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Analysis of the physical and mechanical behaviour of uncompacted soils under the action of cultivation techniques and consequences on cereal development: case of durum wheat

M.N. Mebarki[1], M.A. Feddal[1*], S. Feddal Taibi[2]

[1]Laboratory for the control of water in agriculture, National Higher school of agronomy (ENSA), ES16.03, Dept. of agricultural engeneering, El Harrach, Algeria.
[2] Saad Dahleb university, Dept. Of engeneering of water and the environment Blida, Algeria

*Corresponding author: feddalamine@gmail.com ; Tel: +213 559 655 632

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ABSTRACT/ RESUME

Abstract: *This work, which is a part of a research program about the problem of introducing simplified cultivation techniques in Algeria, focuses on an analysis of the effect of three cultivation techniques for the establishment of a cereal crop on the physical properties of the soil and the consequences on root development and the yield of durum wheat. The experimentation was carried out at the central farm of ENSA. The results clearly show that the technique used affects the evolution of soil moisture, porosity, and penetrometric resistance. The water content in the soil is better conserved with direct seeding, the porosity is slightly higher with the conventional technique. As far as penetrometric resistance is concerned, the soil is more resistant on the no-till plot. Root development is better in the plowed plots. It could be concluded that root density is strongly correlated with penetrometric resistance Root density (TC) = 13.89 - 0.41 * Rp (TC). The soil compressibility test showed that the water content increases the compaction phenomenon.*

I.Introduction

Cereal growth continues to occupy an important place in Algerian agriculture. The three main kinds of cereal (barley, durum wheat, and soft wheat) cover about 5 million hectares annually, i.e. 60% of the country's UAA, the majority of these crops being located in semi-arid and arid areas. They are essentially rain-fed, depending directly on rainfall, which fluctuates greatly from one year to the next. These rainfall conditions are the first explanation for the low yields in these areas. In addition, cultivation techniques are often poorly adapted to these climatic constraints [13].

Producing more cereals has become a worrying issue for Algeria, whose needs, for a growing population, are estimated at over 111 million quintals by 2020 [11].

There are a large number of more or less well-defined cultivation systems or techniques for soil preparation and crop establishment.

The classic approach is to group them according to whether or not they involve deep tillage, which gives two main groups: tillage and no-till. A third major group is generally accepted, that of direct seeding, i.e. where the drill is the only tillage equipment used. Each of these techniques has advantages but also disadvantages. [3]

Plowing, with a moldboard plow, is still the most widely used tillage technique in the world. This practice has increased crop productivity by controlling weed growth and breaking up the soil structure. However, during the 20th century, new soil fertility problems appeared, particularly in the United States where serious erosion problems ("Dust Bowl") led to the development of alternative techniques to tillage. Since then, the results of numerous research studies, such as those of [14]; [15], in different climatic zones around the world, have revealed problems common to plowed soils: compaction, reduction in soil organic matter content,

erosion, limitation of water circulation. Therefore, a gradual transition from conventional plowing (plowing with mouldboard, turning over the topsoil to a depth of 20-30 cm) to various forms of preparation without turning over the soil layers, up to direct seeding (working only on the seed line), has been taking place throughout the world for some decades. [3]
The tests carried out by [2] also showed that the action of the tillage pieces strongly modifies the values of porosity, moisture, and penetrometric resistance of the soil. The porosity increases considerably after ploughing, from 40.4% to 49.3%. After tillage, the porosity increases significantly from 40.4% to 49.3%. After tillage, the porosity increases to 51.02% and after tillage, the total porosity increases to 52.65%. According to [12], tillage affects biotic and abiotic soil factors either directly by changing the structural properties of the soil such as void arrangement, aggregates, pore connectivity or indirectly by changing the conditions of aeration, temperature and root penetrability of the soil.
The tests carried out by [2] also showed that the action of the working parts strongly modifies the values of porosity, moisture, and penetrometric resistance of the soil. The porosity increases considerably after ploughing, from 40.4% to 49.3%. After tillage, the porosity increases significantly from 40.4% to 49.3%. After tillage, the porosity increases to 51.02% and after tillage, the total porosity increases to 52.65%. According to [12], tillage affects biotic and abiotic soil factors, either directly by changing the structural properties of the soil such as void arrangement, aggregates, pore connectivity, or indirectly by changing the conditions of aeration, temperature and root penetrability of the soil.
According to [21], roots lead a secret life in the soil. One hectare of winter wheat can hide 300,000 km of roots that bring water and nutrients to the crop. A well-developed root system is the result of a good soil structure and is essential for a high yield. Cultivation methods, therefore, have a profound and definite influence on the shape and development of the roots, as they affect many aspects of the root environment, namely: soil moisture and temperature, pore space, oxygen concentration, distribution of organic matter, mobilization of nutrients and the physical configuration of the soil surface.
This observation led us to focus our work on conventional soil preparation techniques. Our work is part of a research project to identify tillage tools and models to predict their effects under different conditions and soil types. Thus, our contribution in this field consists in reviewing the cultivation techniques, (to choose adequate technical itineraries that take into account the climatic, edaphic, and economic parameters and that slow down at the same time the degradation of the natural environment, notably the soil.
The question we asked ourselves before starting this study was what would be the best way to improve the structural state of the soil, with the tools that most Algerian farmers have. Thus, we know that almost all farmers have a cover crop, a disc plough or a share plough and sometimes a harrow and/or a smooth or croskill roller on their farms.

