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Effects of Nitrogen Fertilizers and Winter Cover Crops on Corn Yield and Some Soil Characteristics

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ABSTRACT
This study aims at evaluating the effect of green manuring by different cover crops and nitrogen on yield and some soil characteristics, this experiment was conducted a split-plot arrangement in a randomized complete block with four replications in Shahre-Rey, Tehran-Iran. Treatments including, winter cover crop [barley (HordeumVulgareL.), Oat (Avena Sativa L.), rye (Secale Cereal L.), Radish (RaphanusSativus Var. Oleiformis L.) and Perko (Perko PVH)] and no cover as main plot and three levels of nitrogen (recommended amount of nitrogen [300kg/h], 50% more and 50% less than this amount) as a sub plot.The results showed that cover crops had significant effects on biomass, 1000-seed weight, seed yield and harvest index. The maximum corn seed yields (12557 and 1177 kilograms per hectare) were obtained when perko and radish were applied, respectively. On the other hand, nitrogen fertilizer had significant effects on biomass, number of grain per cob, number of grain per row, 1000-seed weight and seed yield so that these traits increased when higher rates of nitrogen were applied. Application of cover crops led to an increasing in organic carbon and nitrogen of soil.
Keywords: Corn, cover crop, green manure, organic carbon

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INTRODUCTION

A cover crop is any living ground cover that is planted into or after a main crop and then commonly killed before the next crop is planted. The use of cover crops is one measure that has been taken in agricultural production in order to increase environmental protection and to encourage sustainable use of natural resources. Cover crops offer many benefits to sustainable agriculture [1]. Soil organic matter (SOM) is a very reactive, ubiquitous component in soils and is important soil quality attribute, which influences the productivity and physical well-being of soils [2]. Cover crops increase soil quality by improving biological, chemical and physical properties including organic carbon content, cation exchange capacity (CEC), aggregate stability and water in filterability [1]. Correspondingly, in cropping systems where use of WCC may result in lower corn yields, possible negative effects need to be decreased. Although using of winter cover crops have been recognized as an effective strategy for reducing potential nitrogen leaching and N maintaining within the cropping system [2]. Evaluating ecophysiological characteristics of corn under WCCs can lead to improved management decisions that maximize positive effects and minimize negative effects associated with the use of WCCs [2]. The main objective of this research was to evaluate the impact of cover crop systems in different applications of nitrogen on corn yield and yield components and some soil characteristic.

MATERIALS AND METHODS

This field experiment was conducted in research farm of Islamic Azad University of Shahre-Rey Tehran-Iran, Corn was planted using 65cm row spacing on10 Oct 2013. The experimental design was a split plot arrangement based on randomized complete block with four replications. Cover crops were [barley (*Hordeum Vulgare*L.), Oat (*Avena Sativa* L.), rye (*Secale Cereal* L.), Radish (*RaphanusSativus Var. Oleiformis* L.) and Perko (Perko PVH)] and no cover as main plot and three levels of nitrogen (recommended

amount of nitrogen [300kg/h], 50% more and 50% less than this amount) as a sub plot were determined. Whole-plots were 6 m wide by 4 m long. Planting dates for WCCs were 10 Oct. 2012. Seeding rates were 150 kg /ha for rye, oat and barley and 35 kg/ ha for radish and perko. Cover crops were killed approximately 4 wk before planting corn. Above-ground cover crop biomass was harvested from a 0.25cm^2 5cm above the soil surface with a flail mower. The harvested forage from each plot was weighed wet, and a subsample was collected and oven dried at 55°C to determine dry matter. Biomass of corn was harvested in maturity stage. Then was measured number of s per gob, number of in each row, number of row, 1000-geaun weight, yield and was calculated harvest index. Three cobs were collected (avoiding the center rows) to determine yield components. Soil samples are normally takenfrom the surface to the tillage depth (6-8 inches deep). The two samples should be placed in separate plastic bags labeled clearly with “0-1 inch” and “0-6 inch” and send them to the laboratory in the same outer cloth bag with one information sheet.
Statistical analysis included ANOVA, Duncan’s multiple range tests, all applied with SAS software, Version 9.1 (SAS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

