J. Soils and Crops 30 (1) 1-13, June 2020

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)
NAAS Rating - 4.46
Scientific Journal Impact Factor - 7.375

ANALYSIS OF THE COMBINED EFFECT OF DIRECT SEEDING WITH SEEDING DEPTH ON THE BEHAVIOUR OF A DURUM WHEAT

Mohammed Nadhir Mebarki[1], Mohamed Amine Feddal[2*], Sabrina FeddalTaibi[3], Ryma Labad[4] and Zekari Mohammedi[5]

ABSTRACT

Fifty-seven genotypes were evaluated for genetic divergence to identify the likely desirable and this work, which is part of a national problem of introducing simplified cultivation techniques for the introduction of field crops, involves an analysis of the effects of simplified cultivation techniques on the behaviour of durum wheat. These effects are illustrated by an analysis of adaptation characteristics concerning stand per m^2, plant height, length of spikes, length of beards and flag leaf surface. An analysis was also carried out on the water behaviour of the crop, and the parameters related to production in this case: the number of wheat ears per m^2, the number of grains wheat ear^{-1}, the weight of a thousand grains, and the grain yield. It can therefore be concluded that the choice of cultivation technique to be adopted and the planting depth have a considerable and not insignificant effect on the parameters studied.

The number of plants surveyed square^{-1} meter varies between 140 and 382 for all depths and SCT, the lowest rate of emergence was recorded at the level of plots conducted in DS and sown at a depth of 2 cm. While the highest rate of emergence is to be found in plots prepared with chisel and sown to a depth of 4 cm.

In the same context, it took 33, 23 and 10 days for the crop to rise to seeding depths of 07, 04 and 02 cm respectively. At the MT level, the emergence time is less important, wheat took only 14 days to emerge at a planting depth of 2 cm, but in terms of emergence rate, it remains better at the TMP2 level despite the fact that the duration is only 18 days.

On the other hand, the analysis of variance reveals a very significant difference between the two cultivation techniques, the stems were higher at the level of direct seeding with an average of 90 to 93 cm, against 83 cm for the minimum tillage. The depth effect was not statistically significant.

The results on the length of the wheat ears showed that at minimum tillage the wheat ears were longer, this was true for all three planting depths. The length of the beards is more important at the MT level between 10 and 11 cm, compared to 9 cm at the DS.

The flagleaf develops larger dimensions under minimum tillage compared to direct seeding. This increase takes values from 26 to 29 cm^2 and 19 to 21 cm^2, respectively under minimum tillage and direct seeding.

Finally, concerning the yield and its components measured during the season, the results indicate a highly significant combined effect of cultivation technique and seeding depth. The analysis of variance also reflects a significant effect of the relative water content (RWC %) of the leaves under the influence of cultivation techniques, seeding depth and CT x depth interaction. The average RWC values varied according to the cultivation techniques. The behaviour of this wheat grown in MT was measured by an average RWC of 68.57%, 77.44%, 80.56% for P1, P2, P3. and in direct seeding 43.71%, 51.38%, 54.33% for P1, P2, P3.

The quantities of water present at seeding of the different treatments varied from 16% to 19%. Minimum tillage had more soil moisture equivalent to 3% compared to direct seeding.

(Key words: Direct Seeding, seeding depth, durum wheat, production characteristics, morphological characteristics, yield, water use efficiency)

1. Ph. D. Student, Laboratory for the control of water in agriculture, National Higher School of Agronomy (ENSA), ES1603, Dept. of agricultural engineering, El Harrach, Algeria
2 & 5. Assoc. Professor, Laboratory for the control of water in agriculture, National High School of Agronomy (ENSA), ES 16.03, Dept. of agricultural engineering, EI Harrach, Algeria
3. Assoc. Professor, Saad Dahleb University, Dept. of engineering of water and the environment, Blida, Algeria
4. Assoc. Professor, Laboratory for the control of water in agriculture, Ferhat Abbes University, Dept. of Agronomy, Setif, Algeria

INTRODUCTION

Cereal farming continues to occupy an important place in Algerian agriculture. The three main cereals (barley, durum wheat and soft wheat) cover about 5 million hectares annually, or 60% of the country's UAA, the majority of these crops are located in semi-arid and arid areas. They are mainly grown in rainfed conditions, directly depending on rainfall, which fluctuates greatly from one year to the next. These rainfall conditions are a first explanation for the low yields in these areas. In addition, farming techniques are often poorly adapted to these climatic constraints .

Producing more cereals has become a matter of concern for Algeria, whose needs, for a rapidly growing population, are estimated at more than 111 million quintals by 2020 (Hervieu *et al.* , 2006).

Producing more implies that the environment is suitable and that the technology follows. This is not always the case in Algeria, where the major cereal-producing areas are characterized by a variable climate and soils with decreasing fertility (Lahmar and Ruellan,2007). Techniques do not always follow, due to the preponderance of low yields. Thus, the grain yield of the most widely planted durum wheat varieties, such as Hedba, Mohamed Ben Bachir, Adjini, Beliouni, Djazairi and Tounsi, varied from 3.5 to 10.3 q ha^{-1} during the period 1920 to 1929 (Ducellier,1930). During the period 2000 - 2010, they would vary from 10 to 15 q ha^{-1}, for a route that is limited to ploughing, seeding and harvesting with little weeding and/or phytosanitary protection (Benniou and Brinis,2007; Adjabi,2011). With the advent of the Green Revolution in the 1970s, hope was based on the use of high-yielding varieties to radically change the evolution of the grain production curve, which is characterized by a sawtooth shape (Hakimi,1993). These varieties, if in favourable environments or under irrigation, they manage to express their yield potential, in rainfall and in semi-arid climates, they are more variable and often as, if not less productive than the local cultivars they are supposed to replace, due to their sensitivity to stress (Benmahammed *et al*., 2010). With the increase in input prices, the application of the technical itinerary popularized by the Technical Institute of Field Crops, by the cost of cereals was becoming too high, especially since yields are not always high (Bouguendouz, 2011). The advent on the market of equipment capable of sowing directly without ploughing, and ploughing tools capable of stirring the soil without turning it upside down, raises the question of the basis and reasons for the practice of deep ploughing (Lahmar and Bouzerzour,2011). Indeed this operation is expensive, its removal would reduce costs, which improves the farmer's income if the yield does not decrease significantly.

Simplified farming techniques have been in renewed interest in Algeria since 2006, when a farmers' association was created to popularize this practice (Lahmar and Bouzerzour,2011). Since then, the Technical Institute for Field Crops has joined the initiative to extend this practice to several regions of the country. The results of the first tests conducted indicate problems related to wheat emergence,

Indeed, the first component of yield is conditioned by the success of the sowing. Therefore, it is essential to control the sowing process. To do this, it is necessary to determine the soil, climate and technical constraints that hinder the success of this operation (Bouaziz,1987;Watts and Mourid,1988;Chekli,1991). Seeding is the first decisive step in the success of cereals in these areas. Indeed, the first component of yield is conditioned by the success of the sowing. Therefore, it is essential to control the sowing process. To do this, it is necessary to determine the soil, climate and technical constraints that hinder the success of this operation.

Studies have shown that even with healthy seeds with good germination capacity, emergence is often defective and very variable depending on the rainfall sequences during the sowing and emergence period as well as on the techniques used. This implies that the installation practices of autumn cereals remain uncontrolled. The objective of this work is to better understand the phenomena that limit the success of seeding among farmers. It will be about understanding how farmers make tillage and seeding decisions and what standards do they have to reason with them?

