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Influence of cropping systems on soil properties in semi-arid conditions of Setif, Algeria

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ABSTRACT

The effect of two culture systems, conventional and no till combined the previous crop (lentil and wheat) on soil properties were studied in the experimental site of the station ITGC Setif (Algeria) during the crop year 2011/2012. The results indicate that the no-till system affects positively the variables of soil properties and the organic matter has a rate of 2.89% compared to 2.44% in conventional tillage. If the conventional system has an infiltration of moisture relatively higher than that observed for no till throughout the cycle, the no-tillage is distinguished by a higher storage of moisture at the end of cycle wheat cultivation. The results also indicate that the density (1.44), permeability (22.79cm/h) and soil compaction (12.51kg/cm^2) in no-till were significantly higher compared to conventional tillage (1.35, 14.13cm/h, 7.40kg/cm^2)) respectively.

Key words: Conventional tillage, no till, preceding crop, bulk density, infiltration, compaction, organic matter.

Introduction

The semi-arid region in Algeria is an agricultural area large enough. However, this area is more vulnerable under severe constraints; the most important are drought, low rainfall, random and often aggressive, unproductive soils, low fertility and poor in organic matter (Hanachi and Fellahi, 2010). Several authors argue that for sensible environments, the intensive work contributes to the physical deterioration of soil and the decline of fertility and fauna, which is a real threat of declining productivity in the long term (Lopez Billido, 1992; Kribaa *et al*., 2001). To remedy this, several authors advocate the replacement of conventional labor by the no till or zero till (Mrabet, 2000; Lahmar and Ruellan, 2007). The adoption of conservation agriculture has been an initiator to the growth of grain yields, and to improve the physico-chemical properties of the soil and the ability to store water in the soil (Kacemi *et al*., 1995). In this context, this study aims to follow the introduction of direct seeding in semi-arid region, as an alternative to conventional labor through monitoring the evolution of some parameters related to the soil.

Materials and Methods

The experiment was conducted at the seed farm ITGC-Setif, Algeria, representative site of the semi-arid zone. The soil is shallow limestone with a surface charge stony infertile. The organic matter content is low with a value of 1.54% (Aït Ouali and Kourougli, 2010). On this site, an experimental test is installed since 2009 to evaluate the effect of tillage systems and rotations on the production of wheat grain and soil quality. The experimental design adopted is the split-plot randomized complete block design with three replications. The main factor is the system of two types: direct seeding and conventional tillage. The second factor is the previous crop with two levels wheat-wheat (BB) and wheat lens (BL). In total, 12 plots were cultivated where each has total area of 180 m² (30x60).

The implementation of the test with two species of durum wheat (*Triticum durum* Desf) and lens (*Lentis culunaris* L) was carried out on 12/01/2012 using a classic seeder (SOLA) and specific seeder for Direct Seeding (Semeato Personale Drill-17). In the conventional system, the preparation of the seed bed was preceded by stubble made at the end of harvest to bury the residues, while on the no-tillage system; no tillage operation was performed, excepting the tillage of direct seeder. Weed control in no-till plots was done in post seeding by the use of glyphosate at a rate of 3 l / ha whereas conventional tillage, weeding took place on at 2-3 leaves stage of wheat with the Pyroxsulam at the rate of 0.75 l / ha.

Measurement methods:

Soil moisture is derived using the gravimetric method. Soil samples were taken using an auger on the horizon, 0-10, 10-20, and 20-30cm, and placed in cans numbered. Once the fresh weights (PF) determined, samples are steamed at 105 °C for 24 hours to obtain the dry weight (DW). Moisture content is calculated according to the formula: HP = 100% (PF-PS)/PS (Ollier and Chard, 1981).