Effects of cover crops (green manure) on corn biomass yield

Results we obtained show that cover crops had significant effects on corn biomass yield (Table 1). Results of comparison of the means also indicate that there were significant differences between barley and other cover crops (except Perko) that planted before corn (Table 2). The largest biomass of corn (16710.6 kilograms per hectare) was obtained when oilseed radish was planted as cover crop before corn, and the smallest (14499.1 kilograms per hectare) when the cover crop was barley. Adesoji et al. [3] stated that cover crops did not have any significant effects on corn biomass in the first year their project was carried out compared to the control (in which no cover plants had been planted), but that these cover crops had significant effects in the second and third years.

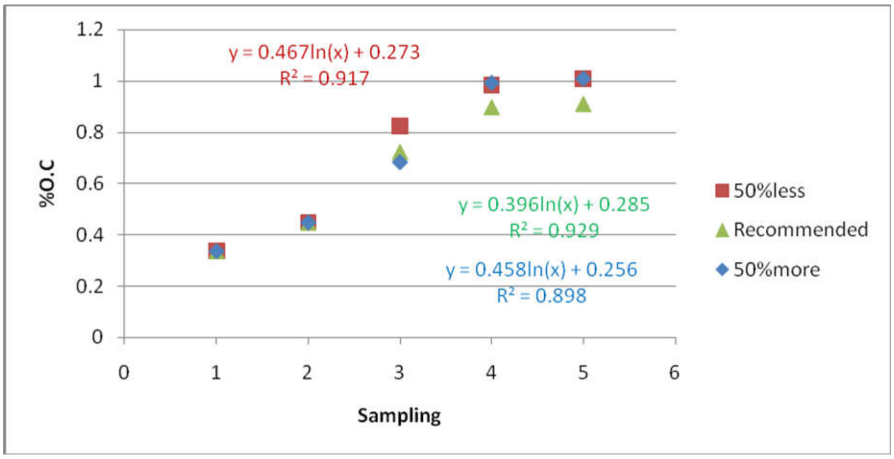

Fig 1- Effect of different levels of nitrogen on percentage of soil organic carbon

