Tillage effects on soil proprieties and plant development in a clay soil in Algeria.

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Abstract

This study aims to evaluate the work of assessment methods of soil preparation tools to characterize their actions on the soil structure. The experiment was conducted during the 2015/2016 crop year at the Central Farm of National High School Of Agronomy. The objective of this study is essentially the analysis of the effect of three chains of agricultural tools (chain 1: deep plowing, chain 2: agronomic plowing, chain 3: Working without plowing), for the establishment of a durum wheat, on soil physical properties and the impact on root development and yield wheat. The results clearly show that the technique used has an effect on the evolution of moisture, porosity and cone index. The technique with agricultural labor has the best positive effect on moisture, porosity and soil penetration resistance. Root density is better in plots plowed in depth, root diameter meanwhile is best in the art without plowing, while root elongation is more important in agronomic plowing. it was concluded that the length of roots is strongly affected by soil parameters.

Keywords: tillage tools, soil properties, root, yield.

1. Introduction

Cereal crops in Algeria is practiced mainly in coastal areas plains and highlands, occupies the security area of 2.9 to 3.5 million hectares, of which one third are in areas where rainfall > 450mm / year.[1]

This crop is the main speculation and drains several processing activities; in semolina, bakery and food industry. They also form the basis of food and occupy a privileged place in the eating habits of the population in both rural and urban settings. But we start to worry very low yields in recent years despite the use of fertilizers and herbicides. It is for this reason that many researchers examine the methods of tillage and their effect on the physical and biological properties of soil. [2]

Soil preparation is one of the largest operations in the technical itinerary; they aim to improve the conditions for plant growth. [3 -6] Farmers have several options work the soil, all of which can be classified in one of the three tillage systems: no-till, minimum tillage, and conventional tillage, the latter has the advantage that the machines used are widely available and the techniques are well known to farmers. Direct seeding may require the purchase of machinery or new accessories and, in many cases, farmers must learn to operate them. The conventional tillage can make the more porous and soft ground, which promotes the exchange of air and root growth. It's also a good way to incorporate manure. In addition, the well worked soil warms faster in the spring. [4-7]

In Algeria, the results of research conducted during ten years In the framework of cooperation with the technical institute of crop of Algiers have Shown that the direct seeding present many problems, the development of these techniques has been accompanied by an increasing use of herbicides needed to control the development of weeds which is no longer provided, in part, by plowing. These systems are efficient but high costs of chemical inputs thus increasing their potential for pollution of surface waters, on field investigations claim that the few farmers using direct seeding are questioning the effect of this technical development of weeds, adapting their equipment fleet. [5]

Another observation to make the assets of Algerian farmers, lack of application of technologies adapted to local conditions and ignorance of the use of agricultural equipment, there are large differences in crop yields, cultivated in a priori conditions identical environment. [8]

This yields change is due; inter alia, the physicochemical characteristics of the different soil. It involves the choice of tillage equipment and shows the lack of decision maker's information (the farmer) as to the precise action of the various tools on the soil conditions in different soil types and in varying climatic conditions. Hence the interest to characterize the effect of tools on the ground and can predict the quality of work that will be obtained in conditions of soil data by a selected tool sequence and according to a procedure known.

This has led us to focus our work on the conventional tillage, our work is part of an early research to identify the tools soil and prediction models of their effects different conditions and soil types. Thus, our contribution in this area is to review agricultural techniques, to select suitable technical itinerary that take account of climate, edaphic and economic parameters, which constrain the same time the environmental degradation including soil.

The question we asked ourselves before starting this study, is what is the best way to improve the structural state of the soil, with the tools that the majority of Algerian farmers have. Thus, we know that almost all farmers have a cover crop, plow disc or moldboard plow and sometimes a harrow Roller (agricultural tool) or croskill.

Many technical and scientific references on the impact of tillage method on soil quality are available, but almost exclusively, these references point to comparisons between conventional tillage, minimum tillage and direct seeding, for our part, we have introduced a tool chain including an agricultural tillage and including a work with no-till cover crop.

The objective of this study is to follow in the first year of application of different tillage techniques (conventional and minimum tillage) the bulk density measurements, moisture, porosity, water filled pore space, cone index, and rooting durum and durum yield.

2. Materials and methods

2.1. Characteristics of plot trials

Data that is used in this project were collected at the experimental station of ENSA (High National School of Agronomy), of Algiers. Its geographical coordinates are: 3 ° 08 'east longitude 36 ° 43' north latitude. It is located 24 m above the sea level; among isohyets 600 mm and 700 mm. It belongs to the bioclimatic subhumid to mild winter.

It occupies an area of 30 ha, it is used for the production of cereals and fodder crops but also for experimentation as part of the research work of the teams of ENSA.

The trial was set up on a ground texture clay loam (clay-loam) according to USDA classification with a clay content of 39.5%, 20.2% fine silt and 3.96 % coarse silt, sand as it is of the order of 20% and 13.6% between sandy and coarse sand.

2.2. Cultivation techniques

Three cultivation techniques which differ in the degree of fragmentation of the topsoil by the turning effect or not of the worked soil layer, by their degree of mixing of the organic matter to the soil and the soil compaction they generate have been compared on the experimental site:

- Conventional tillage (CH1); moldboard plow (30 cm deep) + cover crop + harrow
- Agricultural labor (CH2); moldboard plow (15 cm deep) + cover crop + harrow
- reduced tillage (CH3); cover crop + harrow

2.3. Experimental method

The experimental apparatus is composed of three blocks within which the 3 studied Treatments are randomized.