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The soil bulk density provides information on the porosity of the soil, which is a major feature controlling the hydrodynamic properties of the soil and root development of plants. This is followed by measuring the density of the soil. Samples of the cylinder volume (V, cm3) known, undisturbed samples were carried out on the horizons 0-10cm, 10-20cm and 20 30cm. The weight of the collected soil contained in the cylinder is determined in the laboratory after drying at 105 °C for 24 hours. The bulk density is derived using the following formula:
Da = P (g) / V (cm3) (Yoro and Godo, 1990).

The rate of water infiltration into the soil is associated with the degree of soil permeability. It was determined by the use of an infiltrometer with mini disc suction at 0.5 cm high of water (Colombani *et al*., 1973). The height of the water in the tube (h) is written every minute for 10 minutes in all the elementary plots. The infiltration rate of the water is determined using the formula: K (cm/h) = Q (cm^3)/S (cm^2)
Q (cm/h): volume of water infiltrated, S (cm^2): surface water column = 15.9cm^2.

Soil compaction or penetrometer resistance is an indicator often used to give an overview on the state of soil compaction and stress which opposes the soil to root growth. It is evaluated using the penetrometer (Eijkelkamp Agrisearch equipment) measurements by pressing a metal cone into the soil and measuring the force to be applied. The result is displayed on the surface of the base of the cone defining the index of cone (25N). The compaction is obtained by the formula: Reading x constant factor (20N/cm^2) = density (N/cm^2)^2 = 10N/cm 1Kg/cm^2.

Organic matter plays a central role in maintaining soil functions: it is the food source of most soil organisms, contributes to the stabilization of the structure, water storage and cations, at the adsorption of the chemical elements, and when it mineralizes, provides minerals essential for plant growth. It is determined by the method ANNE modified (Anne, 1945). The organic carbon is oxidized by hot potassium dichromate in sulfuric acid, and the chromium sulfate formed is determined by spectrophotometer.

The statistical analyzes were performed by using SAS statistical software (SAS, Inc., 1990). Analysis of variance was used to determine the significant effect of the factors studied namely tillage and previous crop on the parameters measured in the field. The test of least significant difference (LSD <5%) was used to form homogeneous groups and differentiate between treatments (Snedecor and Cochran, 1980).

Results and Discussion

The climate of agricultural season was characterized by a volume of precipitation of about 313mm spread over the period from September to June This volume is less than the average over a period of 30 years (1981-2010), which amounted to 374.8mm (ONM, Sétif). The evolution of the average monthly temperature is bimodal, very low in winter to be relatively high in summer. The highest monthly temperature was recorded in September with an average of 22.6 °C, while the low was recorded in February with 2.4 °C. The Monthly temperature during February and March remains below 10 °C, which allows vegetation to grow normally to enhance rainwater recorded (68mm). Drought in the end of the cycle was detrimental to the weight of the grain and economic performance.

The soil moisture in semi-arid zone:

water is the limiting factor for grain production and improving crop production need the adoption of a system that stores more water in the soil. Direct seeding through its impact on soil structure and porosity, also improves certainly the capacity of water retention. The kinetic analysis highlighting the set of values for the three horizons in the two factors studied did not show a clear superiority of one system over the other. The monitoring of moisture through sampling revealed increased infiltration of rain water through the system conventional unlike direct seeding. This behavior is reversed when the soil is in a state of moisture loss by evaporation. The gain amounted to 15.23% compared to conventional system (Figure 1). So the advantage of direct seeding is to keep moisture in deficit water situation. This allows the plant a comfort in terms of water supply during the late cycle. These values indicate that this third campaign tillage, soil recorded an improvement in the water reserve at the end of the crop cycle. This is in agreement with results reported by Radford *et al*. (1992) and Nadjem (2012).

Bulk density (Da) was measured at the end of upstream stage (29/04/2012). The analysis of variance revealed that the density varies significantly depending on the mode of tillage and the interaction between previous culture et le system, but not according to the previous culture (Table 1). The average value of the density is higher in direct seeding (1.44) than under conventional tillage (1.35) (Figure, 2), where the LSD at 5% was equal to 0.075 (Table 2). The density reaches minimum values of 1.36 in direct seeding and 1.25 under conventional tillage, while the maximum is 1.53 in direct seeding and 1.46 in conventional tillage.