The objective of this work, which is part of a research program of the ITGC of OuedSmar, is to compare the effects of three techniques for planting a cereal, durum wheat.

II.Materials and methods

The tests took place at the central farm of ENSA, which belongs to the commune of OuedSmar, daïra of El Harrach, Algiers. It is located between latitude 36°42'46.9" and 36°43'16.1" North and longitude 03°09'16.7" and 03°09'44.9" East. The rainfall recorded during the test season did not exceed the 100-year average for this region, just 592 mm compared to the normal 749 mm for the region, which represents a 21% deficit. The most important amount of rain was received between November and February, and this is the period of ploughing - sowing - emergence. What is exceptional for this crop is that the rainfall was well distributed throughout the crop cycle.
The water requirements of durum wheat are estimated at about 600 mm/year, but they must be well distributed throughout the cycle. The trial was set up on a clayloam soil according to the USDA classification with a clay content of 39.5%, 20.2% fine silt and 3.96% coarse silt, while the sand content was around 20% and 13.6% between fine and coarse sand.
The variety used is durum wheat Triticum durum var. Simeto of Italian origin. It is an alternative variety, the result of a cross between two Capeit x Valnova varieties. Introduced in Algeria in 2004 by the ITGC of Tiaret, it is a variety that adapts the Mediterranean climate in general. It is characterized by a good germination capacity reaching (98%) and a weight of 1000 grains 50 and 55g. This variety is characterized by a plant height of 75-85 cm with a compact spike and hollow straw.
Our experiment was carried out on a plot 90 meters long and 30 meters wide, with a total area of 3456 m². The whole area was divided into 9 microplots with spacing of 1 m between microplots.
Given the number of factors studied and the degree of heterogeneity present on the plot, we opted for the Fisher block design.

- Tillage techniques studied

For the comparative study between the three cultivation techniques, the following tillage tool chains were chosen

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- Conventional tillage: bisoc plough + cover crop + vibrocultivator + roller
- Minimum tillage: chisel + vibro-cultivator + roller
- Direct seeding: direct seeding drill

The choice of tillage equipment used is conditioned by the availability at the ENSA experimental station. Nevertheless, the tool chains chosen are the most popular with farmers in areas with the same soil and climatic conditions as the study area.
A chain of ploughing implements consisting of a ploughshare for turning the soil carries out conventional tillage; the cover crop is used afterwards for loosening the soil by cutting the large clods left by ploughing, levelling the soil, and cutting the plant debris left by ploughing. The pulveriser also reduces excessive porosity caused by ploughing.
For shallow tillage, the vibrating tiller is used, which allows the clods to be sorted over the tilled surface, with the fine soil falling from halfway down the tillage depth and the larger clods falling to the surface. This has the advantage of sowing in fine soil and therefore favorable to germination while leaving a cloddy soil that is not very sensitive to surface compaction. For the roller, this tool, entirely dedicated to the preparation of seedbeds, acts in a very superficial way on the soil, which it compacts slightly (we speak of re-compaction of the seedbed), while completing the action of breaking up the clods on the surface.
Two ploughing tools, the chisel followed by the vibrating tiller, carried out the minimum tillage. The major difference with the conventional technique is that ploughing is eliminated, and therefore the turning of the soil and this is referred to as pseudo ploughing. The latter is carried out by the chisel, which bursts the soil by the strong pressure localized on a small surface, which leads to the formation of brake lines for a sufficiently coherent soil (therefore dry). The chisel has the advantage of working deep enough (up to 25 cm) without diluting the organic matter and, above all, leaving enough debris on the surface to ensure protection against the erosive action of water and wind. It is therefore a first-choice tool for simplifying soil cultivation.

III. Results and discussion

III.1. Soil compressibility study

The increasing need for equipment in modern agriculture has led to the birth and development of powerful agricultural machinery industry. And the introduction of new no-till techniques is constantly causing a reduction in the pore volume in the soil, which will have a negative impact on root development. It is in this context that we wanted to study the compressibility of the soil, to highlight the effect of machinery on the soil structure. To this end, we carried out a test in the RDM laboratory of ENSA, which aims to determine the sensitivity of soils to compaction. This test consists of placing a sample of reworked soil in cylinders and varying the moisture content in each cylinder. The soil is compacted in each cylinder using a piston, the pressure exerted and the apparent density are then calculated and the variation curve of the apparent density ρas (g/cm³) as a function of the moisture content w (%) is plotted in the following figure.

