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Rye Green Manure along with Nitrogen Fertilizer Application Increases Wheat (*Triticum aestivum* L.) Production under Dryland Condition

[1]S.B. Mosavi, [2]A.A. Jafarzadeh, [2]M.R. Neishabouri, [2]S. Ostan and [3]V. Feiziasl
[1]University of Maragheh, Maragheh, Iran
[2]University of Tabriz, Tabriz, Iran
[3]Dryland Agriculture Research Institute, Maragheh, Iran

Abstract: The effects of rye green manure application along with different levels of nitrogen fertilizer on wheat production was investigated under rainfed dryland condition. 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) between 1999-2007 years. Results showed that the effects of green manure application with different amount of N fertilizers on wheat production tended to be significant. A maximum grain yield (2484 kg ha^{-1}) was obtained by application of rye green manure along with 26 kg N ha^{-1} and minimum yield (1757 kg ha^{-1}) from rye green manure without nitrogen application. Furthermore, crop morphophysiological characteristics including harvest index, spike length, number of spikes per square meter, number of tillers and thousand kernel weight (TKW) in plant tended to increase compared with check (green manure without N). It can be concluded that, application of green manure with nitrogen could indirectly increase Sardari yield by increasing yield components such as TKW and number of spikes per square meter.

Key words: Rye green manure, nitrogen fertilizer, wheat production, dryland condition

INTRODUCTION

Soil organic matter, composed of soil organic carbon, is the foundation of productive soils. Understanding the role of organic matter in maintaining a healthy soil is essential to developing sustainable agricultural practices. As organic matter decreases, plant growth and yield decline in the absence of substitutes because of lower fertility, less available water and increased soil compaction and erosion (Schulte, 1995; Cropper and Laibson, 1999; Portney and Weyant, 1999; Weitzman, 2001). So for long term productivity, soil organic mater has great importance on sustainable crop production. The ability of a given soil to produce is dependent on the organic matter content and N supply (Brady, 1999; Bruce *et al*., 2006). Land use and management practices affect SOM, for example, cultivation reduces the content of organic matter. Decline in soil productivity will be aggravated if follow is included in the rotation or when crop residues are removed from the soil (Brady, 1999; Feiziasl *et al*., 2005; Brye *et al*., 2006).

Green manures application to soils is considered as a good management practice for increasing the SOM. Such practice can increase cropping system sustainability either by reducing soil erosion and ameliorating soil's physical and chemical properties

Corresponding Author: S.B. Mosavi, University of Maragheh, Maragheh, Iran

(McGuire *et al*., 1998; Johnson *et al*., 2006; Wang *et al*., 2006; Graham *et al*., 2007), or by increasing organic matter and 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 amendment soil structure (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 McCala, 1980; Sainju *et al*., 2006). The grain yield and yield components (number of spike per m^2, number of seed in spike and 1000 grain weight) of wheat increased significantly with the application of different organic materials (Sarwar, 2005). The combination of plant residue with chemical fertilizer further enhanced the biomass and grain yield of wheat (Sarwar *et al*., 2007, 2008). Thus, plant uptake of nutrients increased when organic materials were applied. The effect of combination of plant residue and chemical fertilizers was also positive. This study was carried out to investigate the effects of the 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 at the Research Station of the Dryland Agriculture Research Institute (DARI) in Maragheh (East Azarbayjan Province, Iran). This site is located between 37 north lat and 45 East longitude. The soil of the field experiment was a clay loam (Fine Mixed Active, Mesic Typic Calcixerepts). This study was carried out in three period rotation systems (Rye (*Secale cereale*) as green-manure and wheat (cv. Sardari)) rotation in Randomized Completely Blot Design (RCBD) design with 4 replicated four times. The experiment was conducted between 1999-2007. The climate data for the site between 1997-2007 is shown in Table 1. DARI station soils is from meusen Era. These soils include petrocalcic alluvial and mixed of volcanic ash with petrocalcic alluvial (from Sahand volcanic monstrance) parent materials (Hakimi, 1999). 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 using shovel for general soil chemical and physical analyses. Rye (*Secale cereale*) was cultivated in autumn. In spring, green residues

