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Application of Rye Green Manure in Wheat Rotation System Alters Soil Water Content and Chemical Characteristics under Dryland Condition in Maragheh

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Abstract: This study was carried out with or without rye green manure along with 4 nitrogen fertilization treatments (0, 26, 103 and 337 (kg N ha^{-1}) in 3 rotation system (green manure-wheat). Results showed that, although treatment effects on dryland wheat grain yield was not significant, but maximum grain yield (2484 kg ha^{-1}) was obtained from application of rye green manure along with 26 kg N ha^{-1}; which is 22% more than check (without rye green manure) treatment. Green manure application with or without nitrogen increased EC (dS m^{-1}), but decreased OC, P (av.), Cu (av.), Mn (av.), Zn (av.) and sand in the soil. In contrast to green manure, application of nitrogen along with green manure increased saturation and clay. In the stage of stem appearance, soil moisture content decreased 8% in green-manure application but with nitrogen application the moisture increased 6% compared with check in 0-20 cm depth. It can be concluded that, green manure application is useful along with nitrogen fertilizer application in long term. This treatment could increase soil moisture content, which leads to higher wheat grain yield in dryland areas. In addition, green manure application could change some soil characteristics such as soil TNV%, which decreases availability of some essential nutrients for dryland wheat.

Key words: Plant residual, C/N, urea application, soil moisture, nutrient availability, dryland wheat

INTRODUCTION

For the long term productivity, soil organic mater has great importance. Soil production ability depends on the organic matter content and N supply (Brady, 1999; Bruce *et al*., 2006). Land use and management practices affect soil organic matter, for example, cultivation reduces the content of organic matter. This decline is aggravated if follow is included in the rotation where the soil is cultivated to ensure no plant growth or where crop residues are removed (Brady, 1999; Feiziasl *et al*., 2005; Brye *et al*., 2006).

Green manures application in soils is considered as a good management practice for increasing soil organic matter. Such practice can increase cropping system sustainability either by reducing soil erosion and ameliorating soil's physical and chemical properties (McGuire *et al*., 1998; Johnson *et al*., 2006; Wang *et al*., 2006; Graham *et al*., 2007) or by increasing organic matter, fertility level (Melero *et al*., 2006; Tejada and Gonzalez, 2006) and nutrient retention (Kapland and Estes, 1985).

It was reported that green manure increases soil water storage in dry lands by increasing water infiltration rate, declining evaporation and soil structure amendment (Triplett *et al*., 1968; Zerega *et al*., 1995; Sainju *et al*., 2005). Soil water storage is one of the important factors in crop production in arid and semiarid zones (Unger and McCalla, 1980; Sainju *et al*., 2006).

This study was carried out to investigate the effects application of rye green-manure with different nitrogen fertilizer levels on soil physical and chemical properties under dryland condition.

MATERIALS AND METHODS

The study was conducted in research station of Dryland Agriculture Research Institute (DARI) in Maragheh. The soil of the field experiment was a clay loam (Fine Mixed Active, Mesic Typic Calcixerepts). Before green manure cultivation, combined soil samples were collected from 0-25 cm depth for general soil chemical and physical analyses. Rye (*Secale cereale*) was cultivated in autumn. In spring, green residues of rye were added to soil along with 4 nitrogen fertilization (0, 26, 103 and 337 kg N ha^{-1}) as urea fertilizer plus check (no green-manure, no N) treatment. Different nitrogen treatments were added to the soil at the same time with adding rye residues. This study carried out in three

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period rotation systems (green-manure and wheat rotation) in RCBD design with 4 replicates between 1999-2007 years.

In the stage of stem appearance, soil water content measured in wheat by direct sampling from field experiment in two depths (0-20 and 20-40 cm) using weight moisture method.

For plant characteristics study, 30 randomized samples were collected from each treatment and measured in laboratory. The plots were harvested and straw yield and grain yield were measured. Combined analysis of variance carried out after testing homogeneity of mean square of error. Statistical analyses were done by Genstat software.

RESULTS

Dryland wheat yield: Results of plant characteristics revealed that year had significant effect on biological yield, straw and seed yield, plant high, number of fertile tiller, Harvest Index (HI), productivity degree, number of head and seed per head per m^2. The effect of treatments (green manure along with different rates of N application) was significant only on the number of fertile tiller ($p \leq 0.05$). The interaction between year and treatment was not significant on the measured parameters (Table 1).

