Impact of long term fertilization on soil water content in Haploborolls

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ABSTRACT

Soil water content under no fertilizer (NF), fertilizer (F) (N:30; P_2O_5: 45 kg/ha), and fertilizer plus pig manure (FO) (N:30; P_2O_5: 45 kg/ha; pig manure 15 000 kg/ha in 2003; and 30 000 kg/ha in 2004 and 2005) treatments was measured using neutron probe instrument for a period three years in a long term field experiment in order to investigate the impact of different fertilization treatments on Haploborolls soil water content. Fertilization had significant effects on the soil water content. FO treatment had greater soil water content in 10 cm depth than F treatment with average 9.9% increase ($P < 0.05$) but lower than NF treatment; however, in the depth from 30 to 90 cm, there was no water content difference between F and FO treatments. Treatment with organic amendments reduced total soil water content on the long term experiment basis. Across the three years, no fertilizer treatment had total soil water content higher by 1.2% and 3.1% than fertilizer treatment and fertilizer plus pig manure treatment within 10 to 210 cm soil profile in most of the months, respectively.

Keywords: Haploborolls; fertilization; soil water; soil depth

Water is the factor most limiting crop yield in the rain-fed black soil (Haploborolls) (Soil Survey Staf 1999) region in Northeast China.

Many researches indicated that fertilization significantly influenced soil water content, because fertilization stimulates plant growth and thus plant's use of soil water and its distributions (Ritchie and Johnson 1990). Plants that received fertilizer reduced the soil water more than did non-fertilized plants (McKell et al. 1959). Ouattara et al. (2006) proposed that organic matter input significantly improved soil water content. Gagnon et al. (1998) reported that organic composts had different effects on the soil moisture in sandy loam and clay soils. The soil moisture content (0–15 cm) of sandy loam was notably affected by organic composts treatments at harvest. All composts at high rates showed a positive impact on the soil water content, and the effect was significantly related to the amount of organic matter added. Conversely, the various treatments had no significant effect on the soil moisture (0–20 cm) of the clay soil. Few literatures are available on the relationship between fertilization level and water content in Haploborolls. The objectives of this study were to investigate the impact of different fertilization treatments on Haploborolls soil water content through a long-term experiment, and to provide some frame of reference for water and fertilization management in the Haploborolls region.

MATERIALS AND METHODS

The experiment was conducted in the Hailun county (latitude 47°45'E, longitude 126°92'N), Heilongjiang province of China. The climate is a continental monsoon type of the North Temperate Zone characterized by a cold and dry winter and a hot and wet summer. Mean annual rainfall is about 500 mm. The major soil type is Haploborolls with a 30- to 60-cm-thick black top layer which is rich in organic matter.

A long-term experiment initiated in 1993 at the Hailun Agro-ecological experimental station, Chinese

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Academy of Sciences (CAS) was used in this study. The experimental design was a complete randomized block. It was composed of four blocks (replications) and sixteen treatments. Among them, the no fertilizer (NF), fertilizer (F), and fertilizer plus organic amendments (FO) treatments, which were all under natural rainfall conditions, were retained in this study. The area of each plot was 60 m^2 in size. Each plot was installed with a 3 m long access tube for measuring water content using neutron probe instrument. At the very beginning of the experiment in 1993, plots were separated by a 1.2-m-deep water proof material and reinforced concrete underground to prevent water infiltration from each other.

The test crop was corn in 2003 and 2005 and soybean in 2004. The rates of N for NF, F and FO were 0, 30.0, and 30.0 kg/ha, the rates of P (P_2O_5) were 0, 45.0 and 45.0 kg/ha, respectively, and organic amendments (OA) was 15 000 kg/ha as pig manure in year 2003. In 2004 and 2005, the rates of N were 0, 150.0 and 150.0 kg/ha, the rates of P were 0, 75.0 and 75.0 kg/ha, respectively, and OA was 30 000 kg/ha as pig manure.

Soil water was measured every five days from the beginning of April to mid October during the three growing seasons at the depths of 10, 20, 30, 40, 50, 70, 90, 110, 130, 150, 170, 190, and 210 cm. All data were analyzed using the SAS Systems Release 8.01 for Windows (SAS Institute 2001), significant differences between means of treatments were determined by the Fisher's protected least significant difference (LSD).