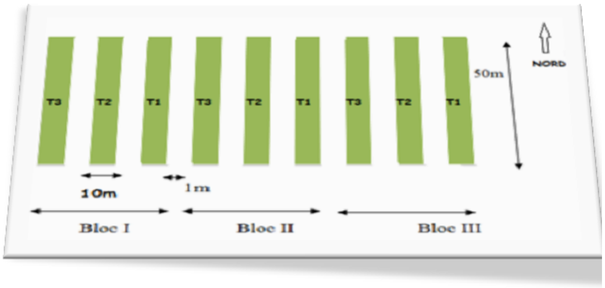

Fig. 1: General diagram of experimental trial site

Taking into account the geometry and topography of the land and taking into account the objectives of our experiment, the blocking was chosen as the device.

The test plot is 0.54 ha surface, and the experimental plots are 50 m long and 10 m wide. They are separated by grass strips 1 m wide.

We have respectively:

The studied factor is the tillage technique with three levels:

- Level 1 (CH1): conventional tillage
- Level 2 (CH2): agronomic tillage
- Level 3 (CH3): minimum tillage

Factors controlled: it is repetitions or blocks with three levels of symbols (B1, B2, and B3).

2.4. The studied wheat

Speculation establishment is durum variety Viton, Sown dose is 120 kg / ha corresponding to a number of grains 300 / m².

3. Results

Two parts make up this part. The first is devoted to structural changes, by measuring the water content of the soil, cone index, and total porosity and WFPS. These results are then discussed. The second part is devoted to the consequences on rooting and yields of durum wheat. These results are discussed and a final conclusion summarizes the results obtained.

After a comprehensive analysis, for a first observation, a principal component analysis and the ANOVA tests then allow a quantification of these effects for each technique.

3.1. Effect of the tillage techniques on moisture content

To analyze soil moisture, was conducted by the timing of the results of soil humidity with daily rainfall samples, the results were analyzed by three depth horizons (0 - 10 - 20 - 30 cm).

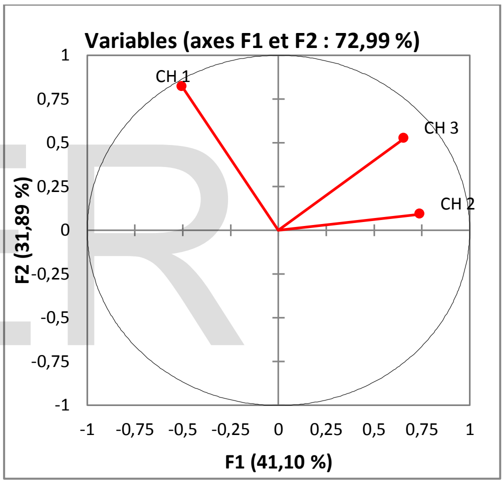

Fig.2 : ACP of moisture for depth 10 – 20 cm.

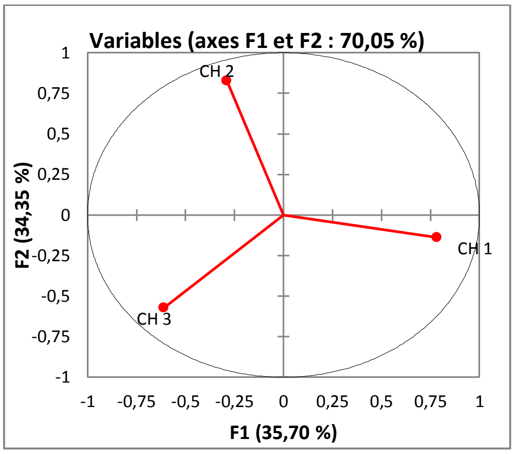

Fig. 3: ACP of moisture for depth 10 – 20 cm

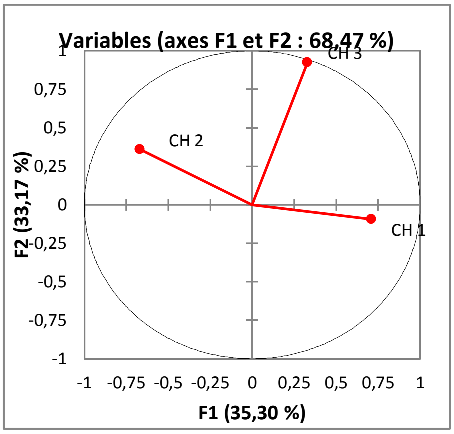

Fig. 4: ACP of moisture for depth 20 –30 cm

In general, the results show that in dry conditions and in conditions of low rainfall, the minimum tillage allows the storage of surface water, while in conditions of heavy rain, deep plowing permits good infiltration, we recorded the highest moistures. The depth 0-20 cm, the agronomic tillage provides good water retention in the soil.

Note, however, that there is little difference in the evolution of soil moisture for the three chains of tools, this development follows that of rainfall. On the other hand, was detected over the entire depth a sudden drop in soil moisture during the latter stages, this is due to the climatic conditions of the region from April or there were significant reductions rainfall.