Our experiment is part of a national research project, which focuses on "the problem of the introduction of direct seeding in Algeria, optimization of crop establishment techniques". It is also part of a joint TIFC and ENSA test on the issue of durum wheat emergence losses under the SCT. Our objective was therefore to analyze the combined effect of simplified cultivation techniques (minimum tillage and direct seeding) and seeding depth (2.5 cm, 4 cm, 7 cm) on durum wheat emergence losses, as well as its morphological and phenological behaviour.

MATERIALS AND METHODS

Description of the experimental site

The tests took place at the ENSA's central farm, which belongs to the municipality of OuedSmar, daïra of El Harrach, wilaya of Algiers. It lies between latitude 36°42'46.9'' and 36°43'16.1'' North and longitudes 03°09'16.7'' and 03°09'44.9'' East.

The rainfall recorded during the experimental period (December-May) was 552 mm, compared to an average of 749 mm in the region, which is exceptional, and an average temperature of 16°C.

The following will present the climatogram of the study campaign:

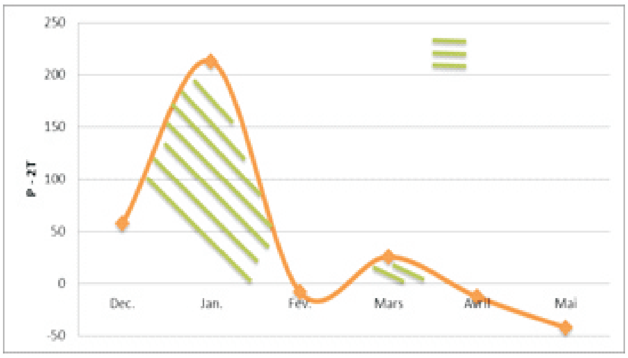


Figure1. Climatogram of the study campaign

With:

P : total monthly rainfall

T : average monthly temperature

The climatogram presented above shows the existence of two wet periods, the first extending from December to the end of January, and the second throughout March. For dry periods, one period is recorded during the month of February and another one during April-May.

What is remarkable during this season is the irregularity of rainfall, the most important accumulation was received during the month of January with 240 mm, which represents almost 50% of the total accumulation of the year, this period coincided with the emergence stage of durum wheat and which had as agro-meteorological consequences:

- a slight decrease in evapotranspiration;
- creation of favourable conditions for weed development;
- Delayed crop development;
- Restoring the soil's water reserve;
- Risk of root asphyxiation due to water stagnation.

For the dry period of February, average temperatures increased over the study area (range from 01 to 04°C); this is due to the increase in minimum and maximum temperatures, combined with very low rainfall, this period coincided with the full tillering stage of durum wheat, which resulted in delayed fertilization and weeding operations.

Finally, the last period April - May, which is a dry period, was characterized by an increase in temperature compared to normal and an increased decrease in rainfall, this period coincided with the grain filling stage, and the crop suffered greatly during this period.

Soil characteristics of the test plots

The test was carried out on **clayloam textured soil (clayey-loam)** according to the USDA classification with a clay rate of **39.5%, 20.2% fine silt** and **3.96% coarse silt**, while sand is about **20% and 13.6% between fine sand and coarse sand.**

This soil is very deep (> 2 m) and is characterized by the presence of a very thick red clay accumulation horizon (between 55 and 170 cm). This soil is well endowed with organic matter in the surface horizon and is well structured throughout the profile. It is also characterized by the absence of coarse elements in the surface and subsurface horizons and by a high gravel load (30%) at depth. Laboratory analyses also indicate that our soil is free of limescale (0%) but that the pH is neutral over the entire profile (Feddal,2011).

The analyses were carried out in the soil laboratory of the National Hydraulic Resources Agency.

The method used for granulometry is the universal Robinson pipette method, using fine soil samples dried in open air, after decarbonation and destruction of organic matter and then dispersion of particles by sodium hexametaphosphate and sampling using Robinson pipette, applying the stokes law.

The experimental protocol

Our experiment was carried out on a plot of land 65 meters long and 63 meters wide, with a total surface area of 4030m². The entire surface area was divided into 18 micro-parcel with a spacing of 1 m between micro-parcel.

Given the number of factors studied and the degree of heterogeneity present on the plot, we opted for the Factoriel block system.

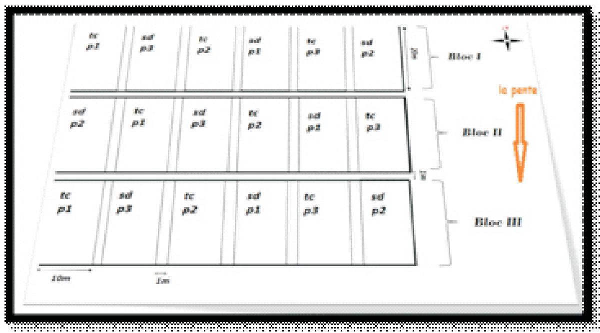


Figure 2. Diagram of the experimental set-up

The dimensions of our plot were:

- Total length of the plot: 65 m.
- Total width of the plot: 62 m.
- Total surface area of the plot: 4030 m².
- Microplot width: 10 m.
- Microplot length: 20 m
- Micro-parcel surface area: 200 m².
- Distance between micro-plots: 1 m.

The first factor is the two-level tillage technique:

Ø **Level 1 (CH1):** chisel + harrow + seed drill + roller

Ø **Level 2 (CH2):** direct seeding: no tillage and direct seeding.

The second factor is the seeding depth with three levels:

Ø **Level 1 (P1): 2.5 cm**

Ø **Level 2 (P2): 4 cm**

Ø **Level 3 (p3): 7 cm**

Tillage techniques studied

Two simplified cultivation techniques were studied: minimum tillage and direct seeding.

Minimum tillage

The objective of this treatment was to limit (relative to tillage) vertical disturbances of the soil and to concentrate crop residues in the first few cm of the soil. This modality can be considered a conservation tillage technique because the tilled soil layer is not turned over and crop residues are roughly buried and are mostly concentrated on the soil surface. It also reduces energy consumption and allows a larger area to be worked than with ploughing (reduction of working time). This technique performs the functions of stubble cultivation, false sowing and loosening of the cultivated soil layer.

This modality was carried out with a chisel-type tine tool on both at a depth of 18 -22 cm.

Direct seeding

The total elimination of tillage remains difficult due to competition from uncontrolled weed development (Drinkwater *et al*., 2000).

In order to limit this competition, new techniques for planting crops in a permanent living plant cover (direct seeding under plant cover or DSPC) have been developed, particularly in Brazil(Labreuche *et al*.,2007) For our part, and in order to study the impact of this system on the behaviour of durum wheat, we have chosen the suppression of tillage as a technique.

Plant material used

The speculation used is **durum wheat**, **Vitron** variety, native to Spain, high to medium straw, half early with medium tillering, susceptible to diseases, it spans the first dekad of April in coastal areas and late April in the high plains. It is characterized by average tillering and slightly higher fertility than **Waha**; it has an average of 50 to 60 grains/epi.

The **Vitron** variety is productive, i.e. 50 to 60 q/ha in dry cultivation, and is also characterized by a high WTG (weight of a thousand grains).

The sown rate recommended by the ITGC for the study area is 120 kg ha^{-1} corresponding to a number of grains/m² of 300.

