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Reflection of the development of cultivation techniques on the growth and development of *durum* wheat (*Triticum durum*) in Algeria

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ABSTRACT

Soil management systems can affect soil physical properties and, thus, have a direct bearing on crop performance. This study determined the effects of conventional and no-tillage management on selected soil physical properties and compared observed yield differences between these tillage systems with soil physical properties. To achieve these goals, two technical tillage chains (deep tillage, Direct sowing), were compared in the same pedoclimatic and historical situations. The experiment was carried out on clayey soil in the experimental station of the Technical Institute for Field Crops, during 2017-18 agricultural campaign. Tillage methods significantly affected the soil physical properties as increase in soil moisture contents and decrease in Penetration resistance of soil was noted The soil moisture contents (21,25 %) and Penetration resistance (2,44 MPa) were maximum in direct sowing as compared to conventional tillage. Whatever the sowing rate, the number of seedlings raised per square meter is greater on direct sowing plots. Concerning the diameter and the length of the roots, and whatever the sowing dose, the large values were recorded in the plots worked conventionally. The yield is higher for direct sowing, it is 64.1 q/ha on the other hand, it is 61.1 q/ha for conventional work. All these results are very encouraging for a possible introduction of direct sowing in cereal crops in Algeria.

Key Words : Conventional tillage, penetration resistance, population density, root system, soil moisture, wheat, yield

INTRODUCTION

The demand for wheat (*Triticum* spp.) among Algerian consumers is constantly increasing, due to increasing urbanization. However, according to statistics, yields are low due to several climatic, genetic, technical and biological factors (Mebarki *et al*., 2020). Apart from climatic factors, man can intervene in all the other factors to improve the production of this cultivated cereal. For this, the intensification of this culture requires the establishment of certain conditions for the use of improved varieties, some of which already exist in Algeria. The establishment of a sustainable cultivation system to improve the physical and chemical conditions of the soil, and finally the use of suitable fertilizers to maintain the soil's production potential.

There are in fact a large number of more or less well-defined cultivation systems or techniques for preparing the soil and planting crops. The classic approach consists of grouping them together according to whether they involve in-depth work or not, which gives two main groups, work with ploughing which

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is generally qualified as classic or conventional (TC), and work without ploughing which is also qualified minimum working time, noted NLT (No-labour technique).

A third large group is generally admitted, that of direct sowing, that is to say that the drill is the only tillage machine used. Each of these techniques has both advantages and disadvantages.

The practice of deep ploughing, the first group, is the most widespread tillage technique in Algeria and throughout the world (Pal *et al.*, 2018; Bentahar *et al.*, 2019; Shrestha *et al.*, 2020). According to Parlawar *et al.* (2017), tillage is the mechanical manipulation of the soil and the incorporation of plant residues to prepare a suitable seedbed for planting crops. Amara *et al.* (2006) mention that conventional tillage (TC) is the result of ploughing the soil with a coulter or disc plough, followed by surface tillage operations for the preparation of the seedbed. The judicious use of tillage practices overcomes edaphic constraints, whereas inopportune tillage may cause a variety of undesirable outcomes, for example, soil structure destruction, accelerated erosion, loss of organic matter and fertility, and disruption in cycles of water, organic carbon, and plant nutrient (Asgari *et al.*, 2017; Alam, 2017; Shrestha *et al*, 2018; Maryam Bayat *et al*, 2019). However, this practice is suspected of being at the origin of fertility problems and especially soil erosion which are becoming more apparent in certain regions of the world (Lyon *et al.*, 1996; Stewart, 2007). Naveen Kumar and Babalad (2017) mention that among the main causes of the degradation of the agro-system are intensive tillage, the decrease in organic matter in the soil induced by agriculture, water and wind erosion, reduced rates of water infiltration, clogging and surface crusting and soil compaction.

Moreover, conversion to no-tillage systems may improve soil physical properties and increase the soil water retention in rainfed environments. In addition, savings on operating costs and reductions in machinery emissions are expected (Blanco Canqui, *et al.*, 2017; Castellini, 2019).