3.2. Effect of the tillage techniques on porosity

The second parameter being analyzed is the porosity, it determines to a large part of water retention by the soil, aerating the roots, and their progress through the ground. The analysis of the effect of conventional tillage, agronomic tillage and minimum tillage on bulk density and porosity for the three horizons is shown in the following figures:

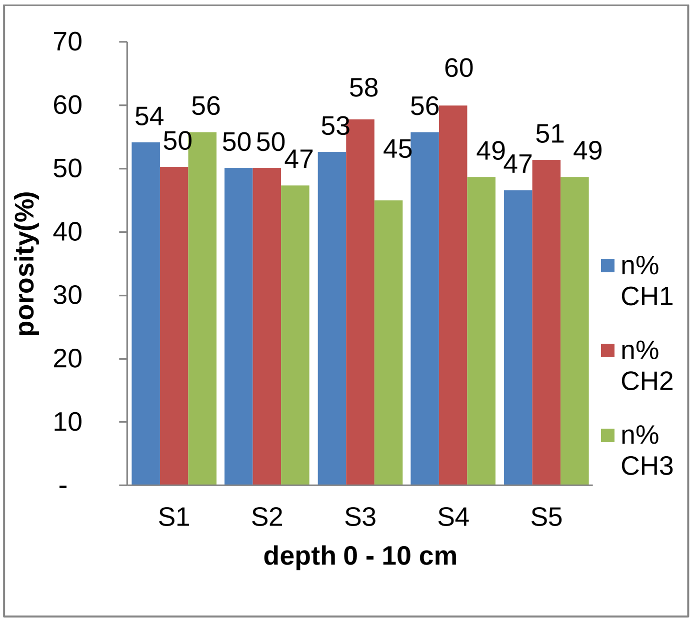

Fig.5 Evolution of porosity for depth 0 – 10 cm

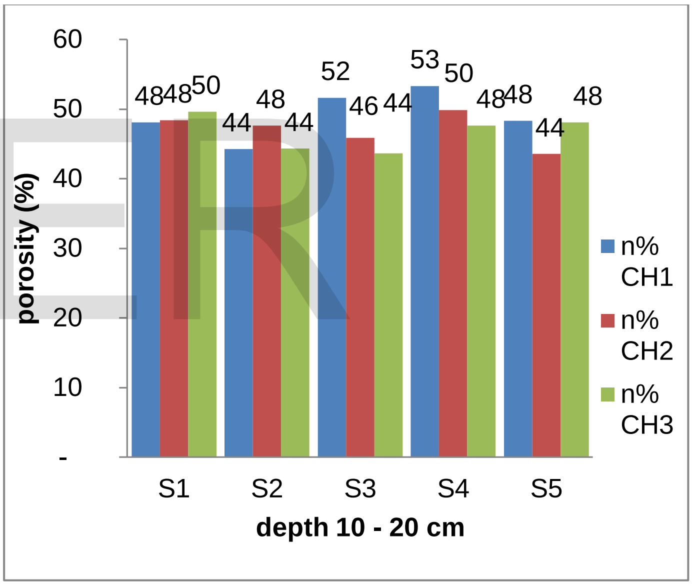

Fig. 6 Evolution of porosity for depth 10 - 20 cm

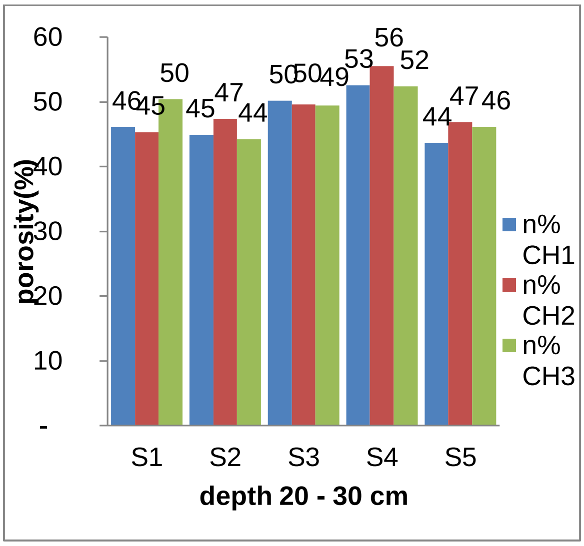

Fig. 7. Evolution of porosity for depth 20 – 30 cm

With :

S1 : before seeding

S2: early tillering

S3 : ear 1cm

S4: bolting

S5: heading-flowering

ANOVA test shows that there is an effect of the three channels of tools on porosity on the horizon with a P = 0.02. The CPA in turn has deepened the analysis highlighting the most important effect is that the assets of the CH2, the analysis recorded three factors: F1 explains the variability of CH1 and CH3, and F2 explains CH2.

Test of Kruskal-Wallis :

K (Valeur observed)	7,457
K (Valeur critical)	5,991
p-value (bilatéral)	0,024
alpha	0,05

We can therefore conclude that the porosity decreases from the conventional technique the minimum technical. At this technique we find homogeneity of soil porosity on almost any profile; which is not the case for other fields where the porosity is higher on the surface.

We must also remember that these results are directly related to the bulk density that does not have a remarkable change during the experiment. However, it is be careful when interpreting the results because they can be noisy by other mechanism (wetting, drying and packing). Minimum tillage is characterized by a decrease of the macroporosity which is original, created by plowing. So the soil porosity is generally reduced in conservation systems but, like biological systems, they favor the formation of macro-pores of biological origin. These changes occur gradually and differences between the systems are measurable after several years of differentiation.