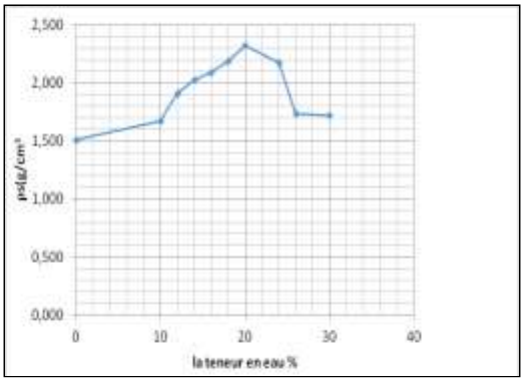

Figure 1. *the variation of bulk density with water content*

The figure above shows the variation of bulk density with humidity, the curve can be interpreted in three phases:

- First phase: moisture content < 10

In this part of the curve, the density attained remains low and hardly varies with the moisture content. Settling is the result of rearranging and possibly crushing the aggregates placed in the mould.

- Second phase: 10% < moisture content <20%.

At the 20% moisture content threshold, the slope of the curve increases sharply. The aggregates become deformable under the effect of the stresses they undergo and this all the more so as they are more humid. The porosity that existed between them gradually disappears. The apparent density reached is 2.41 g/cm³ which is close to the real density, which means that the porosity is close to 0. For some materials, if the energy applied is sufficient, textural settlement can be observed. FAURE described this as plastic behaviour and equated the compaction sensitivity threshold with a plasticity entry threshold.

- Third phase: moisture >20%.

The end of the plastic domain is marked by the existence of a density maximum called the Proctor optimum. Beyond this maximum, the density decreases. The sample is then saturated. As water is incompressible, it can be further compacted, and the higher the water content, the less it can be compacted. The water content - bulk density relationship is hyperbolic and the representative curve is called the saturation hyperbola.

The application of high pressures of up to 10 daN/cm² eliminates all the pressure that exists between the soil particles, increasing the apparent density to 2.32 g/cm3 , thus causing strong compaction of the soil. According to previous tests, ploughed soils can withstand pressures of 0.8 to 1 bar without damage in dry conditions. Above this limit, they start to settle. The pressure the soil receives is not directly the load of the machine, but the pressure exerted by the tire. This pressure is equal to the inflation pressure plus the stiffness coefficient of the tire carcass. In other words, a tractor tyre inflated to 0.6 bar exerts a ground pressure of 0.8 bar, the difference being due to the stiffness of the tyre.
Compaction is influenced by the water status of the soil, and this is all the more important when the pressure is high. It is important not to forget the texture of the soil, which plays a major role in compaction.

III.2. Variation of soil moisture with depth and stage of durum wheat for the three techniques (TC, TM, SD).

The results of the variation of soil water content in relation to depth and vegetative stage for the three cultivation techniques are shown in figure 2.

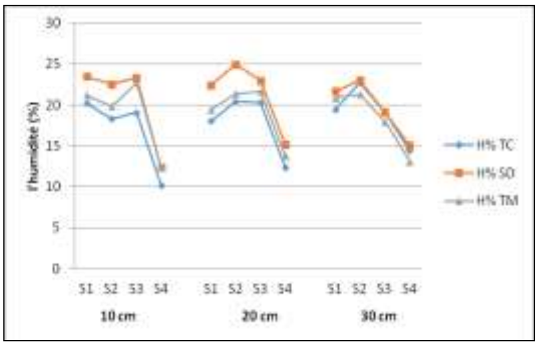

Figure 2. *variation of soil moisture concerning depth and vegetative stage for the three techniques*

With :
S1: emergence
S2 :tillering
S3 : bolting
S4 : heading

In general, the results obtained show that the no-till system allows good conservation of water in the soil. The presence of straw on the no-till plots prevents soil evaporation on the one hand. And on the other hand, the non-turning of the soil allows water storage on the surface. And in-depth, These results are in agreement with those of [9], [20] who note that there is little difference in the evolution of soil moisture of the crop planted under conventional tillage, compared to no-till and confirm that no-till and minimum tillage allow better moisture than conventional tillage.

On the other hand, the statistical analysis showed no significant effect of the technique on soil moisture, the KRUSKAL - WALLIS test gave a p (value) of 0.281.

III.3. Variation of porosity concerning depth and development stages of durum wheat

The second parameter analysed is porosity, which largely determines soil water retention, root aeration and root progress in the soil. The analysis of the effect of conventional tillage, minimum tillage and no-till on bulk density and porosity for durum wheat is shown in figure 4.