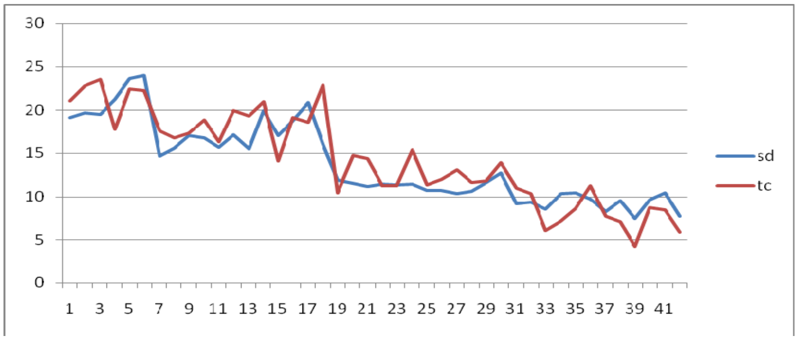

Fig. 1: Moisture variation for the three horizons in the factors studied SD: No till, TC: Conventional tillage.

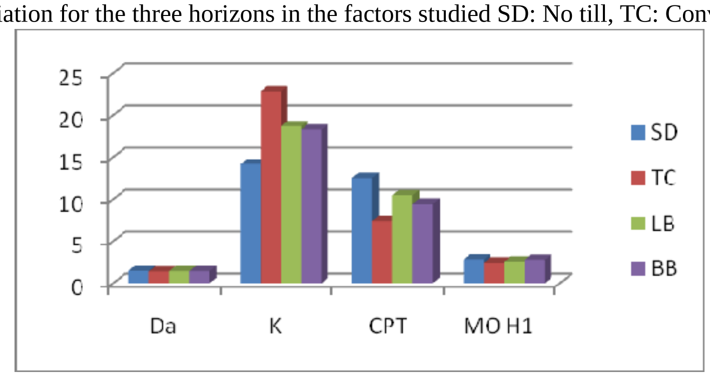

Fig. 2: Variables studied Da (bulk density), K (permeability), CPT (compaction) and MO H1 (organic matter, Horizon 0-10 cm). SD: No till, TC: Conventional tillage, previous crop: LB. Lentil/Wheat, BB Wheat/Wheat.

Table 1: Variance analysis of average squares: Da, K (cm / h), OM H1, OM H2 and OM H3.

Source of variation	Dof	Da	K (cm/h)	Compaction	OM H1	OM H2	OM H3
System F1	1	0,025*	224,85**	78,33**	0,621*	$0,012^{ns}$	$0,0001^{ns}$
Previous crop F2	1	$0,0002^{ns}$	$0,53^{ns}$	$2,98^{ns}$	$0,134^{ns}$	$0,004^{ns}$	$0,0003^{ns}$
F1* F2	1	0,020*	$1,25^{ns}$	$2,00^{ns}$	$0,008^{ns}$	$0,112^{ns}$	$0,0432^{ns}$

Dof.: Degree of freedom. ns, *, ** = non-significant, significant at 5%, Da: bulk density, K (cm/h): infiltration rate in cm/hour, OM: organic matter, H horizon.

Table 2: Mean values and homogeneous groups of variables Da, K, OM, and H1 of soil.

Factors	Da	K(cm/h)	Compaction	MO H1
SD	$1,44^{a}$	$14,13^{b}$	$12,51^{a}$	2.89^{a}
TC	$1,35^{b}$	$22,79^{a}$	$7,40^{b}$	2.44^{b}
L/B	$1,40^{a}$	$18,67^{a}$	$10,45^{a}$	2.56^{a}
B/B	$1,39^{a}$	$18,25^{a}$	$9,46^{a}$	2.77^{a}
Average	1,40	18,46	9,95	2.66
LPS %	0,075	2,27	1,65	0,42

Means followed by the same letter are not significantly different at the 5%.