3.3. Effect of the tillage techniques on WFPS

Water filled pore space, WFPS is one of the determinants the denitrification intensity in soil, (Oehler et al., 2006),

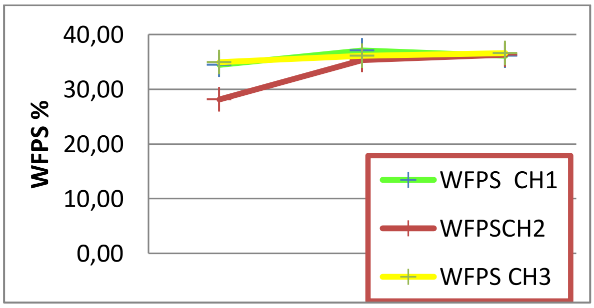

Fig. 8: Evolution of WFPS

The depth effect on the WFPS is not significant, except for agronomic tillage modality whose horizon 0-10 cm has a smaller saturation than the underlying horizons. However, overall, the porosity of the deep plowing modality is more saturated with water than other treatments. The bulk water content of this mode is generally higher than that of others.

Statistically, the depth effect and the treatment effect on the water saturation level of porosity are not significant. P > 0.73.

In general, there is a vertical gradient of saturation of the soil porosity water; the values of WFPS are very close between the three tillage methods from 10 cm up to 30 cm depth.

3.4. Effect of the tillage techniques on cone index

The measurement of the cone index is an indicator often used to quickly assess the extent of soil compaction and the location of the compact area. Our study included an analysis of the variation of this parameter in conjunction with the depth and stages of durum wheat for three chains of tools and the first results are shown in the following figures:

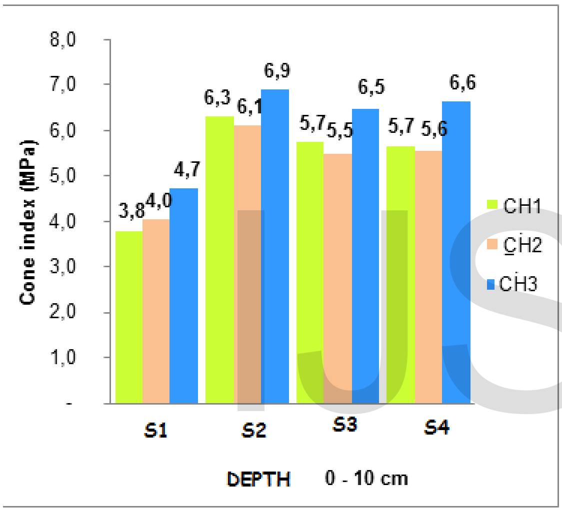

Fig. 9 : Evolution of cone index for depth 0 – 10 cm

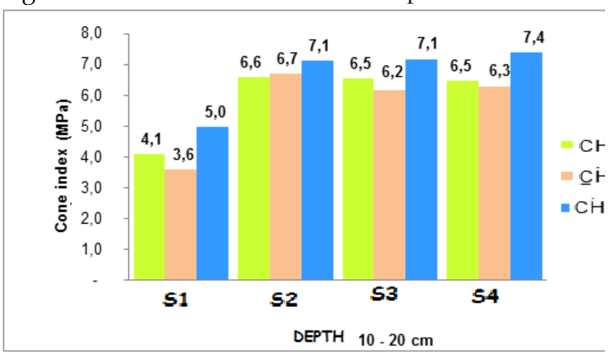

Fig. 10 : Evolution of cone index for depth 10 – 20 cm

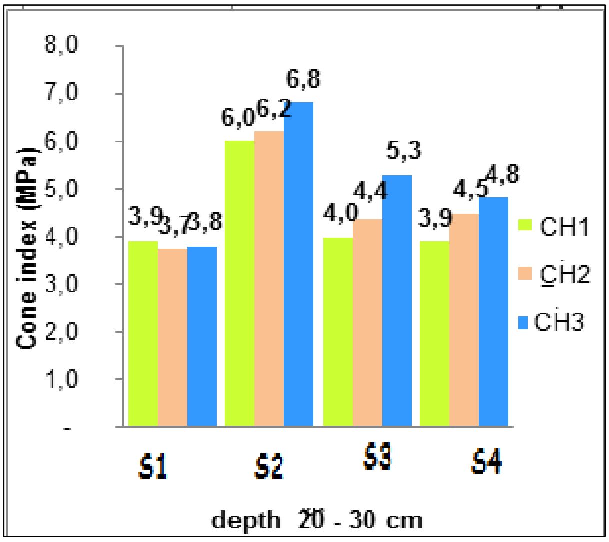

Fig. 11 : Evolution of cone index for depth 20 – 30 cm

The results of cone index, show the highest cone index beyond 10-20 cm, presumably, this compaction tells the story of the plot.