Green-manure application without N tended to decrease biological yield 10%, kernel weight 15%, number of spike per unit 8%, plant height 8% and grain yield 14%; and tended to increase number of seed per spike 5% and fertile tiller 17% compared with control (no green manure, no N application) (Table 2).

Application of green-manure with different levels of nitrogen fertilizer increased grain yield 3-22% compared with control. The highest grain yield (2484 kg ha^{-1}) obtained from green manure plus 26 kg N ha^{-1} treatment and the lowest grain yield (1757 kg ha^{-1}) from green manure application without N treatment. In addition, this treatment tended to increase harvest index, spike length and number of fertile tiller (Table 2).

Green-manure application without N caused decline in biological yield, straw yield and grain yield whereas N use with green manure tented to increase these traits. Similar to the results of this study, Triplett *et al.* (1968) reported that organic matter application increase soil water content and grain production progressively. According to Fageria *et al.* (1991), it is important attention to next plant economical production after green manure application. However, the results reported here were in contrast with the results of Pilipenko and Savoshchenko (1996), who reported that application of green manure had not significant effect on barely production.

Soil physical and chemical characteristics: Data from soil physical and chemical combined analysis in early stage of each 3 period wheat phase rotation (green manure-wheat) showed that year effect was significant on pH, OC%, Fe (av.), Cu (av.), Mn (av.), Zn (av.), sand%, clay % and silt% ($p \leq 0.01$) and TNV%. The effect of treatment was significant on the P (av.), SP%, EC_e (Table 3). Comparison of mean of measured parameters in the beginning of each experimental year showed increasing the amount of $CaCO_3$ (ranging from 80-156%), Fe (26-48%), Mn (18-23%) and Zn (5-20%); and decreasing the amount of P (8-14%),

Table 1: Combined variance analysis of wheat characteristics at different treatments of green-manure

		Mean square										
SOV	df	Biological yield	Grain yield	Straw yield	Thousand kernel weight (g)	Harvest index	Productivity degree	Spike length	No. of head per m^2	No. of seed per head	Plant height	No. of tiller
Year	2	61533441**	7245988**	27429190**	13.2ns	0.010*	73.3*	10.4	119025*	276.5*	4232.1**	2.76**
Residual	3	559591	24249	371761	9.9	0.001	4.9	4.3	14095	19.1	17.3	0.04
Treatment	4	1952643ns	443201ns	720839ns	58.5ns	0.011ns	130.1ns	3.8ns	5184ns	9.8ns	58.7ns	0.16*
Year*Treatment	8	2594212ns	215439ns	1486727ns	56.7ns	0.009ns	75.1ns	2.6ns	6259ns	24.3ns	77.2ns	0.08ns
Residual	12	1538240	185806	788588	43.1	0.004	43.9	2.7	5684	32.0	79.0	0.05
CV (%)		20.7	20.2	23.0	16.6	17.5	14.8	26.5	17.5	28.9	12.5	14.8

ns: Non significant; *,**Significant at the 5 and 1% levels of probability, respectively

Table 2: Comparison of means for green-manure treatment effects on the dryland wheat crop properties

Treatment	Biological yield	Grain yield	Straw yield	Thousand kernel weight (g)	Harvests index	Productivity degree	Head height	No. of head per m^2	No. of seed per head	Plant height	No. of tiller
	----------(kg ha^{-1})----------										
Control	5944	2042	3901	40.9	0.336	41.6	5.9	422	19.6	72.2	1.40
0	5368	1757	3611	34.8	0.318	39.0	5.7	387	20.5	66.1	1.64
26	6645	2484	4161	42.1	0.406	49.7	7.5	444	18.9	73.2	1.57
103	6522	2282	4240	37.9	0.354	44.2	5.5	466	17.8	70.5	1.35
337	5540	2107	3433	41.7	0.414	49.1	6.2	438	20.9	74.0	1.74
LSD 5 (%)	1560.2	542.2	1117.1	8.3	0.08	8.3	2.1	94.8	7.1	11.2	0.29

Table 3: Combined variance analysis for soil characteristics in different green-manure treatments