Concerning the chosen sowing rate

The sowing rate (kg ha^{-1}) = number of seeds hectare^{-1} * WTG (g) / 1,000,000

In our case

The number of grains per m² to be sown = recommended number of grains per m² (according to soil, date, sowing conditions) / germination capacity (58% /95%)

So the number of grains per m² to sow = 240/0.61 = 393 g /m², and we will have: the sowing rate kg ha^{-1} = 196 kg ha^{-1} instead of 120 kg ha^{-1}.

Methodology followed

Determination of soil moisture

sThe water content (H %) of the soil (drying 48 hours at 105°C) expressed as a %.

The fresh (FW) and dry (DW) weights are determined with a precision balance. Soil weight humidity (H %) is deduced by the following formula:

$$H\% = \frac{100(FW - DW)}{DW}$$

The amount of water available in the profile (H, mm) is deduced by the formula:

$$\mathbf{H(mm)} = \frac{[(H\% - HWP) \times h \times da]}{100}$$

Where:

H% = soil weight humidity, HWP = soil humidity at wilting point, taken as 11%; h = horizon depth in mm, da = apparent soil density of the experimental site under consideration.

The amount of water used (WU) by the crop is estimated according to Chen *et al.*(2003), from the residual humidity measured at raised seeding (HS) and harvest (HH), to which is added the precipitation (P) recorded during the same period:

$$\boldsymbol{WU(mm)} = P + HS - HH$$

Water use efficiency (WUE) is calculated by dividing the grain yield by the amount of water consumed:

$$WUE = \frac{YLD}{WU(mm)}$$

Measured production characteristics

·**Exercise period**

Emergent sowing: Counts are carried out as soon as the first seedlings appear on the soil surface up to the 2-leaf stage, it is expressed in days.

The exercise rate

It is obtained by direct calculation, based on the theoretical expected density and the number of plants emerged per m².

Population density

It represents the number of plants per m². It is determined by counting, at the 2-leaf stage.

Morphological parameters

The different morphological parameters measured are:

The height of the plant (HP)

A sample of 5 plants treatment^{-1} was measured at maturity from ground level to the top of the wheat ear beards. It is expressed in cm.

The length of the wheat ear (LE)

A sample of 5 barbless wheat ears without barbs treatment^{-1}was measured at maturity from the base of the wheat ear (1st item of the spine) to the top of the terminal spike. It is expressed in cm.

The length of the beards (LB)

A sample of 5 ears treatment^{-1} was measured at maturity from the top of the terminal spikelet to the top of the beards. It is expressed in cm.

Leaf area (LA)

The leaf area expressed in cm² (L, cm) by the average leaf width (l, cm) by 0.7149, according to Spagnoletti-Zeuli and Qualest, (1990),

$$LA(cm^2) = L \times 1 \times 0.7149.$$

Relative water content (RWC)

The relative water content is calculated by:

$$RWC\,(\%) = \frac{100(FW - DW)}{(PT - FW)}$$

Performance components

The number of spikelets wheat ear $^{-1}$(NS/E):

At maturity, the number of spikes per wheat ear is counted to indicate the fertility rate of the plant.

The number of grains wheat ear^{-1} (NG/E)

It is obtained by direct counting of a sample of 5 wheat ears of corn / treatment.

The weight of a thousand grains (WTG)

This parameter was measured after determining the average weight of one grain per plant of each genotype, multiplied by one thousand to find the weight of one thousand grains.

Estimated grain yield (YLD)

According to Vilain, (1987),

$$estimated\ yield\left(\frac{Q}{ha}\right) = number\ of\ grains\ per\ m^2 \times \frac{WTG}{10000}$$

With:
WTG: (g)
YLD: QX/ha

RESULTS AND DISCUSSION

Analysis of the combined effect of SCT and seeding depth on durum wheat emergence:

Exercise rate

The results for the number of plants square^{-1} meter are included in the following table in the figure:

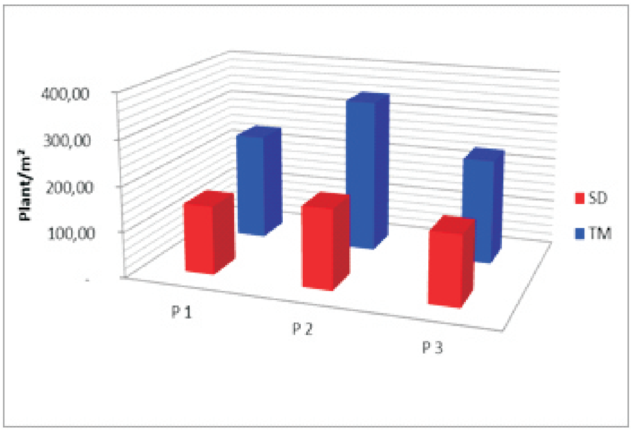


Figure 3 1.the average number of plants per m².

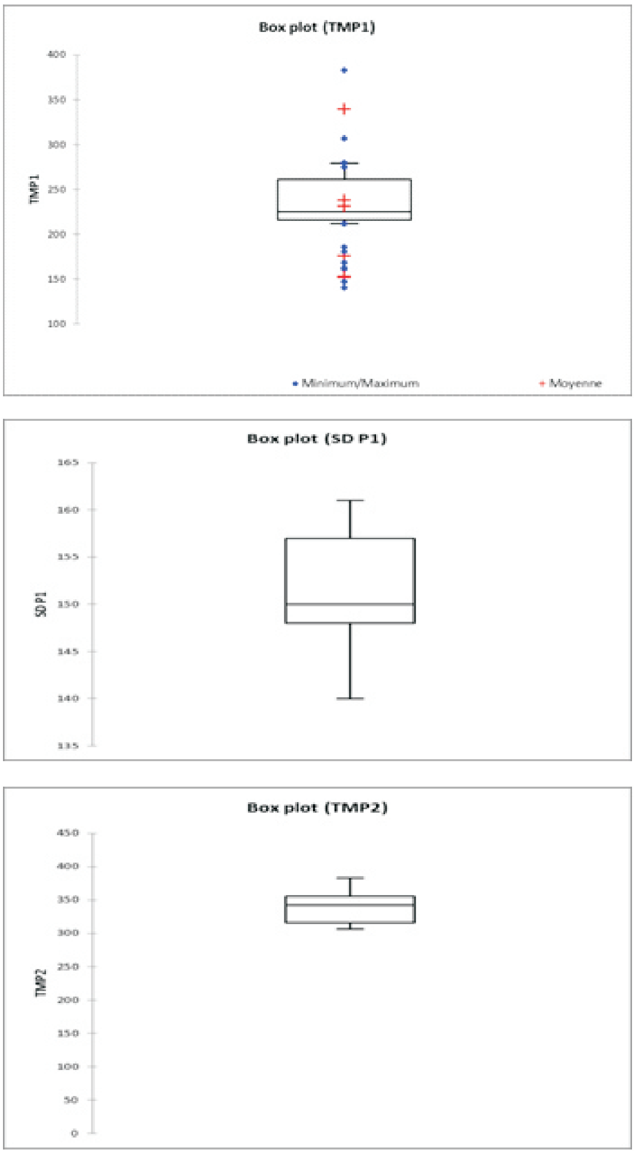


Figure 4.

Table 1: Student's t-test.