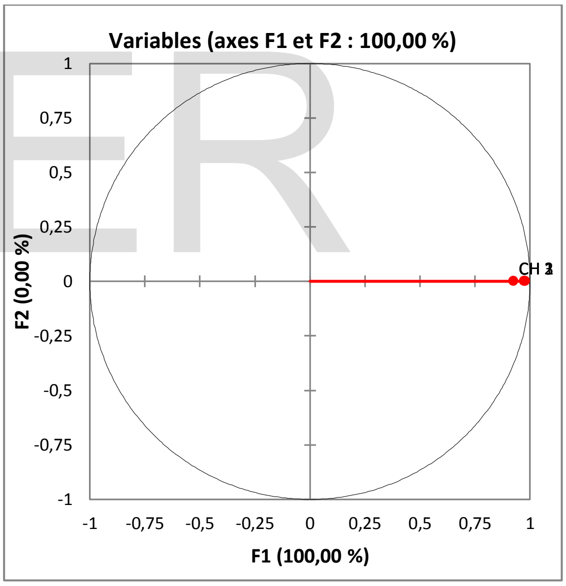

Fig. 12 : ACP of cone index

The agronomic tillage allows better cone index surface and up to 20 cm. While, the conventional tillage significantly reduced cone index in deep 30 cm. The minimum tillage causes an increase of cone index throughout the profile of soil.

From these results we can predict roots growing more easily on the plots worked with moldboard plow. But we must remain cautious, however, because no relationship has been established between the cone index and root growth.

3.5. Effect of tillage on root development of durum wheat

The roots play a fundamental role in the operation and therefore the production of plants. It is thanks to them that is the supply of water and mineral elements thereof. But there are also other functions: anchoring on the substrate, reserves assimilates, metabolism. Roots specifically contribute to hormonal balance that control the growth and functioning of the plant. They are also a source of organic matter to the soil; sometimes it is the only regular restitution in many cropping systems in the world. It is therefore important for the production of culture, but also for the maintenance of soil fertility, to have a well-developed root system, including in depth.

The root system should be an important criterion for evaluation by agronomists and farmers, whether or not an improvement of the physical characteristics of the soil profile by tillage, and after completion, the effectiveness of thereof. Unfortunately the root systems of crops are still little known as difficult to observe in the field. This is the hidden side of the plant. Was therefore used core drilling to determine its characteristics, which are: length, diameter, and root density, and the results obtained are shown in the following.

3.5.1.Root density

The following figure shows the variation in root density for the three chains in the last three stages of development of durum wheat.

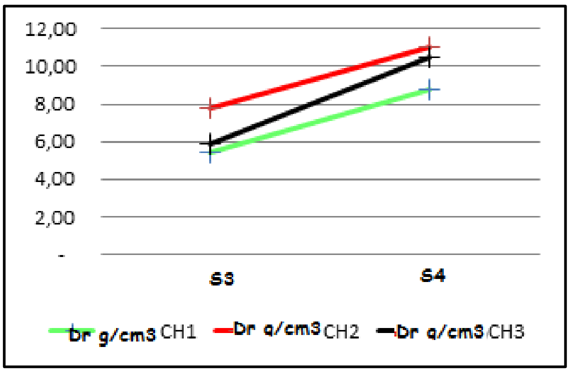

Fig. 13 : Evolution of root density

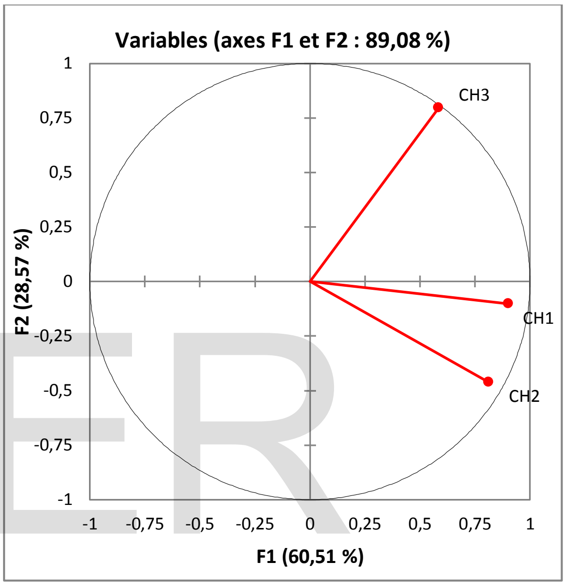

Fig. 14 : ACP of root density

The results showed that the average of the root density varies from one technique to another and from one stage to another. The density varies between 1.2 g / dm^3 and 3.37 g /dm^3, the latter is the most important value to the maturation stage for conventional tillage.

Root density increases the heading stage to stage maturation to reach its maximum value of 3.37 g / dm^3 at CH1, while at the level of CH2 and CH3 root density decreases slightly after the flowering stage to reach respectively 3,02 g/dm^3 and 2.5g/dm^3. However, this density is greater at CH2 in the first two stages.

3.5.2. Root diameter

The following figure shows the change in the diameter of the roots for the three techniques tillage in the last three stages of development of durum wheat.

