The effect of rye green manure application with nitrogen fertilizer on soil water storage, soil aggregate stability and soil water infiltration rate in Maragheh dryland condition

Seyed Bahman Mosavi[A], Ali Asghar Jafarzadeh[B], Mohammad Reza Nishabouri[B], Shahin Ostan[B], Vali Feiziasl[C] and Esmael Karimi[A]

[A]Soil Science Department, Agricultural Faculty, University of Maragheh, Email mosavi@mhec.ac.ir
[B]Soil Science Department, Agricultural Faculty, University of Tabriz.
[C]Scientific member of Dryland Agricultural Research Institute (DARI), Maragheh.

Abstract
With the aim of green manure application improving soil physical characteristics important to soil water retention in dry land 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) in 3 rotation system (green manure-wheat) between 2001 – 2007 years. Results showed that the green manure application effects were significant for soil aggregate stability. Results showed that the green manure application effects were significant on the soil bulk density and soil moisture indexes such as FC and PWP. N-fertilizer application with green manure in order to decrease C/N ratio for best activation of soil microorganisms accelerated these effects. High AWC occurred for C/N=20 treatment. Our data showed that there are regression relationships with highly correlation coefficients between the levels of N–application with green manure and soil moisture indexes. Our results also showed that green manure application had a significant effect on soil water infiltration rate for dry land condition. Higher and lower infiltration rates occurred for C/N=36 and C/N=20 treatments respectively at 30 min. A soil water infiltration prediction Kostiakov model was determined as a best model for its higher R square (R^2 = 0.90) and lower standard error (SE=0.30). The model predicted about 90 % of variation in soil water infiltration rate for all of the treatments in this study.

Key Words
Soil water content, green manure, aggregate stability, dry land condition.

Introduction
Crop production in dryland conditions depends on rainfall as in this region rainfall is limited and seasonal (Farahani 1998; Sandhu *et al.* 1992). Thus increasing soil water storage ability and water conservation in such regions could be one of the most important agricultural management practices (Mosavi *et al.* 2009). For this purpose it is necessary that we improve soil structure and facilitate water infiltration to soil to increase water utilization (Martens and Franken 1992). It was reported that organic mater has a key role in aggregate formation and structure stability in soil (Pikul *et al.* 2005, Annabi *et al.* 2007). Movement of water into the soil is controlled by gravity, capillary action, and soil porosity. Of these factors soil porosity is most important (Martens *et al.* 1992). Soil porosity is controlled by its texture, structure, and organic content (Martens *et al.* 1992). The amount of decayed organic matter found at the soil surface can also enhance infiltration. Organic matter is generally more porous than mineral soil particles and can hold much greater quantities of water (Annabi *et al.* 2007). The general objective of the work presented here was to determine the effect of rye green manure in rotation with wheat on the soil moisture content, aggregate stability and water infiltration rate for dry land conditions.

Materials and methods
The study was conducted at a research station of the dryland agriculture research institute in Maragheh. The soil of the field experiment is a clay loam (Fine Mixed Active, Mesic Typic Calcixerept). Winter type rye (*Secale cereale*) was cultivated in autumn and in spring rye green residues was added to soil along with nitrogen: 0, 26, 103 and 337 kg N/ha from urea fertilizer plus check (without green manure) treatment. This level of N was added synchronous with rye residue additional to soil. This study was carried out in 3 rotation system (green manure –wheat) in PCBD design with 4 blocks at 2001 – 2007. Soil water indexes such as saturation percentage (SP%), field capacity (FC), permanent wilting point (PWP) and 30 cm water column were measured by undisturbed sampling from the field experiment in each treatment at two deptsh (0-5 cm and 10-20 cm) using a pressure plate method and also bulk density was measured in this sample using a cylinder method (Margesin and Schinner 2005). Soil aggregate stability was measured using the Kemper and

Rosenau (1986) method. The 1-2 mm particle size and soil infiltration rate were measured in each treatment in field condition using a double ring cylinder method. Statistical analyses were done using Genstat Software (version9.00, 1995).