Table 1: Climatic data for experiment site from 1999-2007

Cropping years	Sunny (h)	Evaporation (mm)	Humidity (%)	No. of under zero days	Average temperature (°C)
1999-2000	258.7	1809.7	50.4	141	9.6
2000-2001	243.7	1850.8	49.9	123	10.1
2001-2002	234.3	1795.4	52.7	115	8.6
2002-2003	214.0	1589.5	60.1	137	9.2
2003-2004	241.4	1607.6	59.3	126	9.8
2004-2005	247.9	1631.4	57.5	129	9.2
2005-2006	248.0	1797.8	47.5	140	10.1
2006-2007	231.9	1674.5	52.0	148	8.3
Mean	240.0	1719.6	53.7	132	9.4

Cropping years	Average Max. tempratuer (°C)	Average Min. tempratuer (°C)	Absolute temperature Max.	Absolute temperature Min.	Precipitation (mm)
1999-2000	14.7	4.6	23.5	-3.0	296.0
2000-2001	15.0	5.2	23.2	-1.3	203.9
2001-2002	14.0	4.0	22.0	-3.6	389.2
2002-2003	14.6	3.9	22.5	-4.3	368.5
2003-2004	15.4	4.0	22.8	-3.2	416.2
2004-2005	13.6	-2.3	22.2	-5.1	383.2
2005-2006	15.9	4.8	23.5	-4.2	383.3
2006-2007	13.0	3.6	20.8	-4.0	421.3
Mean	14.5	3.5	22.6	-3.6	357.0

of rye were added to soil along four N levels (0, 26, 103 and 337 kg N ha^{-1}) as Urea fertilizer plus check (no green-manure, no N) treatment. Different N-treatments were added to the soil at the same time with adding rye residues. Wheat cultivated in autumn with 400 grain per m^2 density and the other cultivation operation to basea of Maragheh Dry land Station current methods was fulfilled with current mechanical machine for wheat cultivation and 2,4 D herbicide with 2l ha^{-1} concentration was used against weed in GS21 stage of wheat growth. wheat harvested in physiological raping stage. To study plant characteristics, 30 plants were collected randomly from each plot and the intended traits were measured. Then the plots were harvested by hand from 2 cm above root and, then biological yield including straw and grain yield were measured. Combined analysis of variance was carried out after testing homogeneity of mean square of errors and data analyses were done using Genstat Software (version 9.00, 1995).

RESULTS

Results of combined analysis of variance of measured plant characteristics revealed that the year effect was significant on all measured traits but TKW and spike length (Table 2).

Application of green manure along with N treatments significantly affected only the number of fertile tiller. Interaction year × treatment was not significant.

Table 2: Combined analysis of variance for dryland wheat characteristics in different traits

		Mean square				
Source of variation	df	Biological yield	Grain yield (kg ha^{-1})	Straw yield	TKW (g)	Harvest index
Year	2	61533441**	7245988**	27429190**	13	0.01*
Residual	3	559591	24249	371761	10	0.001
Treatment	4	1952643	443201	720839	59	0.01
Year*treatment	8	2594212	215439	1486727	57	0.01
Residual	12	1538240	185806	788588	43	0.004
CV (%)		21	20	23	17	18

		Mean square				
Source of variation	df	Productivity degree	Spike length (cm)	No of head per m^{-2}	No of seed per spike	Plant height (cm)
Year	2	73*	10	119025*	277*	4232**
Residual	3	5	4	14095	19	17
Treatment	4	130	4	5184	10	59
Year*treatment	75	3	6259	24	77	
Residual	12	44	3	5684	32	79
CV (%)		15	27	18	29	13

*Significant at %1 level, ** Significant at %5 level

Table 3: Mean comparison of year effects on dryland wheat characteristics

Production year	Biological yield	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	TKW (g)	Harvest index	Productivity degree
First	3145.0	1162.0	1983.0	40.2	0.39	43.3
Second	7585.0	2499.0	5085.0	40.0	0.33	43.0
Third	7282.0	2743.0	4539.0	38.1	0.38	47.8
LSD5%	1064.7	221.6	867.8	4.5	0.04	3.2

Production year	Spike length (cm)	No of spike per m^{-2}	No of seed per spike	Plant height (cm)	No. of tiller
First	5.01	353	16.9	52.7	1.16
Second	6.99	556	25.6	93.4	1.32
Third	6.44	385	16.1	67.5	2.14
LSD5%	3.00	169	6.2	5.9	0.28

Mean comparison of plant characteristics during three years showed that biological (3145 kg ha^{-1}), straw (1162 kg ha^{-1}) and grain (1983 ka ha^{-1}) yields of the first year were the lowest, whereas in second year, biological yield (7585 kg ha^{-1}) and straw yield (5085 kg ha^{-1}) were maximum (Table 3). The highest grain yield (2743 kg ha^{-1}) was obtained in the third year. Furthermore, in the second year compared with the first year, an increase up to about 130% was observed in biological, straw and grain yields, 30% in the number of spike per square meter and plant height and 85% in the number of fertile tiller. Regardless of rye green manure effects on yield increase during the experimental years, continuous increase in annual precipitation in the second and third year compared with the first year could explain somehow yield rising.