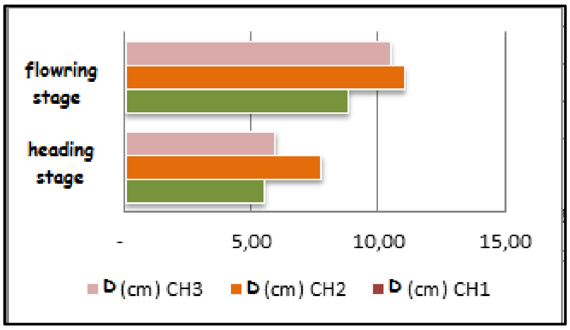

Fig. 15 : Evolution of root diameter

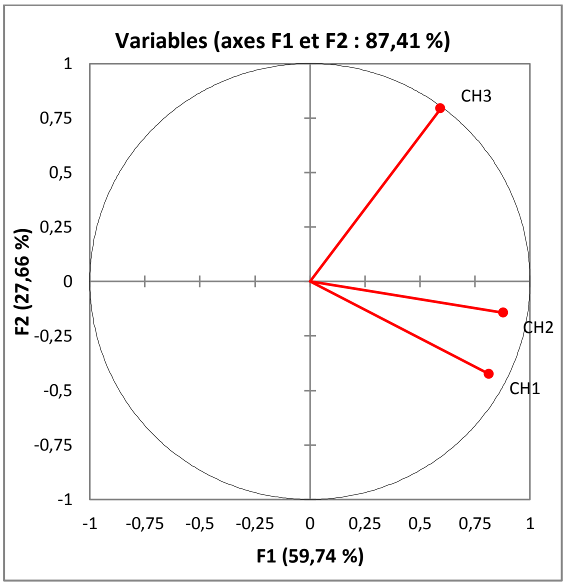

Fig. 16 : ACP of root diameter

The root diameter measured in the last three stages of growth of durum wheat is well above the level of the parcels not worked with the plow, root diameter reaches 1.38mm against 1.22 mm CH2 and 1,08 mm for CH1.

The reduced tillage as is the case of CH3 does not promote good root development in depth given the tools intervention superficiality, this finding was confirmed by the results of the cone index or there was a compaction in depth, which may have caused root development horizontally and not vertically.

The principal component analysis confirms this, since it gives two axes F1 and F2, the first is clearly linked to CH1, CH2 then F2 is essentially linked to CH3, confirming a highly significant effect of not turning the soil and that the working depth of the root diameter. Test CPA is presented in the following:

3.5.3.The root elongation

The following figure shows the change in the root elongation for the three chains in the last three stages of development of durum wheat.

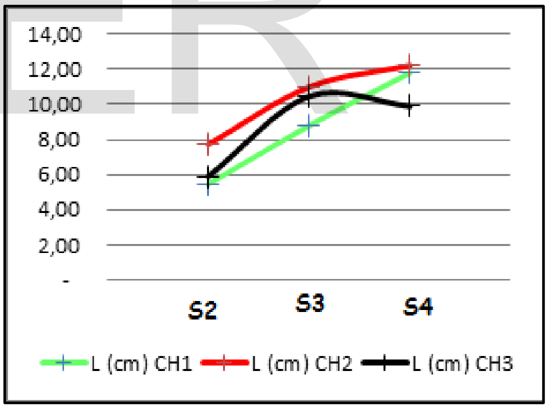

Fig. 17 : evolution of root elongation

The first observation to be drawn from these results is that the root length growth is faster at CH3 it from 5.9 cm to 10.46 cm of heading stage at flowering stage but it stagnates in this state until end development of durum wheat. The rapid root elongation is due to CH3 can be created at the structure of the surface layers which promotes the start of the growth, while in depth the soil is not worked or cone index high soil the elongation stops.

In terms of soil worked with moldboard plow whether deep or agronomic plowing, root elongation is still the heading stage to the last stage where it reaches the highest value in CH2 with 12.23 cm against 11.81 cm CH1.

The principal component analysis shows no significant effect of three channels on root length.

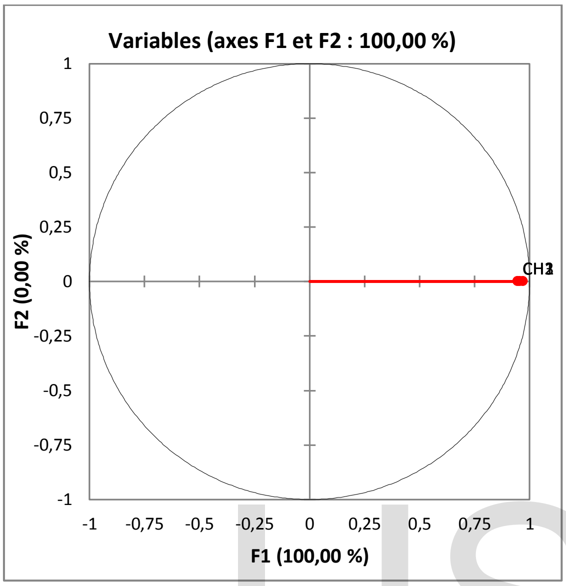

Fig. 18 : ACP of root elongation

3.6. Impact of cultivation techniques on yield of durum wheat

In this part, we will try to present and discuss all the performance results achieved.

We have tried to focus our study on some parameters that seem to us the most important are:

- The thousand grain weight; (PMG)
- The number of grain per ear;
- The number of ear per square meter;
- And the estimated grain yield. (Qx / ha)

The results of yield and its components are assigned in the following figure:

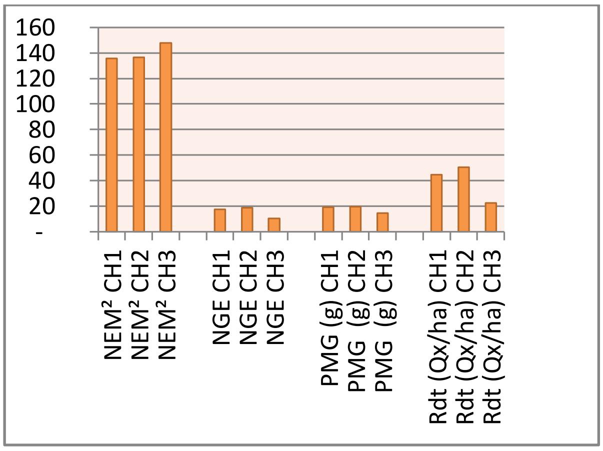

Fig. 19 : estimation of wheat yield

The number of ear per unit area is an important performance component, it also reflects the potential of the variety that the conditions under which develops and externalizes this culture. The values obtained are low relative to the potential of the variety that has good power tillers and thus a good ear stand. This brings us to think about the cultivation technique used in order to avoid a poor root development and therefore a low population spike per unit area.