[redacted]			
[redacted]	[redacted]	[redacted]	[redacted]
	TMP1/SDP1	TMP2/SDP2	TMP3/SDP3
Différence	[redacted]	[redacted]	[redacted]
t (Valeur observée)	[redacted]	[redacted]	[redacted]
|t| (Valeur critique)	[redacted]	[redacted]	[redacted]
p-value (bilatérale)	< 0,0001	< 0,0001	< 0,0001
alpha	[redacted]	[redacted]	[redacted]

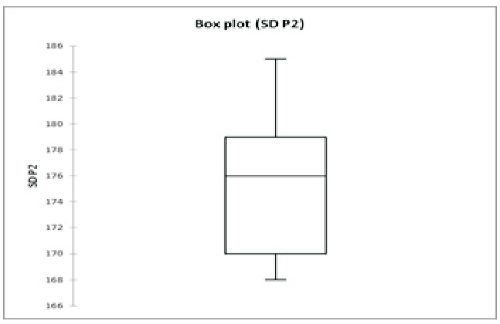


Figure 5:

Table 2. Multiple comparisons (DS P1, DS P2, DS P3)

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Critchlow-Fligner					
Echantillon	**Effectif**	**Minimum**	**Maximum**	**Groupes**	
SDP1	9	140,000	161,000	A	
SDP3	9	168,000	185,000	A	
SDP2	9	147,000	162,000		B

Table 3. Multiple comparisons (MT P1, MT P2, MT P3).

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Critchlow-Fligner					
Echantillon	**Effectif**	**Minimum**	**Maximum**	**Groupes**	
TMP3	9	211,500	279,000	A	
TMP1	9	306,000	382,500	A	
TMP2	9	180,000	274,500		B

The number of plants surveyed square^{-1} meter varies between 140 and 382 for all depths and SCT, the lowest rate of emergence was recorded at the level of plots conducted in DS and sown at a depth of 2 cm. While the highest rate of emergence was to be found in plots prepared with chisel and sown to a depth of 4 cm.

The statistical analysis showed a significant effect of depth and cultivation technique on the variable number of plant/m², the Student Test showed a highly significant effect of the chosen technique (MT, DS) on emergence (plant/m²), the comparison between pairs MTP1/DSP1, MTP2/DSP2, MTP3/DSP3 gave values of 0.0001, 0.0001, 0.0001 and 0.0001 respectively which were well below 0.05.

Multiple pairwise comparisons according to the Steel-Dwass-Critchlow-Fligner procedure gave the same pairs whether in minimum tillage or direct seeding: P1 with P3 and P2 different.

It can therefore be concluded that the choice of cultivation technique to be adopted and the depth of sowing have a considerable and not insignificant effect on the number of plants surveyed square^{-1} meter. However, durum wheat produces fewer plants when sown on soil with direct seeding. Although the Direct Seeding system offers a much more regular seeding depth than the conventional system thanks to hydraulic depth control, it nevertheless has a lower emergence rate, in fact, the number of plants square^{-1} meter is influenced by two important conditions:

- Condition related to the seed grouped under the notion of germination capacity and germination energy.
- External conditions that are the pedoclimatic conditions (water, O_2, temperature, and soil). And these are obtained by conventional or minimum tillage.

Exercise loss rate

At a seeding rate of 393 grains per m², there were significant losses on emergence at direct seeding for the three depths, reaching a rate of 61% for the 2 and 7 cm depths compared to 40% for TMP1 and TMP3.

The lowest loss rate was recorded at the TMP2 level with 14%.

The results for the exercise loss rate are shown in Figure 14.

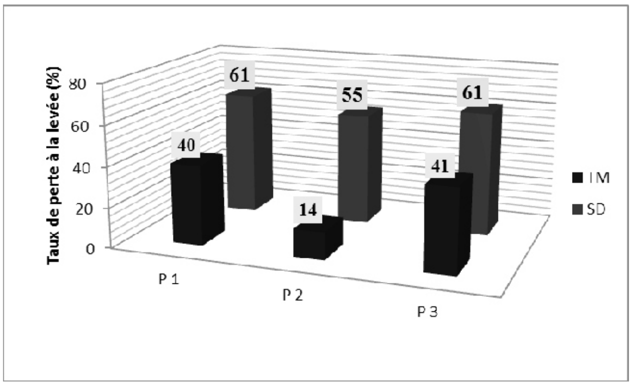


Figure 6. Exercise loss rate

Indeed, sowing was carried out very late, at the end of December. During this period, the soil is certainly wetter but the temperature is lower, which does not favour emergence. Add to this the ineffectiveness of herbicide treatments in Direct Seeding plots due to low temperatures, which has increased weed competition by depriving durum wheat of water.

The sowing time is longer in direct seeding for the three depths, which increases the loss rate.

Exercise period

At the DS level, durum wheat took 33, 23 and 10 days to emerge at seeding depths of 7.4 and 2 cm respectively.

At the MT level, the emergence time is less important, wheat took only 14 days to emerge at a planting depth of 2 cm, but in terms of emergence rate, it remains better at the MTP2 level despite the fact that the duration is only 18 days.

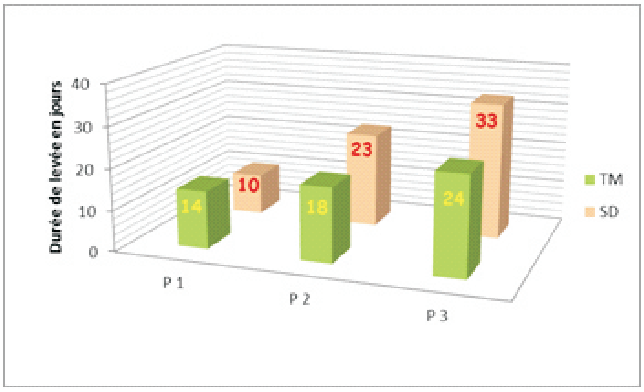


Figure 7. Exercise duration in days

According to Lithourgidis (Lithourgidis *et al*,2006) the density of emerged plants is often reduced under direct seeding, but this effect is no longer reflected in the density of wheat ears produced unit^{-1} area or in yield. On the other hand(Fellahi *etal.*,2010) observed a more homogeneous emergence and a better regularity of sowing depth, in direct sowing, whereas conventional sowing has a significantly higher loss rate at emergence.

Abdellaoui (Abdellaout *et al.*,2011), say that the number of plants surveyed is higher in direct seeding than in conventional seeding.

Analysis of the effect of cultivation techniques on the morphological characteristics of durum wheat

Plant height

The results for durum wheat stem height for the two cultivation techniques and the three depths are shown in the following figures and tables

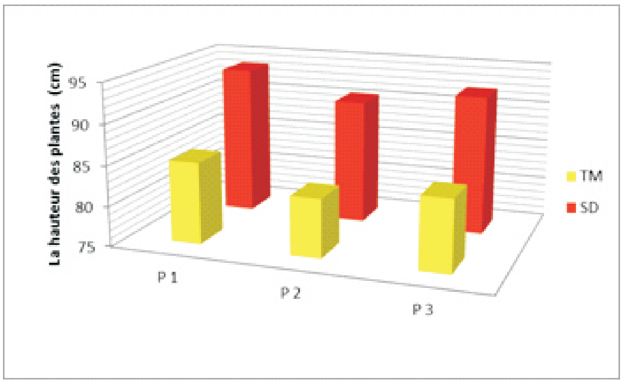


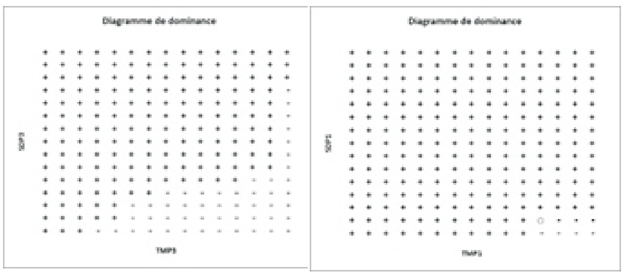
Figure 8: The height of the plants.