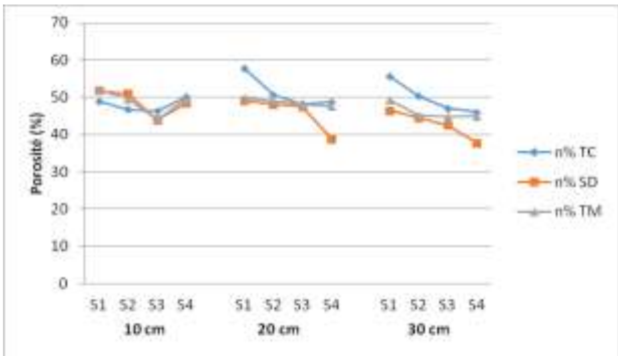

Figure 3. *variation in porosity in relation to depth and stage of development of durum wheat*

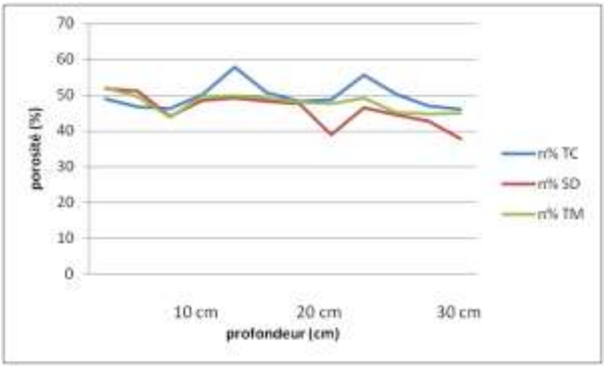

Figure 4 .*variation of porosity with depth.*

As for moisture, the statistical analysis showed no significant effect of the techniques on soil porosity, the KrusKal - Wallis test gave a P-value of 0.224.
It can be concluded that the porosity decreases from the TC technique to the SD through an average for the TM technique. In the TM plots we observe a homogeneity of the soil porosity on almost the whole

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profile; this is not the case for the other plots where the porosity is more important on the surface.

It should also be remembered that these results are directly related to the bulk density, which did not show a remarkable change during the experiment. Numerous studies have been carried out to characterize porosity under no-tillage conditions. As mentioned in [24], the results are difficult to interpret as they may be affected by other mechanisms (wetting, drying and settling). For [25] and [24], no-tillage is characterized by a decrease in macroporosity that is originally created by tillage. Thus, soil porosity is generally reduced in conservation systems but, like organic systems, they favor the formation of biologically derived macro-pores. These changes take place gradually and the differences between the systems can be measured after several years of differentiation.

III.4. Variation of penetrometric resistance according to depth and development stage of durum wheat for the three cultivation techniques

Penetrometric resistance measurement is an indicator often used to quickly assess the extent of soil compaction and the location of the compacted area. Our study focused on an analysis of the variation of this parameter in relation to the stages of durum wheat for three cultivation techniques and the first results obtained are shown in the following figure:

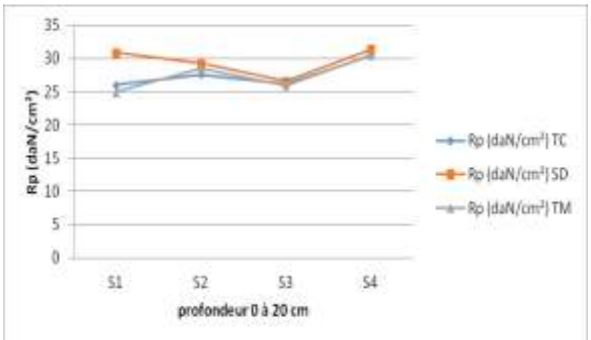

Figure 5. *variation in penetrometric resistance in relation to vegetative stages for the three techniques.*

At first sight, the results show that the three techniques present the same trends of Rp from the first to the last stage and the values are almost similar, except for SD at the first stage which presents a much higher Rp than TM and TC.

When analysing the results in more detail, it seems that the plots that worked have a lower Rp than TM and SD, with Rp ranging from 26 to 30 daN/cm² at the last stage.

For the TM and TC plots, Rp increases from the first to the second stage decreases slightly at the third stage and then increases again at the fourth stage to reach a maximum value of 03 MPa.

For the SD plots, Rp is highest at the first stage, then follows the other two techniques to reach 31 daN/cm² at the last vegetative stage.

A profile of the Rp according to the depth of the soil was established, and it was concluded that the Rp is proportional to the depth, the deeper you go the more the Rp increases, this observation is valid for the three techniques. However, we notice a persistence of the resistance at a depth of 20 cm, where the ploughing sole is located, the resistance then decreases beyond the 20 cm depth.