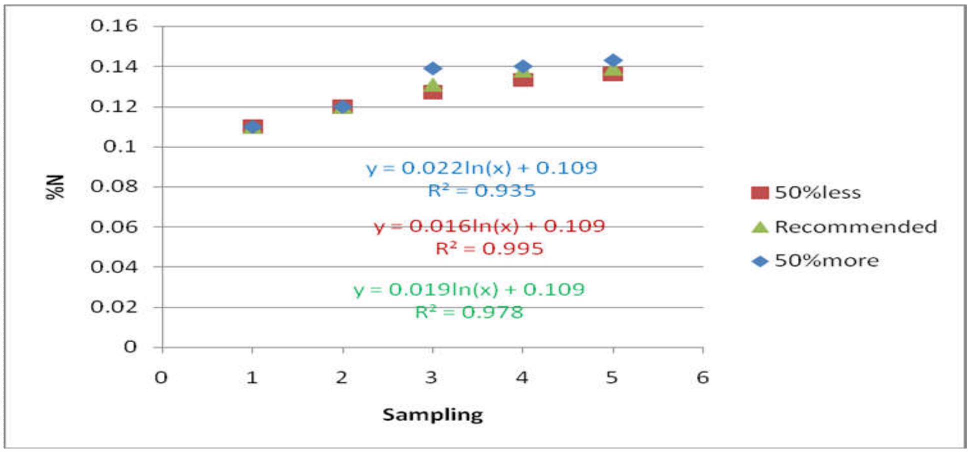

Fig 2- Effect of different levels of nitrogen on percentage of soil nitrogen

Table1. Analysis of variance for yield and yield competitions

S.O.V.	d.f.	MS						
		Biomass	Number of Kernals on row	Number of Kernals	Number of row	Thousand s weight	Yield	Harvest index
Covercrop	5	8409524.1*	24.82 n.s	4300.46n.s	0.68n.s	21763.45**	31178304.3**	0.01*
Block	3	2596774n.s	21.10n.s	2018.31n.s	5.16n.s	9226.42n.s	16754691.2n.s	0.009n.s
Cover crops*Block	15	3274535.8n.s	32.34n.s	7795.01n.s	1.92n.s	5375.18n.s	8819004.3n.s	0.004n.s
Nitrogen	2	52898481.1 **	139.69**	29451.43**	1.48n.s	23030.91**	63081768.9**	0.006n.s
Cover crops*Nitrogen	10	3591142.6n.s	10.80n.s	3591142.6n.s	0.42n.s	6402.99n.s	11183839.3n.s	0.005n.s
Error	72	2515217	23.65	5423	2.28	3289.71	6719309.5	0.003
C.V	-	9.91	16.23	19.97	12.32	18.94	25.23	16

* Significant at the 0.05 level.
** Significant at the 0.01 level.
ns = not significant.

Table2.Means comparison for yield and yield competitions

Cover crop	Biomass	number of Kernals	number of row	number of Kernals in row	Thousand s weight (g)	yield	Harvest index
Radish	16710.6 a	394.24 a	12.62 a	31.31 a	330.27ab	11777 ab	0.40ab
Perko	15716.8 ab	370.37 a	12.52 a	29.58 a	370.68a	12557 a	0.43a
Oat	15907.5 a	340.28 a	12.08 a	28 a	246.24c	8193 c	0.34c
Rye	16539.5 a	367.05 a	12.20 a	30.05 a	287.94bc	9584 bc	0.35bc
Barley	14499.1 b	357.51 a	12.16 a	28.99 a	290.54bc	9458 bc	0.38abc
Control	16605.5a	382.88 a	12.05a	31.85 a	291.17bc	10066 bc	0.37bc

For a given means within each column of each section followed by the same letter are not significantly different (p<0.05)

Table3. Means comparison for yield and yield competitions

Nitrogen	Biomass	Number of Kernals on row	Number of row	Number of Kernals in row	Thousand s weight (g)	Nield	Harvest index
N1	17093.9a	385.88a	12.29a	31.4a	337.35a	11834a	0.39a
N2	16588.4a	391.87a	12.51a	31.32a	293.59b	10385a	0.38a
N3	14307.2b	328.42b	12.02a	27.18b	277.49b	8597b	0.36a

For a given means within each column of each section followed by the same letter are not significantly different (p<0.05)
N1= 1/2 more than recommended
N2= recommended amount
N3= 1/2 less than recommended

Effects of nitrogen on corn biomass

Results in the table of ANOVA show that application of nitrogen had very significant effects on corn biomass (Table 1). Comparison of the means of characters also indicates that there were no significant differences between applying the recommended rate of nitrogen and applying 1.2 times more than the recommended rate (Table 3). The maximum corn biomass (17093.9 kilograms per hectare) was achieved when 1.2 times more than the recommended rate of nitrogen was applied, and the minimum (14307.2 kilograms per hectare) when the rate was 1.2 times less than the recommended one.

Adesoji et al. [3] reported that nitrogen had significant effects on the total dry matter produced in corn, that if more nitrogen were applied the total dry matter produced would also increase, and that the largest quantity of dry matter was obtained when the application rate of nitrogen was 120 kilograms per hectare. Nitrogen increases total dry matter through increasing vegetative growth, plant height, number of leaves, and leaf area index. Results of an experiment carried out by Hokmalipour and Hamele Darbandi [4] demonstrated that raising the rate of application of nitrogen fertilizers caused increases in corn biomass so that the maximum biomass (2350 grams per square meter), compared to the control, was achieved at the application rate of 180 kilograms of nitrogen per hectare. Iqbal et al. [5] reported that increasing the rate of application of nitrogen had significant effects on corn biomass.

Effects of cover crops on the 1000-grain weight
Results in the table of ANOVA indicate that cover crops had very significant effects on the 1000-seed weight of corn (Table 1). Comparison of the means also reveals that there were significant differences between the means of this character so that the largest and smallest 1000-seed weights of corn (370.68 and 246.24 grams) were obtained when Perko and oats had been planted as cover crops, respectively. Results of an experiment Dorota [7] conducted indicated that the 1000-seed weight of spring barley increased after a three-year rotation with cover plants, while these cover crops had no effects on the 1000-seed weight in the first year. Other researchers also showed that the 1000-seed weight of soybean planted after cover crops in common cropping systems improved considerably.