DISCUSSION

The results of this study showed existence of significant linear regression between annual precipitation and grain yield and the grain yield can be estimated by $Y = 2.609X+36.345$ ($R^2 = 0.66^{**}$) equation, where Y and X (360 and 430 mm) are yield and precipitation, respectively (Fig. 1). This equation shows that 50 mm increase in annual precipitation will result in 1459 kg ha^{-1} increase in the yield (Fig. 1). This means that 1 mm growth in annual precipitation can lead to 30 kg ha^{-1} raise in grain yield under dryland condition. Feiziasl and Valizadeh (2001) reported that dryland wheat grain yield could be affected mainly by amount and distribution of the annual precipitation in Maragheh. Singh and Byerlee (1990) studied wheat production variation in 57 countries for 35 years and reported that annual precipitation was a major reason for yield losses. Smith and Harris (1981) studies in the West Asian and North African (WANA) countries showed that cereal yield in dryland condition related to seasonal precipitation in these regions.

Green manure application without N decreased 15% thousand kernel weight (TKW) and 14% grain yield compared with control (no green manure, no N) (Table 4). It is known that increase in C/N ratio to above 30 (like in control treatment) can cause competition among soil microorganisms in the use of more soil plant available N, which will result in appearance of N deficiency symptom and yield reduction in the plants (Salehrastin, 1978). Hence, green manure application with 26 kg ha^{-1} nitrogen treatments increased 24% biological yield, 28%

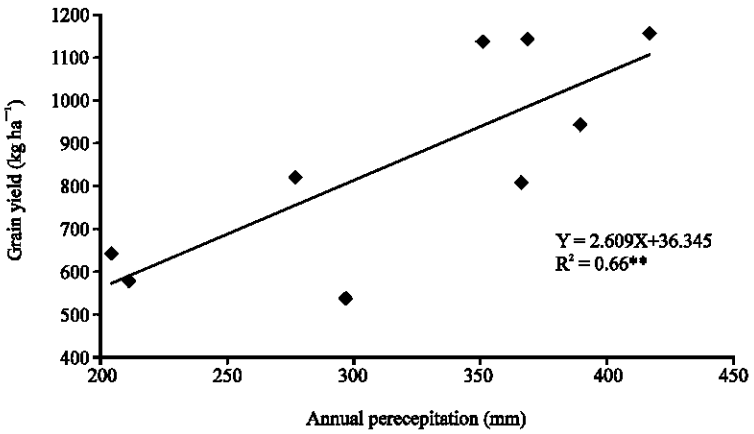

Fig. 1: Relationship between annual precipitation and dry land wheat grain yield in Maragheh region

Table 4: Mean comparison of treatments effects on dryland wheat characteristics

Treatment	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	TKW	Harvest index	Productivity degree
Control	5944	2042	3901	40.9	0.34	41.6
N0 + R.G.M*	5368	1757	3611	34.8	0.32	39.0
N26 + R.G.M	6645	2484	4161	42.1	0.41	49.7
N103 + R.G.M	6522	2282	4240	37.9	0.35	44.2
N337 + R.G.M	5540	2107	3433	41.7	0.41	49.1
LSD**5%	1560	542	1117	8.3	0.10	8.3

Treatment	Spike length (cm)	No of spike per m^{-2}	No of seed per spike	Plant height (cm)	No. of tiller
Control	5.9	422	19.6	72.0	1.4
N0+R.G.M*	5.7	387	20.5	66.0	1.6
N26+R.G.M	7.5	444	18.9	73.0	1.6
N103+R.G.M	5.5	466	17.8	71.0	1.4
N337+R.G.M	6.2	438	20.9	74.0	1.7
LSD**5%	2.1	95	7.1	11.2	0.3