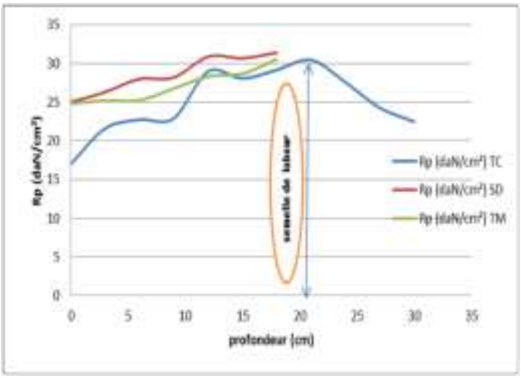

Figure 6 . *variations in penetrometric resistance with soil depth for the three cultivation techniques*

The statistical analysis showed no significant effect of the techniques on soil Rp, the KrusKal - Wallis test gave a P value of 0.181.

Overall, these results allow us to say that roots will develop more easily on plots worked with the plough (TC). Roots in no-till would encounter an obstacle much earlier than those in the conventional technique. However, we must be cautious, because no relationship has been established between penetrometric resistance and root growth.

III.5. Relation between « Rp » and « n »

From the correlation analysis it can be seen that there is a strong correlation between penetrometric strength as a dependent variable and porosity as an independent variable.

The linear regression analysis, relating the two variables gave the following relationship:

$$Rp\ (SD) = 45{,}65 - 0{,}41 * n\ (SD)$$

Avec: **R = - 0,84**
R² = 0,7

Taking into account the p-value of less than 0.05 in the ANOVA table, the model established shows that the relationship between Rp and "n" is highly significant at the 95% confidence level. The coefficient of determination $R^2 = 0.7$ shows that the model is 70% explained. The correlation coefficient is equal to -0.84, indicating a strong relationship between the variables.

So in a no-till system, there could be a strong relationship between these two parameters, they are proportionally inverse, but one should always be careful about establishing this relationship. It is sometimes difficult to establish a correlation between porosity and Rp. It is sometimes difficult to correlate porosity and Rp because porosity is a volumetric measurement whereas Rp is a more punctual measurement; thus the variability between the measurements is not always on the same scale. Moreover, the information provided by one or the other parameter is sometimes different. Sometimes it is possible to observe an increase in Rp with depth without noticing a significant difference in bulk density. This is usually explained by the increase of the action along the rod with depth [23]. Thus, using Rp values alone can sometimes lead to the false conclusion that a compacted zone is present. It is therefore generally recommended that Rp be measured in conjunction with other parameters such as moisture and bulk density.

III.6. Relation between humidity and porosity

As far as this relationship is concerned, it seems that there is a strong correlation between the two parameters, with R=0.81. The more the porosity increases the more the humidity increases, this observation is marked in minimum tillage where the action of the tine tools makes it possible to carry out cracks in the soil, aerating the soil and increasing its water conservation.

III.7. Effect of cultivation techniques on root density

Root biomass samples taken in the later stages of plant life (heading, flowering and maturation) gave the following results:

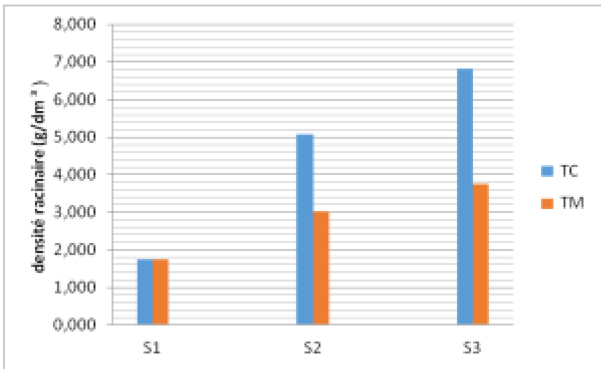

Figure 7. *variation in root density in relation to vegetative stages*

With:
S1: heading stage
S2: flowering stage
S3: maturation stage

Roots Development TM	**Roots Development TC**

Figure 8 . *Roots development*

Two roles are generally recognised for the roots of a plant: on one hand, the plant as a whole. they have the function of absorbing and transporting water and mineral elements to the aerial parts, possibly acting as a reserve organ, and finally as an anchor, to which must be added the functions of synthesis and transport of organic metabolites. In addition, their development plays a role in the evolution of soil properties and more particularly its structure and organic matter content.

The weld test revealed that there was no significant effect of the technique on root density with P value: 0.09.

Conventional tillage favors root development better than other techniques due to the good structure created. One of the essential roles of tillage is to facilitate root growth in a constraining environment. To this end, tillage often decreases the mechanical resistance of the soil to root penetration by improving its structure and, consequently, its moisture. It also improves soil aeration, facilitating gas exchange at the root level. However, a structure that is too porous should be avoided. For several years, researchers have claimed that not turning the soil for minimum tillage reduces the ploughing sole. This hinders root development, but according to a serious study conducted over several years by the Faculty of Biological, Agronomic and Environmental Engineering of the Catholic University of Leuven (UCL) on a comparative trial of different modalities of reshaping a no-till sole on a crop rotation. In a comparative trial of different methods of reshaping a no-till seedbed in a crop rotation, they stated that simplified cultivation techniques, especially minimum tillage, cause the appearance of a "no-till seedbed" more than ploughing if practiced over several years. and concluded that, in the presence of a no-till seedbed, annual or biennial decompacting (depending on the crop rotation) will undoubtedly make it possible to obtain an ideal soil structure, if it is possible to do so under good conditions and if it is accompanied by good harvesting conditions and preparation of the next seedbed.