Result and discussion

Analysis of variance for different important weight moisture indexes such as SP, FC, PWP, 30cm water column and AWC showed that the block effect was not significant for these indexes. Treatment effects was significant on the PWP (P< %5) and FC (P <%1) whereas was not significant for the other investigated moisture indexes. Depth effect was not significant on the FC, PWP and AWC but was significant on the SP and 30cm water column at P<0.01 level. Treatment × Depth effects were not significant for any of the factors that were investigated in this research. Investigation of regression relationships between different N-levels application with green manure showed that a highly correlation coefficient exists among for green manure application and different levels of N use with important soil moisture indexes (data not shown). Our data showed that soil bulk density decreased when green manure applied in rotation with wheat cultivation and nitrogen application, with rye green manure accelerating this effect. Lower bulk density occurred for C/N=20 and highly bulk density for the Control. This trend was not significant between different treatments of this study (Table 1). Our results show that green manure application affected the important soil moisture indexes and increased the soils ability to hold water because organic matter has a higher water holding capacity than a similar volume of mineral soil (Annabi *et al.* 2007). Soil organic matter enhances soil water retention because of its hydrophilic nature and its positive influence on soil structure (Annabi *et al.* 2007). Data for water infiltration into soil showed that between the experimental treatments the highest amount of cumulative infiltration was for green manure application without nitrogen that had a 9% increase with respect to control (Table 4). The high infiltration rate of 46.8 mm/hr over 5 minutes occurred for C/N=30 but after 30 minutes the highest level was for C/N=36 (20.4 mm/hr) (Table 4). Our data were examined with three prediction models for soil water infiltration (Green – Ampt, Kastiakov and Kastiakov – Lewise) and showed that the adjusted Kostiakov model was the best model based on its higher R square ($R^2 = 0.90$) and lower standard error (SE=0.30). The model predicts about 90 % of variation in soil water infiltration rate for all of the treatments in this study (Table 5). Aggregate stability measurements for 1-2 mm particles showed that there are significant differences between green manure treatments ($p < 0.05$). Lowest stability was for C/N=30 treatment and was lower than for control. Stability was not significantly different between C/N= 10, 20 and 30 treatments and was higher than control. These results showed that green manure application has a improves aggregate stability and it seems that the C/N ratio has a determinant role in aggregate stability and some ratio stability decreased.

Table 1. Variance analysis for effects of green manure treatments on soil moisture indexes.

MS							
S.O.V	df	Db(gr/cm^3)	Pm(30cm)	Pm(FC)	Pm(PWP)	Pm(SP)	Pm (aw)%
Replication	3	0.00706 ns	27.42 ns	9.252 ns	18.541 ns	72.64 ns	20.597 ns
Treatment	4	0.00796 ns	9.18 ns	6.727**	22.411*	49.63 ns	13.711 ns
Depth	1	0.93128**	218.76**	0.706	6.174	5651.28**	2.703
Treatment*Depth	4	0.00446ns	3.95 ns	0.919 ns	5.193 ns	19.91 ns	4.756 ns
Residual	27	0.01031	15.11	1.225	8.063	48.92	6.673
C.V%		10.2	9	3.4	11.2	11.1	35.6

Table 2. Comparison of mean values for green manure treatment effects on soil moisture indexes.

Treatment	Db(gr/cm^3)	Pm(30cm)	Pm(FC)	Pm(PWP)	Pm(SP)	Pm (aw)
Check	1.021	42.97	33.71	28.13	60.5	5.58
36=C/N	1.031	42.14	31.47	25.12	60.5	6.35
C/N=30	1.007	44.66	33.03	25.18	63.2	7.86
C/N=20	0.952	44.43	32.82	23.91	66.3	8.91
C/N=10	0.984	42.95	31.8	24.19	64.2	7.61
LSD5%	0.1042	3.988	1.135	2.913	7.18	2.65

Table 3. Comparison of means for soil depth effects on soil moisture indexes.