In terms of the number of grain per ear, according to several authors, the term of the number of grains per ear was related to weather conditions during the period (swelling-heading), significant amounts of rain with temperatures favor an increase in the number of grains per ear. A late and as cold and / or drought combined with high temperatures early in this period can induce sterility of the ear as a result of not opening feathery stigmas. So the technique that promotes the more soil water retention will have an indirect influence on the number of grain per ear, which is the case of the chain 02.

In light of our results, we conclude that the yield is influenced by several parameters, including tillage. Rainfed agriculture, tillage practices represent an alternative to improve the conservation of water in the soil. the availability of water for cultivation at the critical stage depends on the capacity of the ground water at the time of planting and it depends on the tillage, crop residues affecting rainfall storage efficiency.

The agronomic tillage allows obtaining good yield while the minimum tillage records a much lower yield.

3.7. Statistical analysis of relationship between various parameters studied.

In terms of level, it will quantify the effects techniques and the relationships between various parameters studied by correlation analysis and regression, the effects will be illustrated by relations of the form Y = f (X, X ' , X '', ...).

3.7.1.The relationship between cone index, moisture and porosity

The analysis of multiple regressions between the dependent and independent variables Rp H% n% gave the following results:

CI CH1 = -3,19 - 0,15 *H% CH1 + 0,12 * n% CH1

The coefficient of determination R^2 = 0.41, the variables moisture and porosity can explain 41% of the variability of CI.

So this equation shows the relationship between CI, porosity and moisture. Note that the higher the water content, the higher the CI decreases, we also find that the moisture has more effect than the porosity of CI but Note, however, that their coefficients are very close with 0.15% moisture and 0.12% porosity.

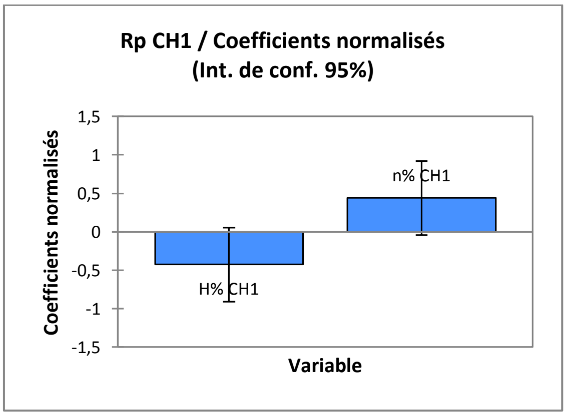

Fig. 20 standardized coefficient

3.7.2.The relationship between the cone index and root development

Increasing the mechanical strength of the phenomenon linked decompacting soil can sometimes impede root growth. Indeed, for a root can grow, it is necessary that the pressure which it is able to exert is greater than the mechanical strength of the soil. As it is still impossible to directly measure the strength of the soil in the root growth is generally used the results obtained with a penetrometer to measure Rp and try to correlate these results and root growth.

The analysis of multiple regressions between the dependent variable LR and the independent variables CI, H%, n% and WFPS gave the following results:

LR CH1 = -270,67 - 10,76 * H% CH1 + 5,64 * n% CH1 + 0,56 * CI CH1 + 4,272 * WFPS CH1 with : R^2 = 0,32

LR CH2 = -45,05 - 2,77 * H% CH2 + 0,84 * n% CH2 + 2,29 * CI CH2 + 1,13 * WFPS CH2 with : R^2 = 0,91

LR CH3 = 58,87 + 1,32 *H% CH3 - 0,87 *n% CH3 - 1,41 *CI CH3 - 0,46 * WFPS CH3 with: R^2 = 0,06

From these regressions, it shows a significant effect of the structural state of the soil on the root elongation especially in soil worked with agricultural plowing with R^2 = 0.91 which means that the structural indicators of soil explain alone 91% variability of the root length.

The analysis of standardized coefficients confirms a more powerful effect of WFPS on LR compared to other parameters:

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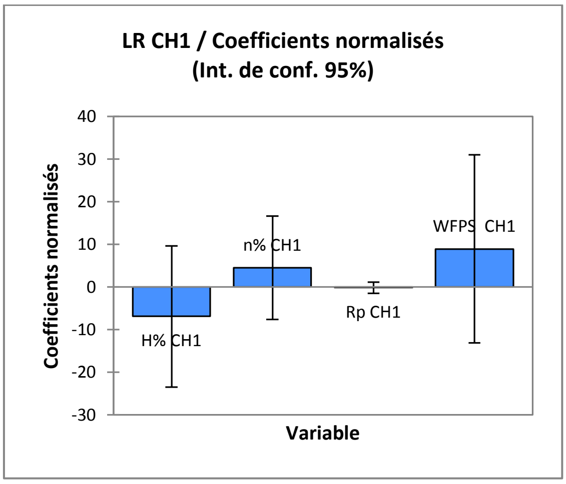

