhibitors of this crop. According to the reports, legumes decay in shorter period than gramineae or grasses (Blevins *et al*., 1990). Various scientific resources emphasize that disk (surface) tillage is suitable method for fine-texture soil (Wei Shi *et al*., 2004). In addition, it is known that in disk tillage the soil resistance, its moisture and its particle diameters are lower but its temperature is higher than those in non-tillage method (Varco *et al*., 1993). It is necessary to notice that even a great deal of N in soil without plant cover can not effectively control weeds. For instance, according to Table 4 and 5, the remaining N in the depth of 20-40 cm in the form of nitrate in control treatment was higher than that in other treatments in all conditions due to lack of crop and growth of weeds, while the weight and total density of weeds were greater in this treatment than other ones.

Probably, it is due to quick decomposition of hairy vetch and clover residue (as they have smooth and aqueous tissue) that lead to the increase in N content of soil at early stages of corn growth. Therefore, corn plants grow quickly and reduce the density of weeds through competition. Or, rye in common tillage produces a great deal of N and organic carbon via decay that lead to the change of C/N ratio and N content of soil and quick decay of plant matters in soil and hence, provoke the decomposition and release of inhibitors. It is also possible that the N-rich matters due to soil decomposition are firstly released in the form of N-rich inhibitors and prevent weed germination and growth (specially, small-grain ones like redroot pigweed as the dominant weed in this experiment). Alternatively, high N content produced by roots and residue of cover crops may have a toxicity effect on weed germination and growth that usually have small organs. The quick decomposition of legume tissue particularly vetch and clover and the release of considerable amount of N into the soil has been reported (Kafi *et al*., 2005). Another important point is about the effect of rye on weight reduction and low density of weeds under common tillage. According to Table 3, weed dry weight and total density was higher in spring common tillage that had carried out after cover crop harvest in order to prepare

Table 6: Means comparison of Fresh Weight (FW) and Dry Weight (DW) and N concentration (Conc.) and content of cover crops after harvest under disk tillage

Variation source	FW	DW	N Conc	N-uptake	N Conc. of root	DW in late winter
Covler crop						
Control (C0)	2.467d	0.580d	4.00ab	24.3d	1.85b	0.00c
Hairy vetch (C1)	27.910b	4.663b	4.53a	212.1b	2.53a	0.279b
Persian clover (C2)	22.230c	2.975c	3.68b	101.4c	2.68a	0.285b
Rye (C3)	48.400a	12.780a	2.65c	318.9a	1.08c	2.170a
Planting date						
Late September (D1)	32.090a	6.124a	3.52a	195.4a	1.84b	1.117a
Early October (D2)	24.700b	5.208b	3.76a	160.3b	2.07ab	0.6146b
Mid-October (D3)	18.970c	4.415b	3.87a	136.9b	2.19a	0.318c
Cover crop×Planting date						
C0×D1	2.467i	0.580e	4.03a..d	24.4f	1.73de	0.00f
C0×D2	2.462i	0.553e	4.00a..d	22.8f	1.68de	0.00f
C0×D3	2.471i	0.562e	3.95a..d	24.6f	21.15cd	0.00f
C1×D1	38.070cd	5.937b	4.25abc	252.5c	2.25bcd	0.731d
C1×D2	29.200ef	5.031b	4.80a	245.5c	2.73abc	0.633ef
C1×D3	16.470gh	3.020cd	4.55a	138.3d	2.63abc	0.00f
C2×D1	33.500de	4.396bc	2.98b..e	128.1d	2.10cd	0.609d
C2×D2	22.270fg	3.063cd	3.70b..e	110.5de	2.85ab	0.245e
C2×D3	10.930h	1.492de	4.35ab	65.7ef	3.08a	0.00f
C3×D1	54.330a	13.610a	2.85cde	376.7a	1.28ef	3.13a
C3×D2	44.870bc	12.160a	2.52e	260.8c	1.03f	1.378b
C3×D3	46.00b	12.570a	2.58de	319.3b	0.93f	1.271c

Mean differences with same letter(s) in columns are not statistically significant based on Duncan test in probability level of 5%

the soil for corn cultivation than spring surface tillage in all treatments. The comparison between treatments shown in Table 3 indicated that common tillage leads to the increase in rye effect on weeds so that rye, persian clover and vetch had significantly the greatest effect on weeds, respectively, while under disk tillage, vetch and clover as cover crops were far more important than rye with respect to controlling effects on weeds. It may be due to the amount of (root and aerial system) residue and the status and time of decomposition or decay of cover crop. The decomposition and decay is quicker under moldboard tillage than surface tillage and it seems that crops with the highest residue can have more effects on the decrease in weeds because of their high potential in producing growth-inhibitors. It is clear that rye produced significantly highest plant matter (and consequently, the highest amount of root and residue) among all treatments and therefore, it can have the greatest effects with respect to producing both N and inhibitors through decay and decomposition into constituents. In this study with respect to weeds, the decrease in redroot pigweed and lambs quarters (as the dominant weeds in corn cultivation) and convolvulus (*Convolvulus arrensis*) (as a permanent weed) was higher than other weeds.

CONCLUSION

In general, Cover plants used in this research such as Rye led to yield increase of subsequent plant (maize) via inhibition of nitrate leaching. Also, these plants and surface or disk tillage preventing the growth of weed plants (Such as, redroot pigweed (*Amaranthus retroflexus*), palmer amaranth (*Amaranthus palmeri*), lambs quarters (*Chenopodium album*), jonsongrass (*Sorghum halephense*) and cocklebur (*Xanthium stramarium*)), in next crops and decrease of use of herbicides, results in reduction of soil and environmental pollutions. Also, these cover plants according to the climatic circumstances, reached to maturity stage as a crop plant and were harvested and afterwards, maize crop was planted and harvested as second crop. It means that using cover plants, ability to planting two crops in the same year and same field, was prepared.

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