Changes in soil physical characteristics affected by green manuring of different cereals

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ABSTRACT

In order to determine the influence of different cereals as green manures on organic carbon and soil physical properties, an experiment was conducted in 2011 in Khaton Abad Agricultural Research Station of Islamic University (Khorasgan branch), Esfahan, Iran (latitude 32^{o} $40^{/}$ N, longitude 51^{o} $58^{/}$ E, and 1570 m elevation). A completely randomized block design with 3 replications was used. Green manures were included barley, rye, triticale and clover with two levels of farm yard manures namely, 30 and 60 ton/ha and one treatment of chemical fertilization as a control treatment and decomposition time of manures in two levels, the first one is one day after turning green manure to soil and the second one is 4 weeks after returning of them. Manure was mixed with soil immediately after spreading it. All crops were returned to the soil with mouldboard ploughing, before heading stage for cereal, and 10 percentage of flowering for clover, respectively. All experimental characteristics, namely, EC, pH, $CaCO_3$, organic carbon (OC), P_2O_5, K_2O, Zn, Mn, Fe and Cu significantly influenced by treatment. The highest EC, organic carbon, P_2O_5, K_2O, Zn and Mn of the soil was related to application of 60 kg N/ha. The maximum pH and Fe content of soil was obtained in application of 30 kg N/ha and in a treatment in which rye was burning. The treatment in which clover was used as a green manure has obtained the highest Cu content of soil, which had significant difference with other treatments. There were no significant differences in $CaCO_3$ among application of 30 kg N/ha, control treatment, rye as a green manure, triticale as green manure, and triticale as a green manure after four weeks. Control treatment had obtained the lowest EC, Organic carbon, P_2O_5, K_2O, Zn, Fe and Cu of soil. Moreover, the maximum $CaCO_3$ and Mn of soil were achieved in a treatment in which clover was used as a green manure. The treatment in which rye was used as a green manure had obtained the highest pH.

Key words: Green manure, cereals, organic carbon, soil characteristics.

INTRODUCTION

Sustainability is considered in relation to organic farming a sector growing rapidly in many countries (Morris et al., 2009). Straw incorporation is considered an important strategy to improve soil quality and reduce dependence on mineral fertilizers (Han and He, 2010). Thomas et al. (2007) concluded that sustainable management such as cover cropping, can increase soil organic matter and reduce soil erosion and nitrogen leaching. The greater organic matter accumulation close to the soil surface and solute

movement in soil under no tillage practice would be beneficial to soil chemical and physical status and crop production in the long-term, whereas the concentration of nutrients such as P and K in surface layers may reduce their availability to crops. Managing soil organic carbon (C) is central because soil organic matter influences numerous soil properties relevant to ecosystem functioning and crop growth. Even small changes in total C content can have disproportionately large impacts on key soil physical properties (Masri and Ryan, 2006). Although the use of residues has long-term positive effects on soil properties and crop yield (Tejada et al., 2008); in the short term, residues may hamper root penetration and cause N deficiency (Shindo and Nishio, 2005). Bierke et al. (2008) on the basis of their experiment revealed no significant changes in organic C and total N in incorporation of crop residue. In contrast, all tested variable increased at the long-term experiment, in which the organic C increased 41% in the residue incorporated plots while at the residue plots the increase was 16%. The importance of soil physical and chemical conditions in optimizing production has been recognized (Kobayashi et al., 2004; Zebrath et al., 2009). The aim of this study was determining green manure effects of different cereals on soil physical properties.