Fig. 21 standardized coefficient

3.7.3.Effect of soil properties on the quality of grain harvested

On several earlier studies, it was highlighted the difference PMG among plots carried out under different conditions, there are cases or technique offers good lifting but the small PMG, this led us to analyze the relationship between the PMG as the dependent variable and soil parameters (CI, H, n) as independent variables and analysis yielded the following results:

PMG CH1 = 22 + 0,65*H% CH1 + 0,43*n% CH1 - 0,35*CI CH1 + 0,05*LR CH1 – 0,73 *D + 0,31 DR CH1 + 0,1*WFPS CH1 avec : $R^2 = 0,83$

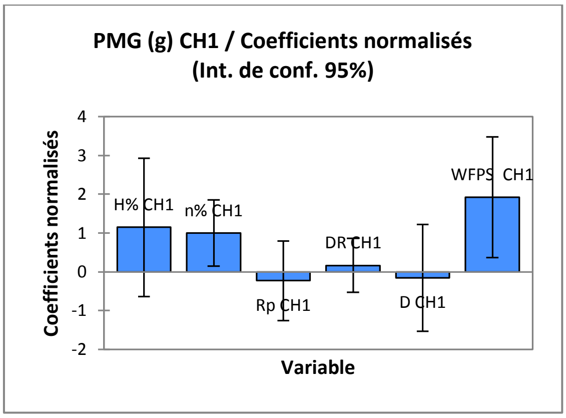

Fig. 22 standardized coefficient

According to this regression model, it appears clear that the soil moisture, WFPS, and n% have more effect than Rp on the PMG, grain filling is strongly influenced by the presence of water in the ground, it is modified by soil preparation techniques.

3.7.4. Introduction to the analysis of coherence between the different parameters studied by wavelet method.

This part covers the initiation and development of treatment methods, linking and data interpretation.

This method can tell us about the nature of correlation between two variables in time for this, we use the tools of the time series. As the name suggests, the object time series is the study of variables over time.

So start for the application of this method, we chose to study the power of correlation between Rp soil characteristics and indications of root development, and results are illustrated in the following figures:

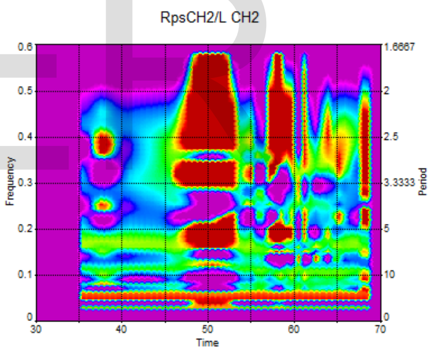

Fig 23. Wavelet representation of the correlation between Rp and root elongation

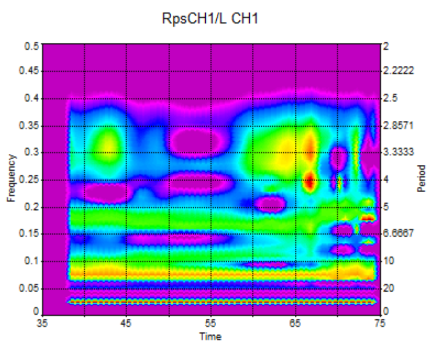

Fig 24. Wavelet representation of the correlation between Rp and root elongation

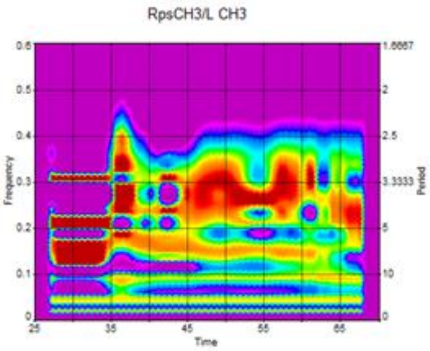

Fig 25. Wavelet representation of the correlation between Rp and root elongation

The analysis wavelet highlights the strong correlation in time between the soil resistance to penetration and root growth, this result is interesting insofar as one side until now no study has able to determine the relationship between live the resistance of the soil and root growth, on the other hand, the root system is an important endpoint, by agronomists and farmers of the need or otherwise of improved features physical of the soil profile by tillage, and after completion, the effectiveness thereof. Unfortunately the root systems of crops are still little known as difficult to observe in the field. This is the hidden side of the plant, so we identify the exact periods of strong correlations between soil strength and root growth, we can characterize the root system from the values of cone index.

4. Conclusion

The main objective of this work was to study the changes that generate the adoption of different tillage techniques on soil structure, the impact of the latter on the roots and consequences on the yield of durum wheat.

In conclusion, we can say that the influence of different tool chains on performance depends on the treatment, be it dry or upland.

Reducing tillage seems difficult to translate to cereal crops because of increased competition from weeds. Today, under the experimental conditions of this study, the technical itinerary of agronomic tillage with plowing appears to be an alternative to conventional tillage. This tillage method is easily achievable from a technical standpoint and can generate economic gains from the practice of plowing, but its effects on soil and crop yields need to be studied in the longer term.

For the future, recommending to focus work on other parameters such as weight distribution of aggregates, which is the best way to assess and characterize the action of the tool on the soil structure, giving more details on the size of the clumps formed after the passage of the tool as well as their ratio to the volume of soil moved.

5. References

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