*Rye green manure, **Least significant differentation

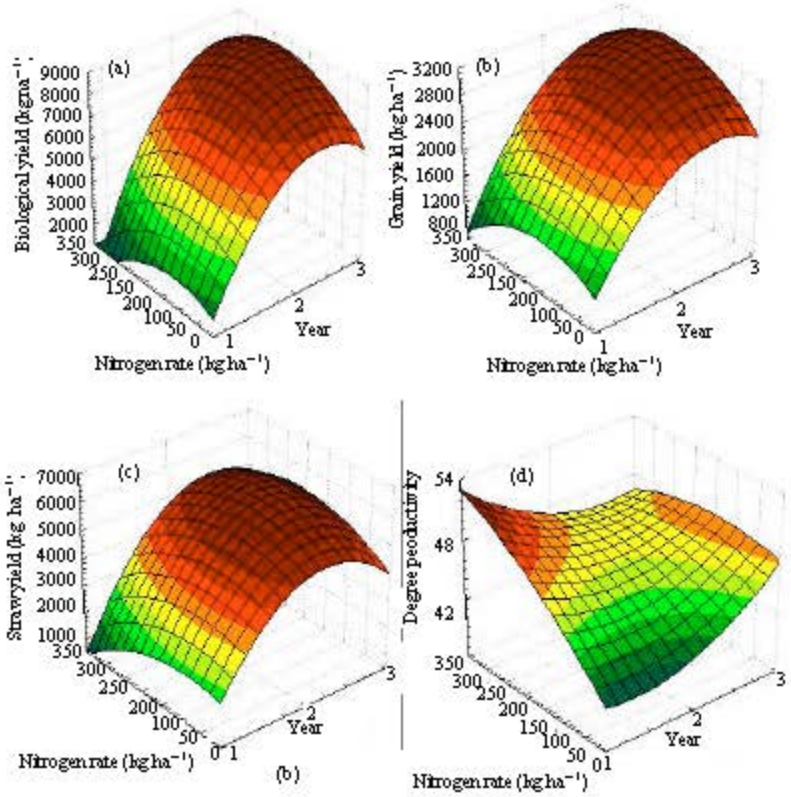

Fig. 2: Infraction of year and nitrogen application on (a) biological yield, (b) grain yield, (c) straw yield and (d) productivity degree

harvest index, 21% TKW and 41% grain yield compared with green manure without N application. Although positive effects of green manure application on crop production has been reported by several studies but there is discrepancy in the results. Triplett *et al*. (1968) showed that organic matter application increase soil water content and grain production progressively. In contrast, according to Fageria *et al*. (1991), it is important attention to next plant economical production after green manure application. Pilipenko and

Savoshchenko (1996) reported that application of green manure had no significant effect on barely production.

Interaction between year×treatment (green manure along with N application) on biological yield showed this triat was mainly affected by year rather than green manure application (Fig. 2). Similarly, straw and grain yields were affected largely by year effect. In other words, differences in biological, straw and grain yields among green manure treatments were mainly related to variation in annual precipitation. Singh and Byerlee (1990) and Smith and Harris (1981) reported that dryland cereal yield was largely affected by annual and seasonal pericipitation in these region. Moreover, increasing in the productivity degree and harvest index in the second year were affected by both annual precipitation and N application. Nitrogen could increase 43% productivity degree in dryland wheat (Feziasl, 2006) and increasing annual precipitation could raise productivity degree (Koocheki and Khalaghani, 1996). It seems that N, compared with percipitation, affects productivity degree more than biological, yield and grain yields in Sardari cultivar.

Percipitation and N had similar effects on the number of spike and seed per spike in this study (Fig. 3b, c). Maximum number of spike and seed per spike were seen in the second year when green manure was used with 103 kg N ha^{-1}. Some researches showed that growth of cereal in the arid and semiarid zone of world was limited by precipitation; and N application can improve yield in these regions by increasing number of fertile tiller and spike per m^{-2} (Halverson *et al*., 1987; Lauer and Partridge, 1990).