MATERIAL AND METHODS

This experiment was done in 2011 in Khaton Abad Agricultural Research Station of Islamic University (Khorasgan branch), Esfahan, Iran (latitude 32^{o} $40^{/}$ N, longitude 51^{o} $58^{/}$ E, and 1570 m elevation). A completely randomized block design with 3 replications was used. Green manures were included barley, rye, triticale and clover with two levels of farm yard manures namely, 30 and 60 ton/ha and one treatment of chemical fertilization as a control treatment and decomposition time of manures in two levels, the first one is one day after turning green manure to soil and the second one is 4 weeks after returning of them. Manure was mixed with soil immediately after spreading it. All crops were returned to the soil with mouldboard ploughing, before heading stage for cereal, and 10 percentage of flowering for clover, respectively. On the basis of soil analysis results before plantation, EC at 0-30 cm and 30-60 cm was 2.5 dS/m and 2.43 dS/m, respectively. The soil analysis showed that pH at 0-30 cm and 30-60 cm was 7.8 and 8.5, respectively. $CaCO_3$ at the depth of 0-30 cm and 30-60 cm was 35% and 38%, respectively. The organic carbon (OC) at depth of 0-30 cm and 30-60 cm was 1.2% and 1%, respectively. Phosphorous content at depth of 0-30 cm and 30-60 cm was 39.6 ppm and 12.2 ppm, respectively (Table 1). On the one hand Potassium (K) content at the depth of 0-30 cm and 30-60 cm was 400 ppm and 380 ppm, respectively. Soil texture at two depths, namely 0-30 cm and 30-60 cm was Si.C and C, respectively. At the depth of 0-30 cm, Cu, Fe, Mn and Zn content was 1.7 ppm, 2.125 ppm, 7.02 ppm and 1.55 ppm. Cu, Fe, Mn and Zn content at the depth of 30-60 cm was 1.58 ppm, 2.075 ppm, 6.98 ppm, and 0.8 ppm, respectively (Table 1). Analysis of variance (ANOVA) was used to determine the significant differences. Duncan 's multiple range test was used for the separation of means. All statistics was performed with MSTAT-C program.

Table 1. Soil Analysis of experimental farm at two depths (0-30 and 30-60 cm).

Depth (cm)	EC (dS/m)	pH	$CaCO_3$ (%)	Organic carbon (OC) (%)	P (ppm)	K (ppm)	Sand (%)	Silt (%)	Clay (%)	Soil texture	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)

0-30	2.5	7.8	35	1.2	39.6	400	11	41	48	Si.C	1.7	2.125	7.02	1.55
30-60	2.43	8.5	38	1	12.2	380	11	37	52	C	1.58	2.075	6.98	0.8

RESULTS AND DISCUSSION

All experimental characteristics, namely, EC, pH, $CaCO_3$, organic carbon (OC), P_2O_5, K_2O, Zn, Mn, Fe and Cu significantly influenced by treatment (Table 2). Minatel et al. (2006) reported that green manuring did not result in positive significant effects on the soil physical properties. The highest EC was related to application of 60 kg N/ha, and the lowest one was related to control treatment. Application of 60 Kg N per had significant differences with other treatments. The maximum pH, which had significant differences with other treatments, is obtained in usage of clover as a green manure; the lowest one was obtained in treatment in which rye use as a green manure. The maximum $CaCO_3$ was achieved in treatment, in which clover was used as a green manure, and its difference with other treatments were significant. On the contrary side, no significant differences were found among application of 30 Kg N/ha, control treatment, rye as a green manure, triticale as a green manure and triticale as a green manure after four weeks. Application of 60 kg N/ha had obtained the highest organic carbon, and the minimum one was related to control treatment. Both these two treatments had significant differences with other treatments. The highest and the lowest P_2O_5 was achieved in application of 60 kgN/ha and control treatment, respectively. There were significant differences between these two treatments and all others. The maximum and the minimum K_2O, which had significant differences with all experimental treatments were belonged to application of 60 kg N/ha and control treatment, respectively. On the one hand, the maximum Zn was related to application of 60 kg N/ha. On the other hand, the minimum Zn was obtained in control treatment. The highest Mn content and the lowest one was achieved in application of 60 kg N/ha and using clover as a green manure, respectively, which had significant differences with each other and all other treatments. Control treatment had obtained the lowest Fe, moreover, the highest one was obtained in treatment, in which rye was burning. Furthermore, all differences among treatments were significant. The recycling of previous crops maintains the soil physical and chemical condition and improves the overall ecological balance of the crop production system (Mandal et al., 2004; Inoue et al., 2008). There were significant differences between the maximum Cu content, namely clover as a green manure, and the minimum one, namely, control treatment. Furthermore, these two treatments have significant differences with other experimental treatments (Table 3).

Table 2. Analysis of variance for experimental characteristics.