Boame (2005) reports that direct seeding is a green and economical practice that brings successes. The adoption of the direct seeding system is done for economic, agronomic and climatic reasons (Lopez *et al.*, 1996). According to other authors, direct seeding also participates in improving the characteristics of soil quality, namely the ability to function in a particular ecosystem to produce more biomass, maintain the quality of air and water, and ensure the health of plants and animals (Carof, 2006).

In addition to these findings, the effect of soil condition on root development and therefore on that of the plant has been and continues to be the subject of concern for several researchers. According to Roger-Estrade *et al.* (2004), the roots lead a secret life in the soil; one hectare of winter wheat can hide 300,000 km of roots, which provides water and nutrients to the crop. A well-developed root system is the result of good soil structure and is essential for high yield.

The major factors influencing root growth are: an appropriate pore system into which roots can grow, root impedance, soil water content, soil temperature, oxygen (Munoz-Romero, 2015).

Currently several studies have highlighted the different effects of agricultural practices on the physical and mechanical state of soils but work on the effects of techniques on root development is still relevant today. Cultivation methods therefore have a profound and certain influence on the shape and development of the roots; because they affect many aspects of the root environment, namely: soil moisture and temperature, pore space, oxygen concentration, distribution of organic matter, nutrient mobilization and physical configuration of surface soils.

In this introduction, we wanted to show that several researchers have been interested in the action of cultivation techniques on the soil. Through these works, it appears that working or not working the soil has advantages and disadvantages, respectively. The choice of cultivation technique is not easy; several parameters should be taken into account, those related to the soil itself and the requirements of the crop to be set up, and those related to the working conditions. For this, the choice of agricultural machinery and more particularly tillage tools need to be done in a reasoned way.

The objective of this study, which comes within the framework of a research program of the ITGC of Oued Smar, is to compare the effects of two techniques of setting up a cereal, *durum* wheat on the state of a soil characterized by its humidity and its penetrometric resistance on the one hand, and on the development of a cereal on the other hand. This will be illustrated by the components of the yield, the diameter and lengths of the roots.

MATERIALS AND METHODS

Location

The tests were carried out during the 2017-18 agricultural campaign at the ITGC experimental station of Oued Smar in El-Harrach, Algiers. The site is located at the coordinates 36 ° 43 'North and 3 ° 68' East at the altitude of 24 m above sea-level.

The ITGC station belongs to the sub-humid bioclimatic level which corresponds to that of the plains of Mitidja. It is characterized by a Mediterranean climate with a hot and dry summer and a cold and wet winter, with irregular rainfall and rare frosts.

The soil is clayey with 46.51% clay, 26.7% silt and 26.79% sand. According to Balpande *et al.* (2020), clay provides more points of contact between larger soil particles and helps bind soil particles together, resulting in better structure.

Experimental Set-Up

The experiment was carried out on a plot of 111 m long and 38 m wide, with a total area of 4218 m². The entire surface was divided into 16 micro-plots with a spacing of 1 m between micro-plots.

Taking into account the number of factors studied and the degree of heterogeneity present on the plot, authors opted for the Factorial Block Design.

The crop used for our tests is *durum* wheat (*Triticum durum*), variety "Siméto", with an average germination rate of 96.6%. It is a variety of Italian origin recently introduced in Algeria. This variety was developed through crossing between two varieties Capeit x Valomova (Zekkour, 2007). It is a variety which is resistant to drought and lodging, it gives good production.

The crop, which was the subject of the experimentation at the same plot level during the 2016-17 crop year, was berseem (*Trifolium Alexandrinum*) variety "Tigri".

The experimental design chosen was the Factorial Block Type with two factors studied, with four replications. The entire area has been divided into four blocks, the latter are subdivided into four micro-plots of equal area, where the two doses and the two techniques are practiced in each block.