		Mean square													
SOV	df	pH	OC	P (av.)	Total N	TNV	Fe (av.)	Cu (av.)	Mn (av.)	Zn (av.)	SP	Clay	Sand	Silt	EC
Year	2	0.376**	0.090**	23.032ns	10.547**	19.89*	9.13**	0.28**	91.7**	0.104**	5.1ns	5273.0**	1046.5**	1621.80**	0.08ns
Residual	9	0.027	0.006	13.253	0.004	5.08	0.68	0.02	6.4	0.005	6.0	8.3	28.7	19.68	0.03
Treatment	4	0.033ns	0.017ns	27.900**	0.011ns	15.08*	0.28*	0.04ns	11.5ns	0.004ns	29.8**	4.6ns	9.7ns	5.09ns	0.39**
Year*Treatment	8	0.033ns	0.011ns	2.350ns	0.006ns	0.53ns	0.96ns	0.01ns	1.6ns	0.004ns	20.4ns	7.5ns	8.9ns	23.80ns	0.14**
Residual	36	0.028	0.019	3.216	0.006	5.09	0.50	0.03	7.1	0.005	10.5	7.4	11.0	10.57	0.02
CV (%)	-	2.1	23.7	12.2	13.4	49.4	9.9	8.5	17.2	12.4	5.6	8.4	18.1	6.6	21.7

ns: Non significant; *, **Significant at the 5 and 1% levels of probability, respectively

Table 4: The effect of different years on soil characteristics in 0-20 cm depth

Year	pH	OC (%)	P (av.) (mg kg^{-1})	Total N (%)	TNV (%)	Fe (av.)	Cu (av.)	Mn (av.)	Zn (av.)	SP	Clay	Sand	Silt	EC (dS m^{-1})
						(mg kg^{-1})				(%)				
First	7.94	0.617	14.70	0.062	4.00	7.10	2.10	13.9	0.60	58	44	13	43	0.77
Second	7.68	0.634	13.70	1.089	5.70	6.50	2.16	14.5	0.50	59	21	23	56	0.68
Third	7.89	0.511	15.80	0.575	4.00	7.80	2.33	17.9	0.64	63	31	20	49	0.66
LSD (5%)	0.12	0.050	2.60	0.050	1.61	0.59	0.10	1.8	0.05	1.9	2.2	4.1	3.4	0.13

Table 5: Means of soil characteristic in different years in 0-20 cm depth

Treatment	pH	OC (%)	P (av.) (mg kg^{-1})	Total N (%)	TNV (%)	Fe (av.)	Cu (av.)	Mn (av.)	Zn (av.)	SP	Clay	Sand	Silt	EC (dS m^{-1})
						(mg kg^{-1})				(%)				
Check	7.79	0.616	17.10	0.592	2.90	7.10	2.26	16.1	0.59	57.0	31.0	20.0	49.00	0.61
C/N = 36	7.92	0.547	13.70	0.520	5.70	6.90	2.13	14.0	0.56	56.0	32.0	19.0	49.00	0.62
C/N = 30	7.84	0.638	15.20	0.586	4.20	7.30	2.24	15.1	0.60	59.0	33.0	17.0	50.00	0.59
C/N = 20	7.83	0.568	13.20	0.587	5.50	7.30	2.19	16.5	0.57	59.0	33.0	17.0	50.00	0.69
C/N = 10	7.80	0.569	14.30	0.591	4.60	7.10	2.16	15.5	0.56	61.0	33.0	19.0	48.00	1.12
LSD (5%)	0.14	0.120	1.49	0.060	1.87	0.58	0.15	2.2	0.06	3.4	2.8	3.4	3.36	0.16

Cu (4-7%) and OC (19%) (Table 4). Further more, application of green manure in three-year-period increased $CaCO_3$ 105, Fe 48, Mn 31 and Zn 16% and decreased P 8, Cu 3 and OC 7% in the soil. The result of this study are not corresponded with the results of Biswas and Mukherjee (1991), who is reported that green manure application increased soil OC and P. Puanglek *et al.* (1993) and Mwaja *et al.* (1996) believed that green manure application did not affect OM, soil physical and chemical properties.