Table 4. Descriptivestatistics

Statistiques descriptives (Données quantitatives) :						
Statistique	TMP1	TMP2	TMP3	SDP1	SDP2	SDP3
Nb. d'observations	15	15	15	15	15	15
Minimum	79,000	77,000	69,000	86,900	84,700	75,900
Maximum	90,000	86,000	98,000	99,000	94,600	107,800
1er Quartile	84,000	80,500	78,500	92,400	88,550	86,350
Médiane	85,000	83,000	84,000	93,500	91,300	92,400
3ème Quartile	87,000	84,000	88,500	95,700	92,400	97,350
Moyenne	85,067	82,200	83,800	93,573	90,420	92,180
Variance	10,781	7,314	57,743	13,045	8,850	69,869
Ecart-type	3,283	2,704	7,599	3,612	2,975	8,359
Coefficient de variation	0,037	0,032	0,088	0,037	0,032	0,088

Table 5. Student's t-test

	TMP1/SDP1	TMP2/SDP2	TMP3/SDP3
Différence	-8,507	-8,220	-8,380
t (Valeur observée)	-6,750	-7,918	-2,873
|t| (Valeur critique)	2,048	2,048	2,048
p-value (bilatérale)	**<0,0001**	**<0,0001**	**<0,008**
alpha	0,05	0,05	0,05



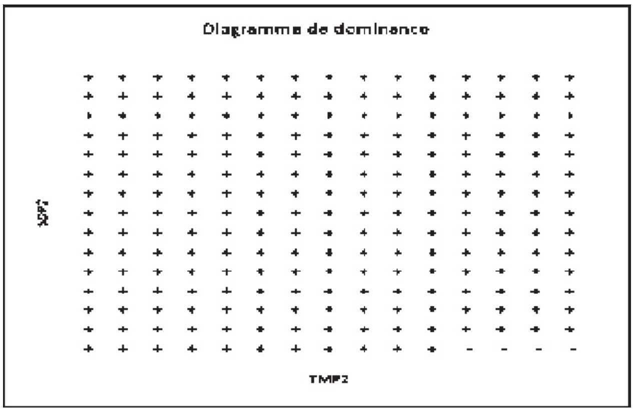


Figure 9.MT/DS dominance diagram

Table 6. Multiple comparisons (MT P1, MT P2, MT P3)

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Fligne				
Echantillon	Effectif	Minimum	Maximum	Groupes
TMP3	15	79,000	90,000	A
TMP1	15	77,000	86,000	A
TMP2	15	69,000	98,000	A

Table 7.**Multiple comparisons (DS P1, DS P2, DS P3)**

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Fligne				
Echantillon	Effectif	Minimum	Maximum	Groupes
SDP3	15	86,900	99,000	A
SDP1	15	84,700	94,600	A
SDP2	15	75,900	107,800	A

The analysis of variance reveals a very significant difference between the two cultivation techniques, the stems are higher at the level of direct seeding with an average of 90 to 93 cm, against 83 cm for minimum tillage. The depth effect is not statistically significant.

Plant height appears as an important selection criterion, finds a positive and significant link between yield and straw height: short plants are more productive than high straw plants. This means that the former have a high tillering capacity, each slope will lengthen and will put an inflorescence and what increases the spur stand, therefore, we are witnessing an increase in yield.

It should be noted that the high height of the straws is an important advantage in promoting good drought resistance, this can be explained on the one hand by the fact that a high straw is often accompanied by a deep root system, which would give the plant a higher water extraction capacity, and on the other hand:

According to Monneuveux (Monneveux and Nemmar,1986) it is thanks to the carbohydrate component that it preserves and that contributes to the development of the dry matter of grains in the event of a water deficit.

Fisher and Maurea(1978) mention that high wheat has a lower sensitivity to water stress than low wheat.

The length of the wheat ears

The results for the length of the wheat ear are represented by the following figures and tables:

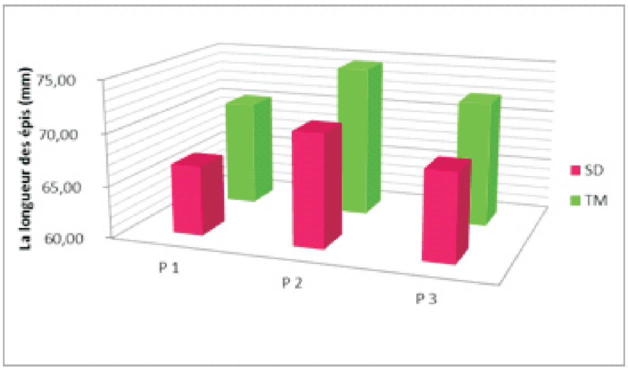


Figure 10. The length of the wheat ears (mm).

Table 8. Descriptive statistics

Statistiques descriptives (Données quantitatives) :						
Statistique	TMP1	TMP2	TMP3	SDP1	SDP2	SDP3
Nb. d'observations	15	15	15	15	15	15
Minimum	60,000	70,000	65,000	57,000	66,500	61,750
Maximum	79,000	80,000	77,000	75,050	76,000	73,150
1er Quartile	69,000	72,000	70,000	65,550	68,400	66,500
Médiane	71,000	74,000	72,000	67,450	70,300	68,400
3ème Quartile	72,000	78,000	74,500	68,400	74,100	70,775
Moyenne	**70,200**	**74,533**	**72,000**	**66,690**	**70,807**	**68,400**
Variance	20,029	12,410	10,571	18,076	11,200	9,541
Ecart-type	4,475	3,523	3,251	4,252	3,347	3,089
Coefficient de variation	**0,062**	**0,046**	**0,044**	**0,062**	**0,046**	**0,044**

Table 9. Student's t-test

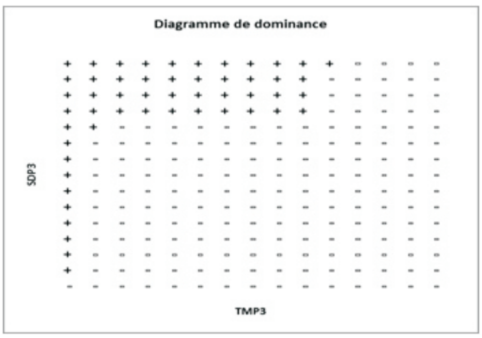
	TMP1/SDP1	TMP2/SDP2	TMP3/SDP3
Différence	3,510	3,727	3,600
t (Valeur observée)	2,202	2,970	3,109
|t| (Valeur critique)	2,048	2,048	2,048
p-value (bilatérale)	**<0,036**	**<0,006**	**<0,004**
alpha	0,05	0,05	0,05

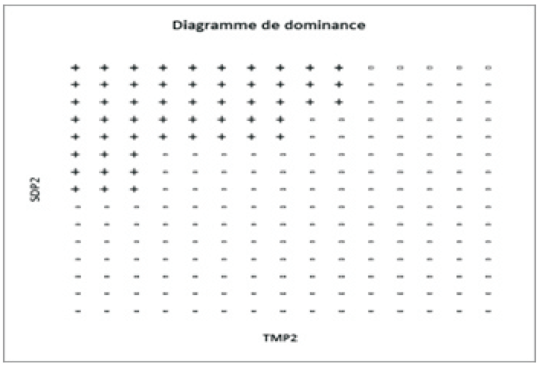
Table 10. Multiple comparisons (MT P1, MT P2, MT P3)