III.8. The variation of the relative water content

In order to know the influence of the cultivation techniques on the relative water content of the leaves, an analysis of the variation of the ERR on three stages of the wheat was carried out and the results obtained are represented in the following figure:

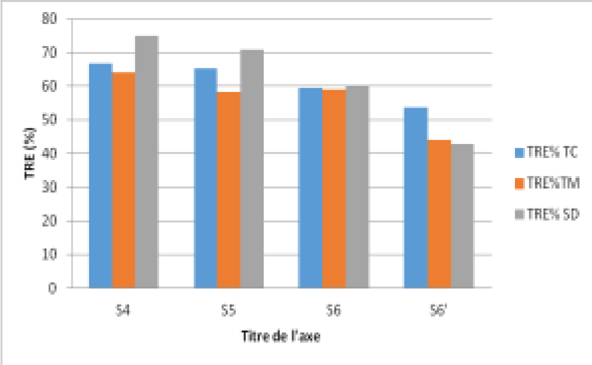

Figure 9: *The relative water content in relation to the vegetative stages for the three cultivation techniques*

With :
S4 : (heading stage)
S5 :(flowering stage)
S6 : (grain filling stage)
S6: (milky stage).

Monitoring the evolution of the relative water content of all techniques and during the last stages of plant, development showed a decrease after each stage in all three techniques. For the first two stages (4 and 5) the relative water content is high in no-till, in contrast to the last stage where the lowest ERR is recorded in this technique.
In general, the results indicate that the relative water content decreases as the crop cycle draws to a close. It should also be noted that the ERR is high in the TC at the end of the cycle when the filling of the grains requires large amounts of water in reserve in the leaf organs.
On the other hand, statistical analysis shows that there is no significant effect of the technique on this parameter, the P value obtained is 0.472.
The decrease in ERR over time means that water stress becomes more important towards the end of the crop cycle. This deficit is the result of lack of rainfall and high temperatures during the day that favors the evapotranspiration of the water reserved in the leaves. And also the water in the soil, these results have been confirmed by [5] the water content of the wheat leaves decreases proportionally with the reduction of the water contained in the soil and [22], the decrease of the relative water content is due to the closing of the stomata because of the rise of the temperature

III.9. Variation of dry matter according to vegetative stages for the three techniques

The dry weight or dry matter is the result of the fresh weight of the plant and its weight after drying in an oven, so it is the weight of the plant after elimination of the reserve water in its particles. In this section we present the variation of plant dry matter according to the stages heading, flowering, grain filling and ripening, and the dry matter of the ears in the last two stages for the three techniques. The results of the dry matter variation in the different stages are shown in figure 10 for the plant dry matter and figure 11 for the cob dry matter

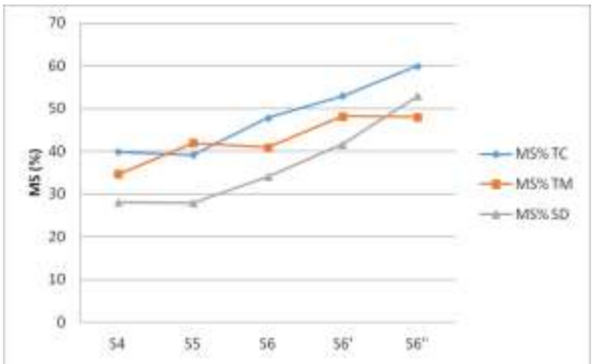

Figure 10 : *The variation of the dry matter of durum wheat plants according to the vegetative stages for the three techniques.*