Cultivation Techniques

The conventional technique (TC) was followed for conducting this study. The ploughing was carried out by a reversible Bisoc plough at an average depth of 25 cm of the flat type. The resumption of ploughing was carried out by a Vibrocultor. The sowing was done by a row seeder (AGRIC) keeping 2.5 cm sowing depth. The direct sowing (SD) was carried out at a depth of 2.5 cm by a direct sowing machine after doing complete weeding by chemical (glyphosate). Two seed rates *viz.,* 160 kg/ha (D_1) and 180 kg/ha (D_2) were used in this experiment.

The tillage operations were carried out at the end of October 2017. The sowing operation was carried out on December 25, 2017 using an AGRIC type seed drill for TC and with a SULKY type seed drill for SD.

Chemical weed control was carried out on December 22, 2017 in pre-sowing for SD, with the application of glyphosate at a concentration of 3 L per 150 L of water.

For the two cultivation techniques, 100 kg/ha of urea was added as cover fertilizer. Half amount of urea (50 kg/ha) was applied at the start of tillering on 29th January 2018 and remaining half amount of urea (50 kg/ha) was applied to the late tillering stage on 2nd November 2018.

Statistical analysis was carried out using Xlstat software. It relied on single and multiple regressions to quantify the relationship between soil properties and crop yield on the one hand and the relationship between crop characteristics and yield on the other hand.

Changes in Soil Moisture by Weight (H%)

The studies on change in soil moisture were carried out on all the micro-plots by the cylinder method. This method consists of driving a metal cylinder into the ground on a soil profile of 30 cm depth. Soil sampling was measured by weighing before oven drying which gives the initial weight (P_i) and weighing after the oven dried at 105°C for 24 h, which gives the dry weight (Ps). These data were used to determine the weight of the soil moisture according to the formula cited by Duchauffour (1997) as given below:

$$H\% = 100\ (Pi-Ps)/Ps$$

The effect of tillage on the underground part of the plant (the roots) was assessed by the mechanical resistance to penetration (Rp in MPa). For its determination, a static penetrometer was used. The method consists in applying a force in order to have a depression of the rod of the penetrometer in the ground, which allows us to measure the depth, using a graduation of the rod that carries the cone, and read the force value indicated by a cursor on the penetrometer (graduated in kilogram force).

Population Density (plants/m²)

The interest of knowing the stocking density relates mainly to the adaptation of wheat seeds in the soil. It is determined by counting the number of feet lifted per (m²) using a wooden frame measuring 1 m on each side.

Root Diameter (dR in mm)

After the roots were collected and sorted, their diameters were measured using an electronic Calliper. The clean roots were placed between the two ends of the Calliper, the device displays the diameter of the root on the screen.

Root Length (LR in cm)

After the roots were collected, their lengths were determined using a ruler.

Number of Ears/m²

This measurement was made using a square one meter wide thrown randomly into the micro plot. The number of ears contained in the square was counted directly. We took the average of eight samples per treatment.

Wheat Yield

The wheat yield was measured using the following relationship:

Estimated yield (kg/m²) = Number of ears/m² x PMG x Number of grains by ear.

Climatic Data from The Study Campaign

The cumulative rainfall recorded during the experimental crop period (from September 2018 to June 2019) was 588.5 mm, which was lower than a normal year for the central and eastern areas (especially Algiers) characterized by rainfall around 600 to 800 mm for the same period. The months of November, January and February were the wettest months with a maximum recorded in January (96.9 mm).

RESULTS AND DISCUSSION

Soil Moisture (Humidity)

The choice of cultivation technique is essentially based on the ability to allow the soil to store water and make it available to the plant, especially when there is little or no rain. In this experiment, and regardless of the block, the soil moisture was greater at the level of direct seeding (Fig. 1).