RESULTS AND DISCUSSION

Soil water content in different soil depths. The soil water content from chemical fertilizer plus organic amendment in 10 cm was significantly greater than chemical fertilizer treatment in all three years, with a 9.9% averaged increase, and was also significant at 20 cm in 2004 with 6.1% increase ($P < 0.05$). However from 30 to 90 cm, there was no water content difference between fertilized and fertilized plus organic amendment treatments except in 70 cm in 2004 (Table 1). It means that the addition of organic manure increased surface soil water content, which does not confirm from the results of Subramanian et al. (2000) and Durgude et al. (1996); they found that organic manure-amended plots recorded higher soil water content than the inorganic N-fertilized plots, irrespective of soil depths. This might be due to the difference in manure incorporation. The manure applied in the present study was surface-incorporated into the field, while their researches were deeply ploughed.

The higher water content in NF treatment at almost every depth from 10 to 70 cm in this study

Table 1. Average soil water content (%) V/V during growing season in different soil depth in three year

Depth (cm)	2003			2004			2005		
	NF	F	FO	NF	F	FO	NF	F	FO
10	30.1^{a*}	27.2^{c}	28.6^{b}	22.2^{a}	18.2^{b}	21.4^{a}	25.0^{a}	21.3^{b}	22.8^{c}
20	34.3^{a}	32.2^{b}	32.1^{b}	27.6^{a}	24.7^{c}	26.2^{b}	29.1^{a}	26.3^{b}	26.6^{b}
30	36.3^{a}	34.3^{b}	34.4^{b}	30.1^{a}	27.8^{b}	27.6^{b}	31.2^{a}	29.1^{b}	27.7^{c}
40	37.2^{a}	36.1^{b}	36.2^{b}	32.9^{a}	30.9^{b}	30.3^{b}	33.6^{a}	31.8^{b}	30.2^{c}
50	37.9^{a}	37.1^{b}	36.8^{b}	34.9^{a}	33.0^{b}	32.2^{b}	35.5^{a}	33.4^{b}	31.7^{c}
70	38.9^{a}	38.7^{a}	38.5^{a}	37.4^{a}	36.6^{b}	35.8^{c}	37.1^{a}	36.6^{b}	35.0^{c}
90	39.0^{a}	39.8^{a}	39.3^{a}	37.2^{b}	38.0^{a}	37.4^{ab}	36.6^{c}	37.6^{a}	37.1^{b}
110	38.8^{ab}	39.4^{a}	38.1^{b}	36.8^{b}	37.9^{a}	36.0^{b}	36.8^{b}	37.7^{a}	35.8^{c}
130	37.6^{b}	38.5^{a}	37.8^{b}	35.5^{ab}	36.2^{a}	34.6^{b}	35.7^{b}	36.8^{a}	35.6^{b}
150	38.8^{a}	38.8^{a}	37.9^{a}	34.6^{a}	35.3^{a}	34.3^{a}	35.7^{b}	37.2^{a}	35.9^{b}
170	37.8^{a}	38.6^{a}	38.2^{a}	36.1^{b}	37^{a}	35.8^{c}	37.1^{b}	37.9^{a}	36.9^{b}
190	37.7^{a}	38.2^{a}	37.9^{a}	37.2^{b}	38.3^{a}	37.2^{b}	37.2^{b}	38.6^{a}	37.2^{b}
210	38.6^{b}	39.5^{a}	38.6^{b}	38.3^{b}	39.8^{a}	38.0^{b}	38.4^{b}	39.6^{a}	38.2^{b}

*significant differences between means of treatments were determined by Fisher's protected least significant difference (LSD)