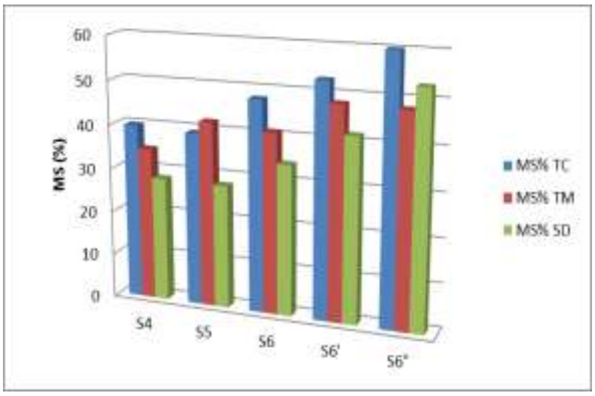

Figure 11. *comparison of dry matter for the three techniques*

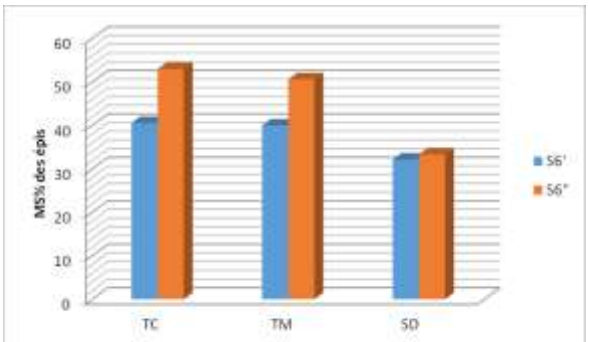

Figure 12 . *The variation of the dry matter of durum wheat ears according to the last two stages for the three techniques.*

The DM evolution curves overlap well with an advantage for CT. The gap between the three techniques decreases as the plant cycle draws to a close. The available data do not allow us to attribute this difference to soil and climatic conditions or genetics or even the technique used.

The statistical analysis does not show a significant effect of the technique on the dry matter: plants in the tillage soils are almost higher in the heading, grain filling and final ripening stages, for the flowering stage the highest value is recorded in minimum tillage and in the ripening stage the highest value is recorded in direct seeding.

Overall, soil evapotranspiration is a major source of water loss [26]. The presence of crop residues on the soil surface in no-till plays a major role in decreasing soil evaporation, as the presence of residues, prolongs the drying time of the soil surface by keeping the soil wetter for a longer time. In this experiment, soil moisture during the follow-up period of dry matter accumulation decreases in the soil horizon. This indicates that the crop uses the water in the soil to produce biomass. Thus, the sensitivity to end-of-cycle stress is reduced. The ability to produce acceptable above-ground biomass at maturity is a desirable characteristic, especially in semi-arid areas due to climate variability.

On the other hand, measurements confirmed the very rapid evolution of DM content: from 47% to 60% DM in a few days. It is therefore interesting to use the sum of the average temperatures since heading to anticipate the reservation of the harvesting machine and avoid exceeding a DM content compatible with conservation. There is an antagonism between the search for yield or energy value, linked to the ear content, and the assurance of good conservation.

III.10. The influence of cultivation techniques on yield components

III.11. The number of ears/m2

The number of ears per square meter is an important parameter for the determination of the yield, the figure below represents the variation of the number of ears per square meter for two cultivation techniques:

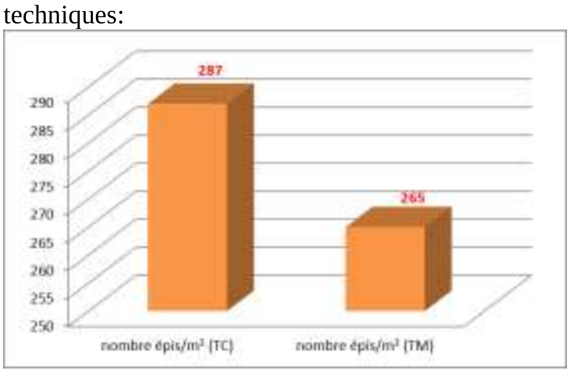

Figure 13 . *variation in the number of ears/m2 concerning cultivation techniques*

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The figure above shows that the best stand was obtained in the tilled plots with an average of 287 ears/m², while a slightly lower value was recorded for the SD of 265 ears/m².The analysis of variance shows that there is no significant effect of the cultivation technique on the number of ears/m². In general, the number of ears per unit area is important and reflects the potential of the variety as well as the conditions in which the crop develops and grows. The values obtained are more or less low with the potential of the variety which has a good tillering power and therefore a good ear population. This leads us to think about the cultivation technique used in order to avoid poor root development and, consequently, a low ear stand per unit area.

III.12. The number of grains/epi

The second yield component studied is the number of kernels per year. The figure below illustrates the variation in the number of kernels per ear for the two cultivation techniques, conventional and minimum tillage:

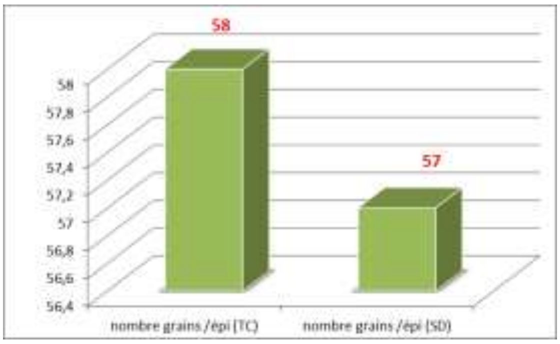

Figure 14. *variation in the number of grains per ear according to cultivation techniques*

The results show that the number of grains is almost equal for both techniques with a slight advantage for the TC where the average is around 58 grains against 57 grains for the TM plots.