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Fligne					
Echantillon	Effectif	Minimum	Maximum	Groupes	
TMP1	15	60,000	79,000	A	
TMP3	15	70,000	80,000	A	B
TMP2	15	65,000	77,000		B

Table 11. Multiple comparisons (DS P1, DS P2, DS P3)

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Fligne					
Echantillon	Effectif	Minimum	Maximum	Groupes	
SDP1	15	57,000	75,050	A	
SDP3	15	66,500	76,000	A	B
SDP2	15	61,750	73,150		B





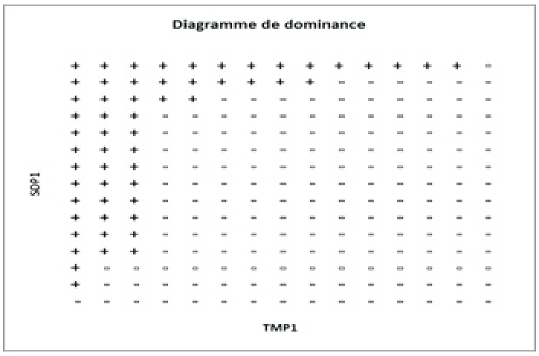


Figure 11.MT/DS dominance diagram

The results on the length of the wheat ears showed that at minimum tillage the wheat ears were longer, this was true for all three planting depths.

The maximum value was recorded at MTP2 with 80 cm, while the minimum value was obtained at DSP1 with 57 cm.

Statistical analysis reveals a very significant difference between cultivation techniques, while for seeding depths, P2 was different from P1 and P3 in both MT and DS.

The length of the wheat ear is a varietal characteristic that is not influenced by variations in the environment, more precisely it depends on the amount of water reserved during the growing cycle, and therefore indirectly on the retention of water in the soil, and therefore on the influence of cultivation techniques. Also the length of the wheat ears is proportionally inverse to the sowing density.

The short wheat ear contributes to limiting water losses, there is a positive correlation between grain yield and wheat ear length, the wheat ear provides significant photosynthetic activity during grain filling and its contribution to plant photosynthesis is estimated at between 13% and 76%. In the event of a water deficit, photosynthesis of the spike participates relatively more in filling than the flag leaf.

The characteristics of the wheat ear (short ear) also contribute to limiting water loss.

A short wheat ear allows a better compactness of the grains which makes it possible to fight against climatic hazards as well as against ginning.

The length of the beards

The results relating to the length of the beards are represented by the following figure and tables:

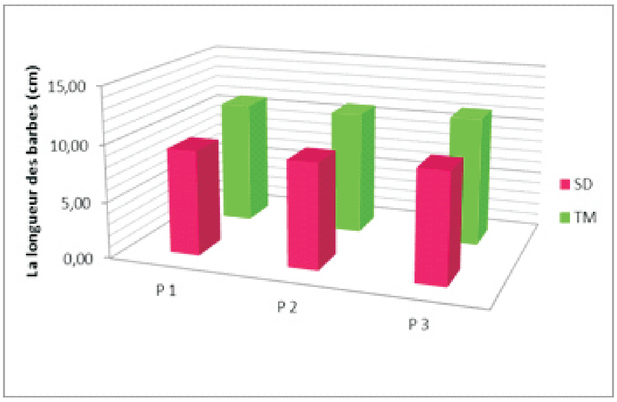


Figure 12. The length of the beards (cm)

Table 12. Descriptive statistics

Statistiques descriptives (Données quantitatives) :						
Statistique	TMP1	TMP2	TMP3	SDP1	SDP2	SDP3
Nb. d'observations	15	15	15	15	15	15
Minimum	9,200	8,000	10,000	7,820	6,800	8,500
Maximum	12,500	12,500	13,000	10,625	10,625	11,050
1er Quartile	10,050	10,250	10,950	8,543	8,713	9,308
Médiane	11,400	11,100	11,300	9,690	9,435	9,605
3ème Quartile	11,600	11,900	11,500	9,860	10,115	9,775
Moyenne	**10,913**	**10,927**	**11,340**	**9,276**	**9,288**	**9,639**
Variance	0,973	1,566	0,565	0,703	1,132	0,409
Ecart-type	0,986	1,252	0,752	0,838	1,064	0,639
Coefficient de variation	**0,087**	**0,111**	**0,064**	**0,087**	**0,111**	**0,064**

Table 13. Student's t-test

	TMP1/SDP1	TMP2/SDP2	TMP3/SDP3
Différence	1,637	1,639	1,701
t (Valeur observée)	4,898	3,865	6,675
|t| (Valeur critique)	2,048	2,048	2,048
p-value (bilatérale)	**<0,0001**	**<0,001**	**<0,0001**
alpha	0,05	0,05	0,05

Table 14.**Multiple comparisons (DSP1, DSP2, DSP3)**

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Fligne				
Echantillon	Effectif	Minimum	Maximum	Groupes
SDP1	15	7,820	10,625	A
SDP2	15	6,800	10,625	A
SDP3	15	8,500	11,050	A

Table 15. **Multiple comparisons (MTP1, MTP2, MTP3)**

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Fligne				
Echantillon	Effectif	Minimum	Maximum	Groupes
TMP1	15	9,200	12,500	A
TMP3	15	8,000	12,500	A
TMP2	15	10,000	13,000	A

The length of the beards is more important at the MT level with values between 10 and 11 cm, against 9 cm at the DS.

Statistical analysis reveals a very significant difference between cultivation techniques, and not significant between planting depths.

Past research has shown that the presence of barbs in cereals increases the possibility of water use and the development of dry matter during the maturation phase.

It is a morphological parameter that seems to be closely related to tolerance to terminal water deficit at least in durum wheat, bearded wheat is the most resistant to water deficit. Indeed, the presence of beards plays an important role in grain filling: during this phase, photosynthesis is less sensitive to the inhibitory action of high temperatures in bearded animals compared to hairless ones.

Bearded wheat is sought after especially in areas where the climate is dry and hot, as is the case in Algeria, while beardless wheat is predominant in temperate and humid regions.

The surface of the flag leaf

The results for the area of the flag leaf are represented by the following figure and tables:

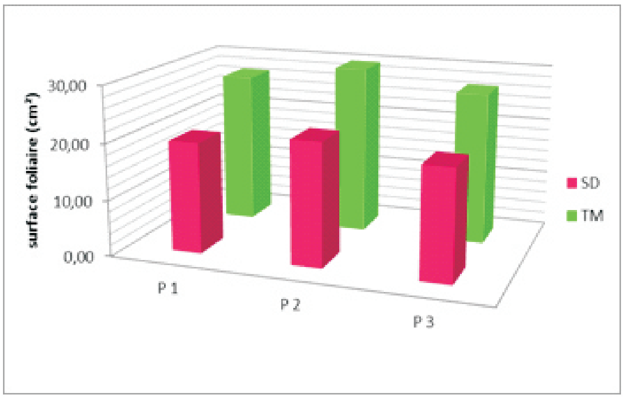


Figure 13. Leaf area (cm²)

Table 16. Descriptive statistics

Statistiques descriptives (Données quantitatives) :						
Statistique	TMP1	TMP2	TMP3	SDP1	SDP2	SDP3
Nb. d'observations	15	15	15	15	15	[illegible]
Minimum	[illegible]	[illegible]	[illegible]	15,184	[illegible]	[illegible]
Maximum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1er Quartile	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Médiane	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3ème Quartile	[illegible]	[illegible]	[illegible]	22,411	[illegible]	[illegible]
Moyenne	27,022	29,910	26,860	19,726	21,834	19,608
Variance	22,315	[illegible]	[illegible]	[illegible]	5,616	[illegible]
Ecart-type	4,724	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Coefficient de variation	0,156	0,097	0,179	0,156	0,097	0,179