At the level of the conventional technique, the reworking of the soil causes a large contact surface between the soil and the atmosphere, which leads to greater evaporation of water. At the level of direct-seeding plots, water was trapped in the soil and

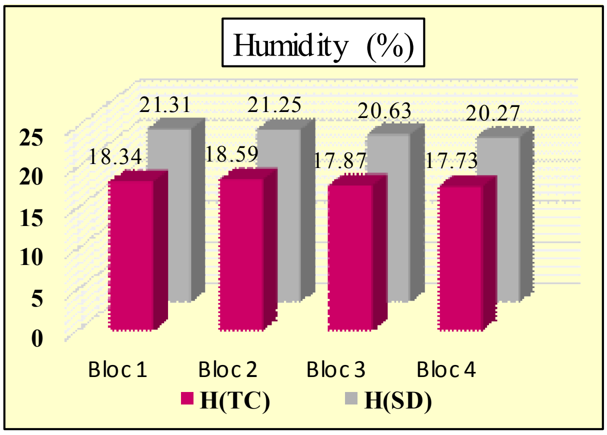

Fig. 1. Effect of cultivation techniques (TC) and seed rate (SD) on humidity.

more particularly on this type of clay texture, having a high retention capacity.

Penetrometer Resistance

The analysis of the penetrometric resistance of the soil is interesting in more ways than one, in fact this characteristic tells us about the soil's aptitude for compaction, which is an interesting mechanical property to know.

Fig. 2 shows a significant effect of cultivation technique on resistance to soil penetration. Rp is more important in the direct seeding technique. The average values are 2.35 MPa for direct sowing and 1.96 MPa for the conventional technique. The penetrometer tip penetration depth is between 9 to 26 cm for conventional work, for direct sowing this depth is between 2 to 19 cm. The same result was also recorded by Yachi *et al.*, 2020.

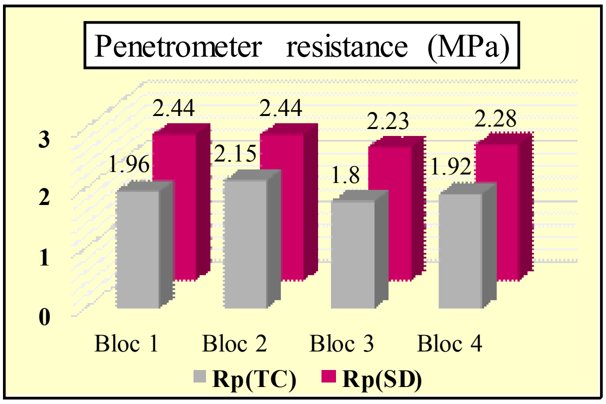

Fig. 2. Effect of cultivation techniques (TC) and seed rate (SD) on resistance to penetration.

Population Density

According to Fig. 3, and regardless of the sowing rate, the population density (Lv) is better on direct sowing plots. This could be explained by a shallow sowing depth on these plots (3 cm). On the other hand, on conventionally cultivated plots the depth of the seed after sowing was greater (between 3 and 7.9 cm) given the light and porous structure on the soil surface. This corresponds to the results of Fellahi *et al.* (2010), where they observed a more homogeneous emergence and a better regularity of the sowing depth in direct sowing, while the conventional sowing presents a significantly higher rate of loss on emergence.

This is what makes poor seedbed preparation one of the main factors affecting non-germination of seeds, even if they have good germination power. Mebarki *et al.* (2020) mention that among the causes of non-emergence, the size of the clods at the level of the seed beds are the most important. In this study, this phenomenon could be reduced with a passage of the roller before sowing. The same observation was also recorded while lifting of berseem (Yachi *et al.*, 2020).

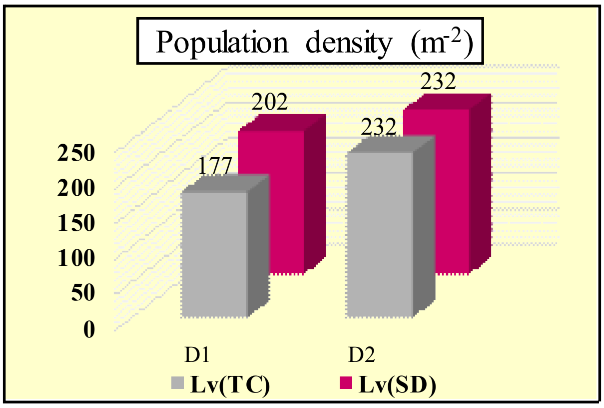

Fig. 3. Effect of cultivation techniques (TC) and seed rate (SD) on number of plants/m^2.