Effects of nitrogen on the 1000-seed weight of corn
Results in the table of ANOVA (Table 1) indicate that application of nitrogen fertilizers had very significant effects on the 1000-seed weight of corn. The table of comparison of the means (Table 3) shows that an increase in the rate of application of nitrogen fertilizers caused a rise in the 1000-seed weight. The maximum 1000-seed weight (227.35 grams) was obtained when the application rate was 1.2 times the recommended one. There were no significant differences between applying the recommended rate and 1.2 times less than the recommended one.

The 1000-seed weight is one of the most important yield components of corn, and raising the rate of nitrogen application causes a significant increase in seed yield resulting from increases in the number of kernels per corn ear and in the 1000-seed weight [8].

Effects of cover crops on corn seed yield
Results in the table of ANOVA (Table 1) show that cover plants planted before corn had very significant effects on its seed yield. Results of the table of comparison of the means (Table 2) also show that there were significant differences among the cover plants with respect to the mean corn seed yield. The maximum corn seed yield (12557 kilograms per hectare) was obtained when Perko was the cover crop, and the minimum (8193 kilograms per hectare) when oats was used as the cover crop.

Salahin et al. [9] conducted a two-year experiment and stated that the use of cover crops in rotation with corn increased corn seed yield in the second year. The maximum corn seed yield in the first year was 9.13 tons per hectare, but it rose to 9.38 tons per hectare in the second year when the cover crop S. aculeate was planted before corn.

Effects of nitrogen on corn seed yield
Our study shows that nitrogen had very significant effects on corn seed yield (Table 1), and that this yield increased when higher rates of nitrogen were applied (Table 3). Comparison of the means indicates that there were no significant differences in seed yield when the recommended rate and 1.2 times the recommended rate of nitrogen were applied, but that the maximum seed yield (11834 kilograms per hectare) was achieved when the rate of application was raised to 1.2 times the recommended one.

There are many reports of positive effects of nitrogen application on corn seed yield [5,6]. Results Hokmalipour and Hamele Darbandi [4] founded in their studies showed that nitrogen fertilizers had positive effects on yield and on physiological characters of different corn cultivars. They stated that the largest corn seed yield and its physiological growth were observed at high rates of nitrogen application. Results of other experiments also indicated that nitrogen fertilizer application increased the biological and seed yield of corn as compared to the control [10]. Nitrogen fertilizers are essential for the rapid start of the vegetative growth of corn, for making the most use of environmental resources, for the absorption of more water and nutrients; they also increase seed yield [11].

Effects of cover cropson corn harvest index
Results in the table of ANOVA (Table 1) show that cover crops significantly influenced the harvest index. Comparison of the means of the characters also reveals that there were significant differences among cover crops planted before corn, and that the maximum harvest index of 0.43 was achieved when Perko was planted before corn (Table 2).

Effects of nitrogen on the harvest index of corn
Our results show that nitrogen fertilizers did not have significant effects on the harvest index of corn, that means of all characters could be placed in the same statistical group, but that different rates of nitrogen application slightly influenced the harvest index (Table 3).

Ali et al. [12] stated that increasing the rate of nitrogen application had no significant effects on corn harvest index.

Effects of cover crops on soil organic carbon content
Our results show that the percentage of soil organic carbon increased under the influence of planting cover crops before corn, and that this increase was greater in soils where cereals were planted before corn because of the high ratio of C/N in these soils. Samples were taken from fields where oats had been planted as cover crop before corn and it was found that the organic carbon content of the soils had risen

to 1.12%, 1.14%, and 1.10% from 0.33% in the control (Figure 1). In files where rye or barley had been planted before corn, soil organic carbon content rose to 1.05 and 1.11 percent, respectively, from 0.33% in the control. However, in the fields where Perko or oilseed radish had been planted as cover crops, the rise in soil organic carbon content was not as much (it was raised to 1 and 1.16%, respectively, from 0.33% in the control).
Results Tejada *et al*. [13] obtained from their four-year study indicated that cover crops such as red clover (*Trifolium pretense*) and colza (*Brassica napus*), and a mixture of these two, improved the biological and physical characters of the soil and its organic carbon content. At the conclusion of the study, the carbon to nitrogen ratio in the red clover treatment (10-12) was in the normal range, in the control treatment (5) less than the normal range, and in the colza treatment (22-24) more than the other two treatments. These results conform to those found by other researchers such as Stark et al. [14] and Fontaine et al. [15].