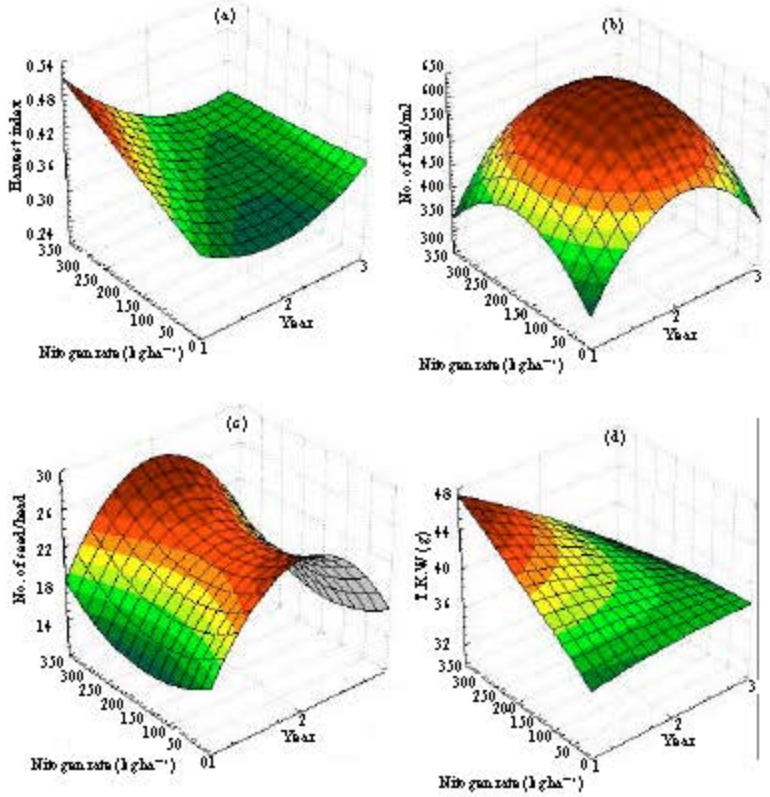

Fig. 3: Infraction of year and nitrogen application on (a) harvest index, (b) number of spike m^{-2} (c) seed number in spike and (d) TKW

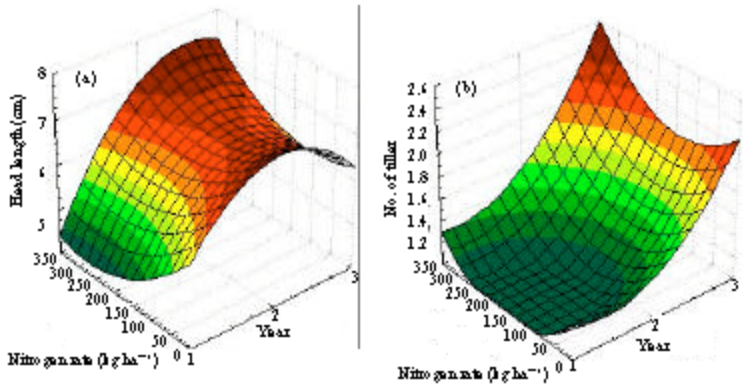

Fig. 4: Infraction effects of year and nitrogen factor application for green manure on (a) spike length and (b) number of tiller

Increasing amount of N application in the first and second year of experiment increased TKW but in the third year increasing amount of N use had negative effect on TKW (Fig. 3d). Probably increasing spike number and length leading to more seed per spike with precipitation increase resulted in decline in TKW (Fig. 4a, b). According to Harmsen (1986) N use had a positive effect on number fertil head in wheat but decreased TKW. Similar results were reported by Gardner and Jackson (1976), Fowler and Brydon (1989), Gorashi (1990) and Bruckner and Morey (1988). Feiziasl (2006) showed that seed number per spike increased by rising N application, which resulted in decline in TKW.

CONCLUSION

According to results of this research, dryland wheat grain yield increased with increasing of annual precipitation linearly. These results showed that the year (arising from precipitation) has greatest contribution to grain yield and yield components (number of spike m^{-2}, number of seed in spike and 1000 grain weight). Many researchers reported that dryland wheat production related to main two factors; rainfall and nitrogen supply, respectively (Smith and Harris, 1981; Singh and Byerlee, 1990; Feiziasl and Valizadeh, 2001). Therefore water and nitrogen are two limiting factors for obtaining of high yield of crops in arid and semiarid conditions in WANA (West Asian and North African).

Rye green manure application without nitrogen decreased dryland wheat grain yield and yield components because without nitrogen application C/N ratio in soil increased to above 30 can cause competition among soil microorganisms in the use of more soil plant available nitrogen. Because, soil microorganisms can access nitrogen in the soil more easily than plants can, so the plants sometimes miss out. This means that if there is not enough nitrogen for all the organisms, the plants will probably be nitrogen deficient (Salehrastin, 1978; Sarwar *et al*., 2007, 2008). But application of green manure together nitrogen fertilizer (26 kg N ha^{-1}), carbon and nitrogen ratio in soil will balance and plants can uptake nitrogen requirement and other nutrients from soil. Thus, plants can growth and have suitable produce in condition.

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