Depth	Db(gr/cm^3)	Pm(30cm)	Pm(FC)	Pm(PWP)	Pm(SP)	Pm (aw)%
5cm	0.846	45.77	32.7	25.7	74.8	7
15cm	1.152	41.09	32.43	24.91	51	7.52
LDS%	0.0659	2.522	0.718	1.842	4.54	1.676

Table 4. Mean cumulative and infiltration rate for different treatment in four different times.

	Time (min)							
	5		10		15		30	
Treatment	Cumulative mm	Infiltration rate mm/min	Cumulative mm	Infiltration rate mm/min	Cumulative mm	Infiltration rate mm/min	Cumulative mm	Infiltration rate mm/min
Check	7.7	0.56	12.3	0.46	18.5	0.38	29.3	0.27
C/N=36	6.8	0.4	10.8	0.4	16.6	0.39	28.5	0.34
C/N=30	11.2	0.78	15.6	0.44	20.8	0.28	28.4	0.21
C/N=20	9.7	0.44	12.5	0.28	17.5	0.28	25	0.2
C/N=10	7.1	0.5	11.9	0.48	17.9	0.37	28.4	0.31

Table 5. Comparison of three different equations coefficients for infiltration rate data.

Treatment	Green - Ampt				Kastiakov				Kastiakov - Lewise				
	k	b	SE	R^2	a	b	SE	R^2	a	b	c	SE	R^2
Check	-0.306	3.029	0.19	0.87**	4.709	0.326	0.193	0.86*	117.893	0.011	0.234	0.158	0.93**
C/N = 36	0.151	1.148	0.182	0.74ns	2.044	0.552	0.147	0.83*	3.094	0.307	0.213	0.157	0.85*
C/N = 30	-0.612	6.099	0.157	0.96**	7.637	0.278	0.126	0.97**	14.532	0.138	0.141	0.133	0.98**
C/N = 20	-6.016	43.213	1.086	0.63ns	186.75	0.019	0.794	0.80*	170.596	0.025	-0.413	0.803	0.84*
C/N = 10	-0.69	4.694	0.307	0.78*	40.818	0.0446	0.261	0.84*	240.125	0.007	0.154	0.254	0.88**

Reference

Annabi m, Houot S, Francou C, Poitrenaud M, Bissonnais YL (2007) Soil aggregate stability improvement with urban composts of different maturities. *Soil Sci. Soc. Am. J.* SSSAJ **71**, 413-423

Bowman RA,Vigil MF, Nielsen DC, Anderson RL (1999) Soil organic matter changes in intensively cropped dryland systems. *Soil Science Sci. Society. of America. journal J.* **63**, , 186-191.

Farahani H J (1998) Soil water storage in dryland cropping systems: the significance of cropping intensification. *Soil Sci. Soc. Am. J.*Soil Sci Soc Am J **62**, 984-991.

Kemper WD, Rosenau RC (1986) Aggregate stability and size 'Methods of soil analysis. Part 1. Physical and mineralogical methods'. (Ed A Klute) distribiution In : Klute A., Methods of soil analysis , part 1. (American Society of Agronomy Inc.: Madison, WI).Agronomy monogragh s, 9. Amercan society of agronomy, Mdison WI.

Margesin R, Schinner F (2005) 'Manual for Soil Analysis – Monitoring and Assessing Soil Bioremediation'. (Springer-: Verlag Berlin Heidelberg). 370 pages.

Martens DA, Frankenberger WT(1992) Modification of infiltration rates in an organic-amended irrigated *Agron J.* **84,**707-717

Mosavi SB, Jafarzadeh AA, Neishabori MR, Ostan SH (2009) Application of rye green manure in wheat rotation system alters soil water content and chemical characteristics under dryland condition in Maragheh. *Pakistan Journal of Biological Science* **12**, 178-182.

Pikul J, Johnson J, Wright J, Caesar S, Ellsbury T, Michael (2005) 'Soil organic matter and aggregate stability affected by tillage'. March 1 conference,. (Taylor and Francis, Inc.: New York. p. 243-258.).

Sandhu KS, Benbi DK, Prihar SS, , Saggar S (1992) Dry land wheat yield dependence on rainfall, applied N and mulching in preceding maize. *Nutrient Cycling in Agroecosystems* **32**, 229-237.