These results are consistent with those reported by Hannachi *et al*., (2010), which state that the soil density is higher in no-tillage compared to what it is in conventional driving. However, these results are in contradiction with the results reported by Eduardo *et al*. (2008); Abdellaoui *et al*. (2011), who reported the advantage of the conventional compared to no tillage. According to Stephen *et al*. (2006), differences in the effect of mode of tillage are influenced by soil texture, organic matter content and tillage equipment used (Chenafi, 2011). Bescansa *et al*. (2006) reported that the increase in density in direct seeding is temporary, because the initial compaction will be compensated later by the development of pores from the soil biological activity.

Infiltration rate of water (K):

The analysis of variance of permeability in saturated state shows a highly significant effect between no-tillage and conventional tillage, and a non-significant for the different types of interaction and previous x system before (Table 1). The water seeps into the ground in conventional tillage more than twice as fast as in untilled soil, the average K is 22.79cm/h, while direct seeding is 14.13cm/h and an overall average of test 18.46 cm/h, with ppds5% equal to 2.27cm/h (Table 2). Conventional tillage shows a percentage of 161.28% permeability more marked than direct seeding. In comparing these figures with those obtained by Fortas and Hamsi (2011) on the same site of the study, which found a value of 5.09 cm/h for direct seeding, and 17.31cm/h for conventional tillage. These results confirm those of Angar *et al.* (2011) reporting an increase in infiltration time plots conducted in no-till and stability in plots conducted in conventional tillage.

Soil compaction (penetrometer resistance):

The analysis of variance revealed a highly significant effect system, but the factor previous and the interaction between the system and the previous display values not significant (Table 1). The analysis of mean factor in the system shows two statistics strongly related to cropping systems used. Represented by the first compaction in direct seeding is higher with an average of 12.51kg/cm², compared to the second symbolized by the Conventional Tillage whose average value is much lower is 7.4kg/cm², with ppds5 is equal to 1.65kg/cm² (Table 2). Direct seeding and conventional tillage have percentages of +25.72% and -25.63% over than the average of the test. These results indicate that soil tillage is more compact than conventional tillage (Figure 2).

Organic matter is the key to fertility, quality and soil biological activity. The results of the analysis of variance of the rate of organic matter have a significant effect for only for surface horizon but an insignificant effect was noted on all remaining variables (Table 1). The analysis shows a mean advantage of direct seeding with an average rate equal to 2.89% organic matter, the conventional tillage has a rate of 2.44% of organic matter in the surface layer (0-10cm). But the effect of the previous is not significant, although the rate of organic matter ranges from 2.56% with the previous lens is 2.77% for the previous wheat (Table 2). This result seems to be attributed to the abundance of organic matter in the surface of direct seeding.

Conclusion:

The introduction of zero tillage (direct seeding) in agricultural techniques has a significant effect on the rate of organic matter in the surface layer (0-10 cm). The monitoring of soil moisture shows significant differences between conventional tillage and direct seeding throughout the crop cycle. The conventional tillage maintains a relative humidity higher than that observed for the direct seeding throughout the cycle. The evolution of humidity shows that the beginning of the cycle, the surface horizons are wetter than the deep horizons. The situation is reversed at the end of the crop cycle of wheat, where the horizons in depth keep moisture more than the surface horizons. The results also indicate that the density and permeability were significantly higher in no-till compared to conventional tillage. These results suggest that direct seeding has the advantage of a rapid implementation of culture, without the costly preparation of the seedbed. This technique seems interesting in arid and semi arid regions, where seedbed preparation is rather difficult in the absence of early rain. It is the leading cause of late planting. It has the advantage of saving time and reducing production costs.

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