Table 17. Student's t-test

	TMP1/SDP1	TMP2/SDP2	TMP3/SDP3
Différence	1,637	1,639	1,701
t (Valeur observée)	4,898	3,865	6,675
|t| (Valeur critique)	2,048	2,048	2,048
p-value (bilatérale)	< 0,0001	< 0,001	< 0,0001
alpha	0,05	0,05	0,05

Table 18. Multiple comparisons (DSP1, DSP2, DSP3)

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Fligner				
Echantillon	Effectif	Minimum	Maximum	Groupes
SDP1	18	15,184	23,389	A
SDP2	18	19,250	25,360	A
SDP3	18	15,651	25,776	A

Table 19. Multiple comparisons (MTP1, MTP2, MTP3)

Comparaisons multiples par paires suivant la procédure de Steel-Dwass-Flign				
Echantillon	Effectif	Minimum	Maximum	Groupes
TMP1	18	20,800	32,040	A
TMP2	18	26,370	34,740	A
TMP3	18	21,440	35,310	A

The surface development of the flag leaf follows the trend of above-ground biomass accumulation due to tillage. The flag leaf develops larger dimensions under minimum tillage compared to direct seeding. This increase takes values from 26 to 29 cm² and 19 to 21 cm², respectively under minimum tillage and direct seeding.

The statistical analysis shows a highly significant effect of the technique but not of the depth. The flag leaf plays a major role in filling the grain, the potential net assimilation of the last leaf depends on: its leaf area, the number of stomata, the chlorophyll content, and the age of the leaf.

The life span of the flag leaf estimated by the evolution of its green surface appears to be a revealing indicator of the level of functioning of the photosynthetic apparatus in the presence of water deficit, during the water deficit, the plant reacts by decreasing the above-ground biomass, in particular the surface of its last leaf, This decrease is considered as a reaction of average resistance or adaptation to water shortage.

Analysis of the combined effect of SCT and seeding depth on durum wheat yield components

Number of wheat ears per m²:The results relating to the number of spikes per m² are represented by the following figure:

Number of grains wheat ear^{-1}

The results for the number of grains wheat ear^{-1} are shown in the following figure:

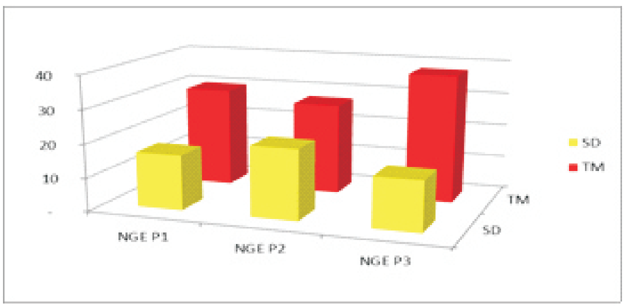


Figure 14.the variation in the number of grains ear^{-1}with cultivation techniques and depth.

The weight of a thousand grains

The results for the thousand grain weight are shown in the following figure:

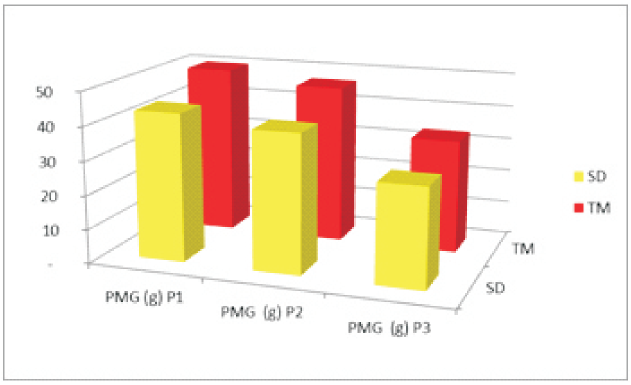


Figure 15.the WTG variation in relation to cultivation techniques and depths

Estimated yield (q ha^{-1}):

Performance results are shown in Figure 15

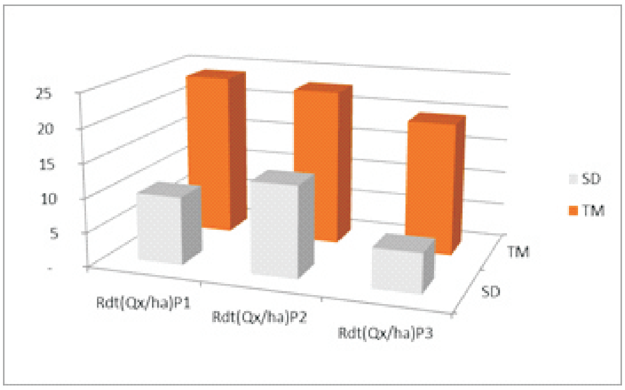


Figure 16 .the estimated yield of durum wheat

The analysis of the combined variance of yield and yield components measured during the season indicates a highly significant combined technical crop planting depth effect for the number of wheat ears per m², the weight of 1000 grains, the grain yield, the number of grains per m² and the number of grainswheat ear^{-1}. These results indicate that the values taken by these variables are largely influenced by the variation in seeding depth and the simplified cultivation technique adopted.

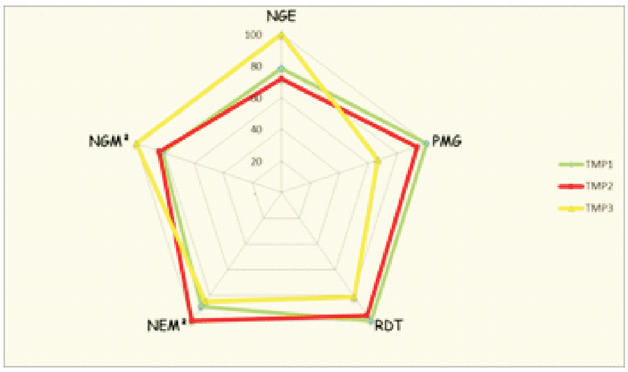


Figure 17. Performance analysis and performance components with MT and depth

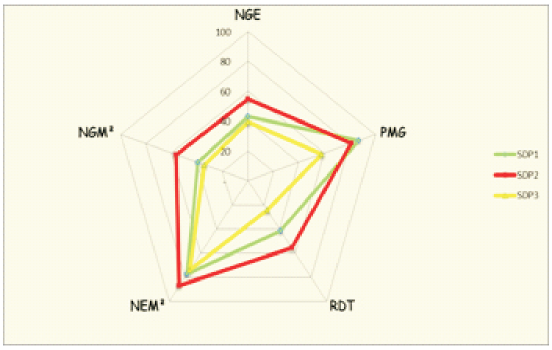


Figure 18. Performance analysis and performance components with SD and depth

The average number of wheat ears (NEM²) were 164 for MT and 143 for DS. However, when driven on MT soil, the variety produces more wheat ears of corn, with a relative increase of 13.8% compared to the average achieved under DS conditions. However, the average wheat ear fertility observed on the six CT treatments and contrasting seeding depths was 32 grains wheatear^{-1} for MT and half for DS.