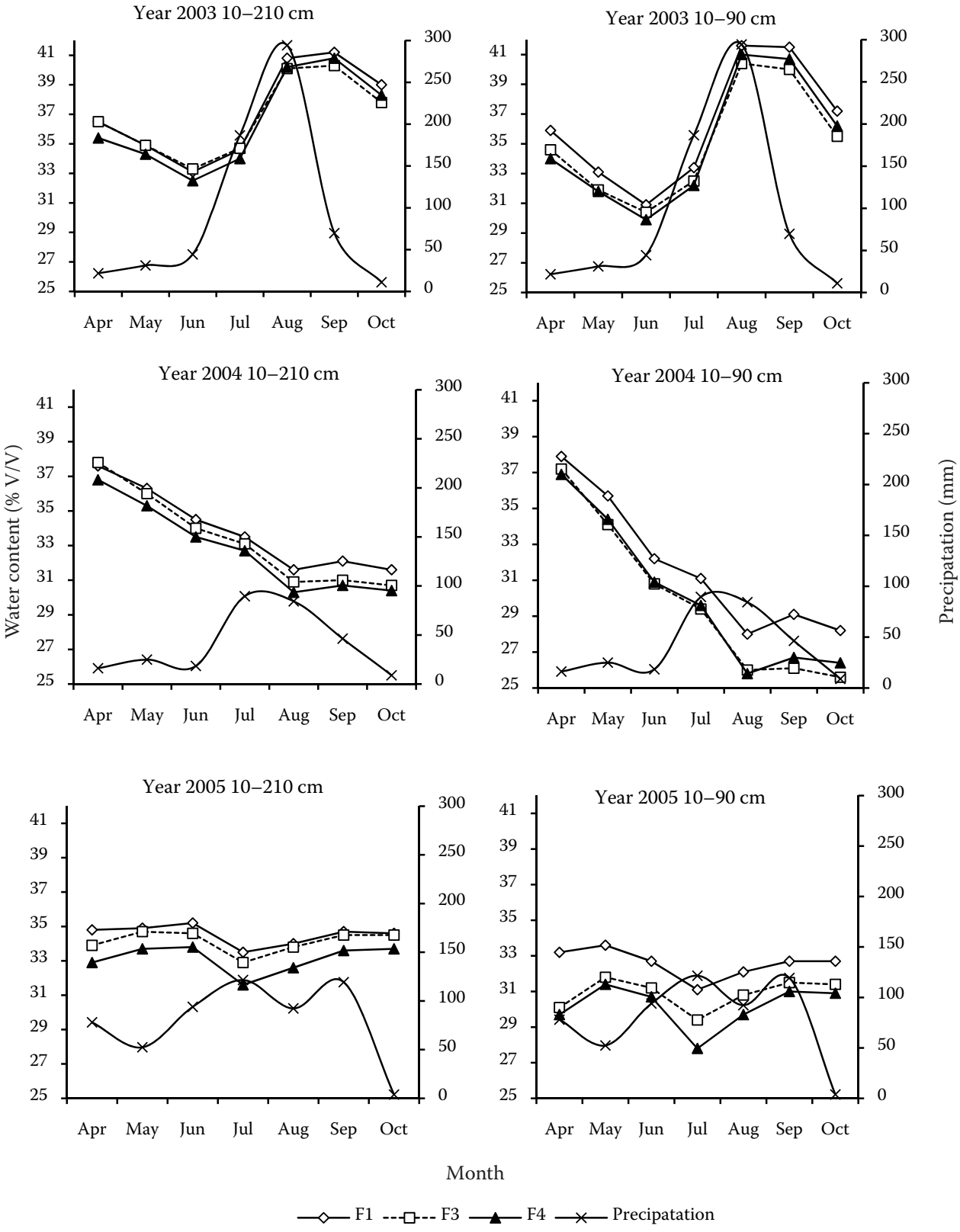

Figure 1. Monthly average water content and precipitation during growing season in three years

might be related to the poor plant stand and lower yield (data not provided).

The highest soil water content was observed in chemical fertilizer treatment when the depth was deeper than 90 cm, though a difference was significantly irregular. This phenomenon needs further investigation.

Seasonal changes of soil water content and total water content. The changes of averaged water content in 10 to 90 cm and 10 to 210 cm profiles

in the growing seasons were similar in the three experimental years. NF had a higher total soil water content than F and FO in most of the months; on average it increased by 1.2% and 3.1% across three years (Table 1). Because of more rainfall in 2003, the difference among treatments was small in the range of 10 to 90 cm and 10 to 210 cm from July. In 2004 and 2005 with less rainfall compared to 2003, differences among the three treatments were relatively larger.

Since 90 cm was the susceptible soil depth found in the present studies, we divided the total soil water content into two ranges: 10–90 cm and 10–210 cm. The average total water content within 90 cm profile and within 210 cm profile in the growing season for the three years was all NF > F > FO.

Non-fertilized treatment had higher total water content in 10–210 cm. There were significant differences between NF with F and FO for three years within 90 cm profile. No difference between F and FO within 90 cm profile for years 2003 and 2004 was found, while there was a significant difference for 2005. There were significant differences between NF and F and between F and FO within 210 cm profile in 2004 and 2005 (data no provided). In general, increased fertilization decreased soil water content in Haploborolls soil characterized with clay loam in our study. The treatment with organic amendments reduced total soil water content on the long term experiment basis. This trend was especially apparent in 2004 and 2005 when the rainfall was less than in 2003 (data no provided).

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