S.O.V	d.f.	EC	pH	$CaCO_3$	Organic carbon (OC)	P_2O_5	K_2O	Zn	Mn	Fe	Cu
Replication	2	0.129	0.323**	2.107**	0.499**	1066.94**	156961.49**	0.0027**	0.6176*	0.077**	0.00665**
Treatment	15	13.189**	0.6**	290.70**	2.533**	3975.37**	599329.20**	1.5626**	500.307**	5.8994**	0.0464**
Error	30	0.2175	0.00187	0.00104	0.00487	40.8108	2031.419	0.00008	0.1417	0.00109	0.000127

* and ** Significant at P=0.05 and P=0.01 level, respectively in F-test., NS: Not Significant.

Table 3. mean comparison for EC (dS/m), pH, $CaCO_3$ (%), organic carbon (OC)(%), P_2O_5 (ppm), K_2O (ppm), Zn (ppm), Mn (ppm), Fe (ppm) and Cu (ppm).

Treatment	EC	pH	$CaCO_3$	Organic	P_2O_5	K_2O	Zn	Mn	Fe	Cu

	(dS/m)		(%)	carbon (OC) (%)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Application of 60 kg N/ha fertilizer	11.44a	7.9b	33.03d	2.15a	183.76a	2141.63a	4.27a	22.57a	7.39d	2.10a
Application of 30 kg N/ha fertilizer	4.89fg	7.8c	36a	1.31cde	148.30b	1535.69b	1.18i	13.37f	6.62f	1.80c
Clover as a green manure	4.04h	8.0a	28.0h	1.19e	59.80ef	664.54j	1.12k	10.63h	6.39g	4.56k
Control treatment	2.43j	7.8c	36a	0.98f	39.33g	397.33k	0.80n	11.49g	2.12l	1.58j
Barley as a green manure	4.12h	7.5f	30.3g	1.35bcd	65.76ef	724.14ij	1.28f	16.83c	6.35gh	1.74de
Barley as a green manure after 1 week	5.22ef	7.7d	30.3f	1.46b	81.85cd	904.93ef	1.62b	16.17d	6.34igh	1.72e
Barley as a green manure after 4 weeks	7.05b	7.7d	34.03c	1.46b	88.90c	995.32d	1.36d	15.59d	5.80k	1.60i
Burning of barley	5.86cde	7.7d	32.03e	1.4bc	70.62e	1598.27b	1.39c	21.59b	7.09e	1.76d
Rye as a green manure	3.66ij	7.0d	36a	1.31cde	57.71f	723.15ij	1.08l	16.29cd	6.33igh	1.74de
Rye as a green manure after 1 week	4.29gh	7.7d	33.03d	1.35bcd	60.59ef	752.95hi	1.32e	14.94e	7.91b	1.74de
Rye as a green manure after 4 weeks	6.39bcd	7.8c	33.03f	1.35bcd	62.28ef	813.54gh	1.22g	14.31e	5.99j	1.68g
Burning of rye	5.74def	7.7d	31.03f	1.27cde	60.29ef	965.52de	1.2h	21.49b	8.10a	1.82b
Triticale as a green manure	3.02ij	7.8c	36a	1.23de	71.65de	633.35ij	1.04m	14.84e	6.29i	1.74ed
Triticale as a green manure after 1 week	5.69def	7.6e	35.3b	1.31cde	66.22ef	693.35ij	1.16j	15.93d	7.77c	1.70f
Triticale as a green manure after 4 weeks	6.59def	7.8c	36a	1.34bcd	86.49c	845.33fg	1.12k	15.69d	6.58f	1.64h
Burning of Triticale	4.09h	7.8c	34.03c	1.32cde	92.10c	1296.3c	1.2h	16.03d	7.95b	1.76d

Common letters within each column do not differ significantly.

CONCLUSION

The highest EC, organic carbon, P_2O_5, K_2O, Zn and Mn of the soil was related to application of 60 kg N/ha. The maximum pH and Fe content of soil was obtained in application of 30 kg N/ha and in a treatment in which rye was burning. The treatment in which clover was used as a green manure has obtained the highest Cu content of soil, which had significant difference with other treatments. There were no significant differences in $CaCO_3$ among application of 30 kg N/ha, control treatment, rye as a green manure, triticale as green manure, and triticale as a green manure after four weeks. Control treatment had obtained the lowest EC, Organic carbon, P_2O_5, K_2O, Zn, Fe and Cu of soil. Moreover, the maximum $CaCO_3$ and Mn of soil were achieved in a treatment in

which clover was used as a green manure. The treatment in which rye was used as a green manure had obtained the highest pH.

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