The Student's t-test shows no significant effect of the technique on this parameter,

According to several authors, the expression of the number of grains per ear is linked to the climatic conditions during the period (swelling-heading), the important quantities of rain with average temperatures favor an increase in the number of grains per year. In addition, according to [17]; Any late cold and/or drought associated with early high temperatures at this period can induce sterility of the ear as a result of non-opening of the feathery stigmas. Thus the technique that favors more soil water retention will have an indirect influence on the number of grains per year, and from studies conducted by [1] previously, it was concluded that the number of grains is related to the cultivation technique, they recorded low values for the technique that consists of surface tillage only. Thus, shallow tillage does not allow the plant to explore the depths properly.

III.13. The weight of a thousand grains

The figure below shows the variation in thousand-grain weight for the two techniques used, i.e. conventional and minimum work:

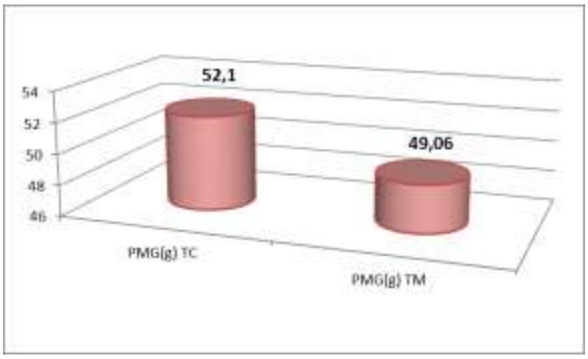

Figure 15. *PMG variation in relation to cultivation techniques*

From the results obtained, it appears that the thousand kernel weight is slightly better for the conventional work 52.1 g, compared to the minimum work 49.06 g

The Student's t-test shows no significant effect of the technique on the GMP.

III.14. Estimated yield of durum wheat

Yield is the most important and determining parameter for understanding the influence of the factors studied on the crop. All the parameters studied so far suggest that it is more important in CT, and this is what we will see in the following histograms:

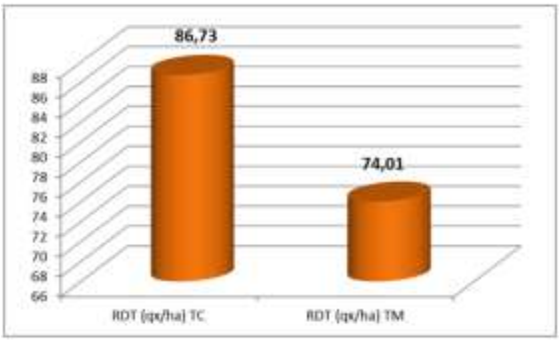

Figure 16. *The estimated yield of durum wheat*

The figure above shows that the yield obtained in ploughed soils is higher than that of minimum tillage. We record 86.73 qx/ha in CT and 74.01qx/ha in MT with a difference of 12.72qx/ha.

The Student's t-test did not show a significant effect of the technique on the crop yield,

In the light of our results, we conclude that yield is influenced by several parameters, including tillage. According to [7], in rained agriculture, tillage practices represent an alternative for improvement by preserving water in the soil. 10]; [16]; [18]; [6] consider that the availability of water for the crop at the critical stage depends on the water content of the soil at the time of planting and it depends on tillage, with crop residues affecting rainfall storage efficiency. 19] considers that water use efficiency is a component of the crop's resistance to water stress and is a determinant of yield.

However, it should be noted that weed infestation caused yield loss in SD, late herbicide treatment could not limit the yield losses recorded in these plots. [1] Demonstrate a considerable change in weed infestation in no-till plots, a higher density of weeds is recorded on the no-till plots. These are generally perennials with a high colonizing power. In these relatively undisturbed environments, and according to [8] the spring chemical weeding seems particularly favorable for this perennial species. Because of its deep rooting, up to 2 m, it is not (or only slightly) affected by root-active herbicides, which usually act on the surface or in the superficial layers of the soil. In addition, the addition of foliar herbicides reduces the competition that might have been induced by other species. And perhaps the dosage of herbicide used is not effective.

IV. Conclusion

This work has dealt with the pedagogical problems linked to the introduction of simplified cultivation techniques in Algeria and the problem of weed control in direct seeding systems. It has also provided technical references on these systems in a temperate Mediterranean climate for clayey loam soils.

The yields obtained in our work and even in previous works such as those of FEDDAL, 2011, HEMANI, 2013, DELMADJI, 2014 are practically similar between direct seeding and conventional seeding, if not better in conventionally worked plots. This leads us to say that the criterion that must be taken into consideration is soil and groundwater pollution, so an environmental analysis is more than necessary, especially in aquifer areas. An economic study is also necessary to decide which technique to use for durum wheat.

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