Application of green manure without nitrogen increases soil pH and TNV, but decreases N, P, Cu and Mn compared with control. On the hand, green manure plus N treatments increase TNV, SP and EC compared with control; but decline P in the soil (Table 5). Kapland and Estes (1985) reported that green manure application has important role in elements availability by releasing elements from soil insoluble mineral fraction or by releasing self elements from its decomposition. Organic matter from green manure decomposition is important sources of essential plant anions such NO_3^-, PO_4^{-3}, BO_4^{-2}, MoO_4^{-3} and Cl^-. Green-manure also increased caution uptake and their availability by releasing from decomposition such NH_4^+ or by increasing their solubility such K, Ca, Mg and microelements especial Zn (Follet *et al.*, 1981; Kapland and Estes, 1985; Subba-Rao, 1988).

Soil water content: The effect of green manure application on soil moisture in three years cultivation is shown in Table 6. The results show that year, green manure and depth significantly affected soil moisture content at shooting stage.

Table 6: Combined variance analysis for soil moisture in depths 0-20 and 20-40 cm under different green manure applications

SOV	df	Sum of square	Mean
Year	3	3266.9	1089.0**
Residual	4	57.4	14.4
Treatment	4	46.9	11.7**
Year×Treatment	12	122.0	10.2**
Residual	16	153.7	9.6
Depth	1	170.9	170.9**
Year×Depth	3	128.6	42.9**
Treatment×Depth	4	14.3	3.6**
Year×Treatment×Depth	12	29.6	2.5**
Residual	20	82.5	4.1
CV (%)	-	10.5	-

**: Significant at 1% probability

Comparison of soil moisture of three years showed that the lowest and highest soil moisture contents were belong to the first and third year, respectively. In comparison with the first year, soil moisture increased 75 and 130% in the second and third years with green manure application, respectively. Soil moisture was 32% more in the third year compared with the second year. Annual precipitation has important role on the soil moisture increasing; but precipitation cannot be involved in increasing of soil moisture of third year compared to the second year in this study because of similar precipitation between these years (Fig. 1). Therefore, higher soil moisture of third year can only be explained by the effect of green manure application.

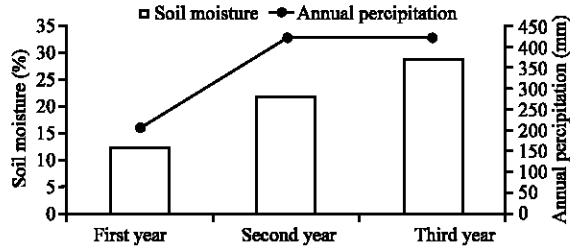

Fig. 1: Variation of annual precipitation and soil moisture weight in 0-20 cm soil depth in three years of wheat cultivation

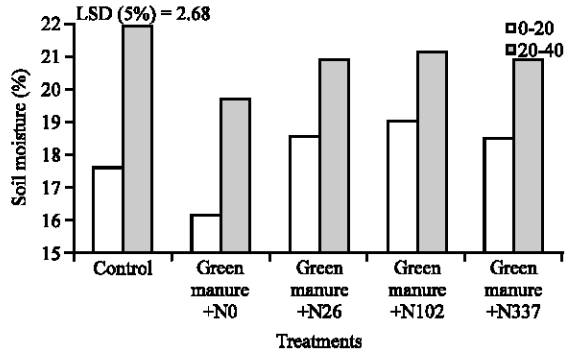

Fig. 2: Soil moisture of three years in two different soil depths at shooting stage

Application of green manure with N tended to increase soil moisture in 0-20 cm soil depth but decreased soil moisture in 20-40 cm depth (Fig. 2). These results are in agreement with those of most previous studies (Trilett *et al*., 1968; Black, 1973; Zerega *et al*., 1995). Also, Pradit *et al.* (1993) reported that green manure application caused enhancement of soil water content by increasing water infiltration rate, decreasing evaporation rate and by amendment of soil physical characteristic and soil structure. In contrast to these results, Pikul *et al.* (1997) found that application of green manure did not increase soil water content.

CONCLUSION

Green manure application could change some soil chemical (such as soil TNV%, pH, EC, OC%, clay and availability of essential nutrients) and physical (soil moisture) properties. Soil moisture content is an important soil property that can be influenced dryland cropping system positively and green manure application along with nitrogen fertilizer application improved this characteristic. Also green manure application with nitrogen fertilizer application increased grain yield of dryland wheat in long term.

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