Effects of cover crops on soil nitrogen content

Results of our study show that the percentage nitrogen content of soils where oats had been planted exhibited an ascending trend and increased to 0.16 percent from 0.11 percent in the control. In soils where the same crop had been planted but the recommended rate of nitrogen or 1.2 times more than the recommended rate had been applied, this increase was greater. The range of changes in soil nitrogen content at various rates of nitrogen application was from 0.110 to 0.158 percent (Figur2).
In the treatment under rye cultivation, soil nitrogen content at application rates of 1.2 times less than the recommended rate, the recommended rate, and 1.2 times more than the recommended rate, increased by 0.13, 0.14, and 0.15 percent, respectively. Other results also indicated that soil nitrogen content under cultivation of rye as cover crop increased at various rates of nitrogen application. However, this increase was smaller and amounted to 0.02 and 0.04 percent during the two years the experiment was conducted in the treatments of applying 50 percent less and 50 percent more than the recommended rate, respectively.
In the treatment where barley had been planted as cover crop before corn, soil nitrogen content rose to 0.14 percent from 0.11 percent in the control. In general, since nitrogen was applied to fields where corn was planted, soil nitrogen content exhibited an ascending trend.
In treatments where oilseed radish had been planted as cover crop and had been buried in the soil, soil nitrogen content rose to 0.12 percent from 0.11 percent in the control. When the rate of nitrogen application was raised, soil nitrogen content also increased: it increased by 0.134, 0.144, and 0.154 percent in treatments where 1.2 times less than the recommended rate, the recommended rate, and 1.2 times the recommended rate of nitrogen had been applied, respectively. Results of soil analysis indicated that, when Perko was mixed with the soil and various rates of nitrogen fertilizers were applied, the total soil nitrogen content exhibited an ascending order and increased to more than 0.15 percent from 0.11 percent in the control.
Nedzinskiene et al. [16] conducted an experiment in loamy sand soils and found that the contents of nitrate and other nutrients increased even as early as two months after the incorporation of the cover crop into the soil. They also stated that increased stability in soil nitrate was observed about one month after the cover crop was incorporated into the soil. Baggs et al. [17] reported that cover crops stored about 10 to 20 kilograms of nitrogen per hectare in their biomass during autumn and winter, and that the next crop could use this nitrogen when the cover crops were buried in the soil and this nitrogen was released. Return of nitrogen from cover crops into the soil depends on the quality and quantity of cover crops.
Planting cover crops in autumn had positive effects on the next crop that was planted. These cover crops did not make any changes in the characters of the number of kernels per corn ear, the number of rows per corn ear, and the number of kernels in each row. Results of previous studies had shown cover crops did not affect the number of kernels per corn ear, but we observed slights changes in the number of kernels in the table of comparison of the means. The reason for this could be that the organic matter added to the soil caused greater phosphorous movement in the soil leading to greater phosphorous availability to plants.During the growing season of corn, the air is warm and substantial evaporation takes place from soil surface. Therefore, the slightly superior seed yield of corn in treatments with oilseed radish and Perko crop plants could be related to the positive role of the biomass produced by these cover plants in increasing moisture stored in the soil, in reducing evaporation from soil surface, and in preserving soil moisture for a longer period. Increases in seed yield of corn through raising the rate of nitrogen fertilizer application could be explained by the fact that leaf surface area increases when more nitrogen fertilizers are applied. This results in more sunlight penetrating plant canopy (which raises the efficiency of using sunlight and leads to greater plant growth rates), increase leaf area index, and raises seed yield [18].

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