Root Diameter

The effect of the techniques on the diameter of the roots is clearly apparent at the level of each of the two doses (Figs. 4 and 5). The conventional technique had a positive effect on the diameter of the roots.

Indeed, the diameter of the roots varies from 0.88 to 0.96 mm for the conventional technique and it is only from 0.68 to 0.74 mm for the direct sowing technique. This could be explained in part by the effect of the different

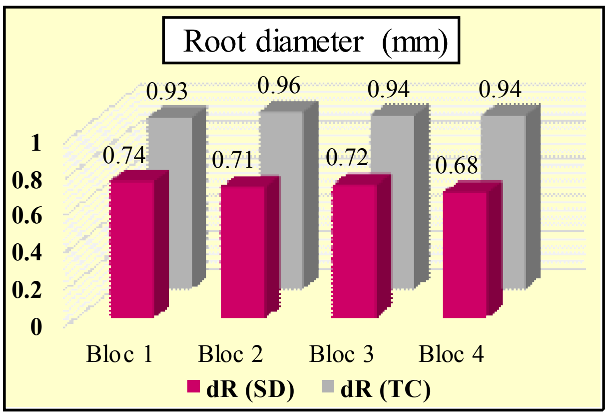

Fig. 4. Effect of cultivation techniques (TC) and seed rate (SD) on root diameter for D_1.

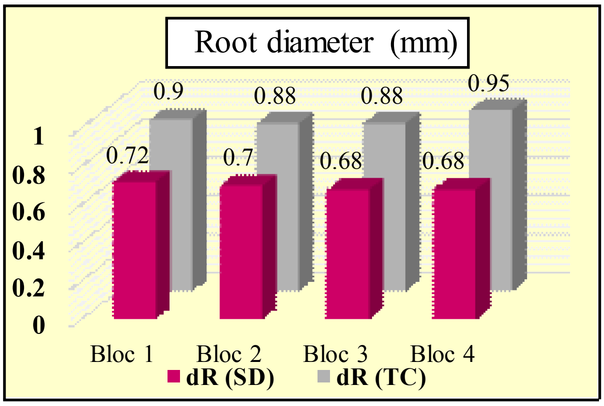

Fig. 5. Effect of cultivation techniques (TC) and seed rate (SD) on root diameter for D^2.

actions of the tools on the ground. At the level of direct seeding, the density is less important than at the level of conventionally cultivated plots. The effect of the dose is therefore, not very apparent.

Root Length

The results relating to the development of the roots clearly show that the length of the roots is well developed on the ploughed plots (TC) whatever the sowing dose (Figs. 6 and 7), This is explained by a greater porosity at the level of the plots. The best root length is 120.8 mm, which is the same length obtained with conventional work.

Yield

Fig. 8 shows that the effect of the seed rate is obvious, whatever the cultivation technique, the second dose of seed rate (180 kg/ha) gives a better yield. These results are not of the same order than those obtained on other sites with the same soil texture by Amara

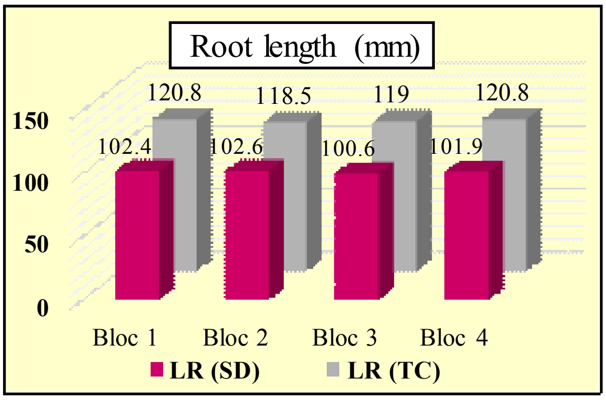

Fig. 6. Effect of cultivation techniques (TC) and seed rate (SD) on root length for D_1.

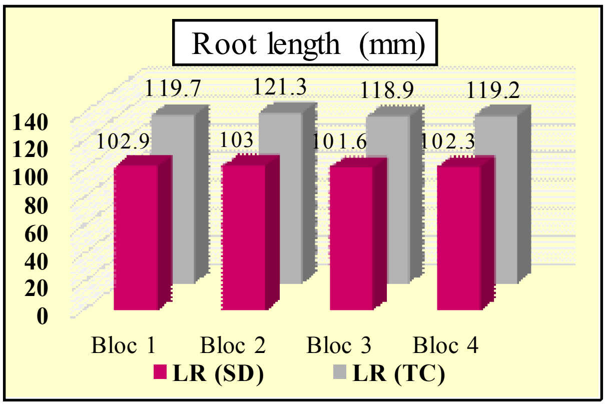

Fig. 7. Effect of cultivation techniques (TC) and seed rate (SD) on root length for D^2.

et al., 2014, who have obtained on the ploughed plots, a yield of 50.03 q/ha, while on direct seeding plots, the yield was only 36.19 q/ha. The difference in yields between both techniques is highly significant.

On the other hand, under the conditions of this study the effect of the cultivation technique shows that the wheat yield is greater in direct sowing regardless of the sowing rate. This result should nevertheless be qualified with the stocking density, which is higher in the case of direct sowing, which may explain this higher yield.

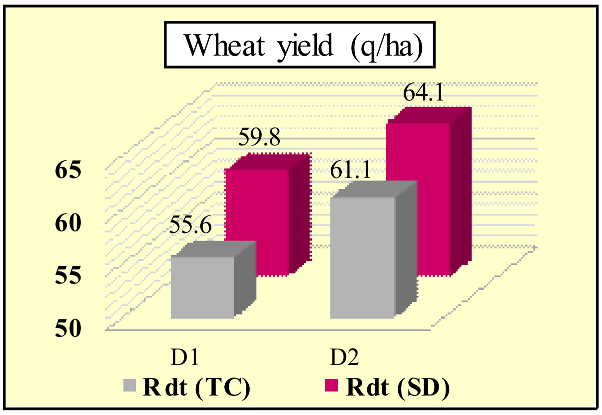

Fig. 8. Effect of cultivation techniques (TC) and seed rate (SD) on whet yield.

The multiple regression relating the yield (Rdt) with soil moisture (H), porosity (n) and penetrometric resistance (Rp) gave the following equations :

RdtT1D1 = 366,275 - 3,84*nT1D1 - 9,40*HT1D1 + 0,29*RpT1D1

RdtT2D1 = -237,877 + 0,79*nT2D1 + 10,91*HT2D1 + 1,70*RpT2D1

For the conventional tillage, the order

of importance of the effects is as follows: Moisture (H) with a coefficient of –9.40 then porosity (n) with a coefficient of -3.84 and finally penetrometric resistance (Rp) with a coefficient of + 0.29. For the direct sowing, the order of importance of the effects is Moisture (H) with a coefficient of +10.91, then the penetrometer resistance (Rp) with a coefficient of +1.70 and finally the porosity (n) with a coefficient of + 0.79.

CONCLUSION

The results obtained in this study are very encouraging for a possible introduction of direct sowing in cereal crops in Algeria. However, it is premature to make a definitive judgment on the advisability and impact of this technique on the behaviour of the wheat, as the study was conducted over a short period of time. For the future, we recommend focusing on other parameters, such as the weight distribution of the aggregates. The aggregation weight distribution is the best way to assess and characterize the action of tools on the soil structure by giving more details on the size of the clods formed after the passage of the devices, and their proportion concerning the volume of soil stirred.

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