The differential response of the variety's behaviour in contrasting cultivation techniques for the weight of a thousand grains (WTG), grain yield (YLD) evaluates the good expression of the variety grown on soil in MT with regard to DS systems. The average weight of a thousand grains of the variety for both modes was 40 g. However, the WTG obtained in MT is characterized by a relative gain of 14% over that obtained on DS soil. For both technical cultivation methods, the variety has an average grain yield of 15.87 qha^{-1}. Nevertheless, the relative yield gains obtained by the variety grown on cultivated soil at least were 23.89, 22.89, 22.89, 19.42 qha^{-1} for P1, P2, P3 respectively, and 9.95 13.31 5.79 on the values observed on soil in the DS for P1, P2, P3 noted in order.

Analysis of the combined effect of SCT and seeding depth on the water behaviour of durum wheat

Relative water content

The results for the relative water content are shown in the following figure:

To know the influence of cultivation techniques on the relative water content of the leaves, an analysis of the wheat RWC was carried out and the results obtained are shown in the following figure:

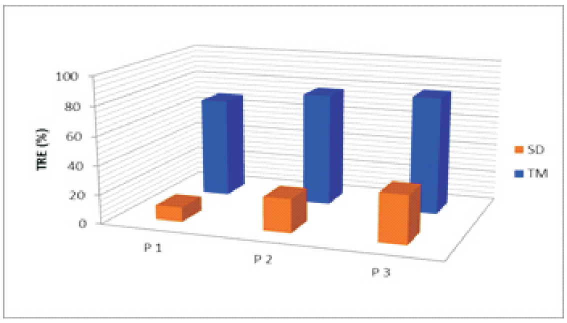


Figure 19. The relative water content

The analysis of variance reflects a significant effect of the relative water content (RWC, %) of the leaves under the action of cultivation techniques, seeding depth and CT x depth interaction. The average RWC values vary according to the cultivation techniques. The behaviour of this wheat grown in MT is measured by an average RWC of 68.57%, 77.44%, 80.56% for P1, P2, P3. And in direct seeding43.71%, 51.38%, 54.33% for P1, P2, P3... The differences in RWC values between CTs are explained mainly by the lack of water in the back cycle at the parcels conducted in DS coinciding with insignificant reduced precipitation.

The interaction CT x seeding depth indicates that the expression of the hydric status of the plant characterized by the relative water content of the leaves at a given stage varies significantly under the effect of CT.

The relative moisture content decreases during the grain filling stage. Nevertheless, driving in MT seems more efficient in the back cycle of the plant. Indeed, the measured values of RWC indicate that MT >DS, expressing that the plant is more stressed in an undisturbed environment in the late vegetative stage.

Precipitation utilization efficiency

The quantities of water present at seeding of the different treatments vary from 16% to 19%. Minimum tillage has more soil moisture equivalent to 3% compared to direct seeding.

Norwood (1994) mentioned that rainwater migrates deeper under a no-till system than under a conventional system.

At harvest, soil moisture is very low, varying around 5%. These differences in soil moisture at seeding and harvesting between treatments resulted in the use of 452.77 mm of moisture for direct seeding compared to 459.07 mm for minimum tillage.

These differences are accompanied by very significant differences in the efficiency with which precipitation is used to produce grain. Indeed, direct seeding has the lowest rainfall utilization efficiency with a value of 210 g ha-1 mm^{-1}. While the minimum tillage has a relatively higher value of 480 g ha^{-1}mm^{-1}.

Table 20. Water use efficiency (WUE)

	TM	SD
PF(%)	13	13
Profondeur (mm)	200	200
da	1,33	1,29
H% semis	19,05	16,91
Hs% - PF (%)	6,05	3,91
HS	16,10	10,09
Pluie (mm)	424	424
H% récolte	5,87	5,76
Hr % - PF(%)	-7,13	-7,24
HR	- 18,97	- 18,68
H2O utilisée (mm)	459,07	452,77
RDT (kg/ha)	221	97
EUE RDT (g/ha/mm)	480	210

Panda *et al*. (2003) note that the water supply to wheat is located at a depth of 0-45cm.

According to Chenaffi *et al.* (2006) the ten-year water requirements of durum wheat cultivation are 103 mm for the swelling-heading period.

Variations in soil water content are due to the interaction of precipitation, temperature, wind and solar radiation with the crop's stage of development. Nevertheless, farming techniques improve the efficiency of rainwater use(Peterson *et al*. ,1998).

Analysis of the correlation between the different parameters studied

Based on the results obtained throughout our experiment, the behaviour of durum wheat cultivation is sensitive to tillage practices. Indeed, the analysis in main components, the first three axes of which explain 65% of the variation, shows that the minimum tillage is opposed to direct seeding throughout axis 1, while DS is more represented by axis 2. These results suggest that the crop's behaviour is completely different depending on the type of tillage adopted. Indeed, NPM², LE, LB, SF, NGE, NEM², WTG, YLD, WUE YLD are positively linked to axis 1. The length of the vegetation positively related to axis 2.

Table 21. Correlation analysis

valeurs propre et % de la variation expliquée			
	F1	F2	F3
Valeur propre	12,729	11,446	7,013
Variabilité (%)	26,519	23,845	14,611
%cumulé	26,519	50,364	64,975
coefficient de corrélation			
variables mesurées	F1	F2	
NPM²	0,9	-0,3	
LP	0,31	0,9	
LE	0,86	0,32	
LB	0,78	0,21	
SF	0,87	0,24	
NGE	0,93	0,21	
NEM²	0,89	0,39	
PMG	0,9	0,24	
RDT	0,81	0,6	
EUE Rdt	0,83	0,56	
coordonnées des traitements sur les axes			
Traitements			
TM	2,9	-0,71	
SD	-0,8	2,41	

These results suggest that direct seeding is best characterized by vegetation height, high above-ground biomass associated with higher rainfall use and low grain yield values, and efficient use of rainfall to produce grain, compared to the minimum tillage crop behaviour, which is characterized by opposite values. Cultivation carried out in minimum labour is mainly characterised by a production of wheat ears and grains per m² and a high WTG. These results suggest that the direct seeding crop produced a high above-ground biomass by using available soil moisture very early on. This has resulted in a low availability of soil moisture for high grain yield, leading to a reduction in harvest and a shortening of the growing cycle. In this context, minimum tillage seems more advantageous.

The experimental work carried out for this thesis aims to enrich scientific and technical knowledge on how it works in Mediterranean climates and on simplified cultivation techniques for the production of durum wheat.

They should provide a better understanding of the behaviour of durum wheat.

Despite the diversification of technical routes and strategies adopted by Algerian farmers in terms of cereal cultivation. The grain yield remains the final objective of the latter.

The results of this experiment showed the importance of the spikes stand and the number of grains per m² in achieving the final yield. This stand is very dependent on the starting foot stand. This highlights the importance of achieving an adequate initial foot stand, an objective that cannot be achieved without a successful lifting.

Germination and seeding rate are the two factors that seem to work most in favour of emergence, while late seeding dates disadvantage it. Among the first two factors only the sowing rate is under the total control of the farmers. Aware of the loss of seeds during installation, and in order to improve the starting foot stand and consequently the spikes stand, these farmers find their solution in increasing the sowing rates (they sow 210 kg ha^{-1} on average in the case of broadcast sowing and 180 kg ha^{-1} on average in the case of seed drills). This situation will remain so until the problems of successful exercise are resolved.

Among the causes of non-stemming, the size of the clods in the seed beds are the most important. The majority of Algerian farmers are waiting for the rains to arrive for planting. Those who sow in dry areas are forced to do so because they have large areas. Dry sowing as currently practiced results in significant seed loss at installation. A dry sowing cannot be advantageous as long as it is not accompanied by an adequate equipment allowing a better covering of the seeds and a good ground-seed contact. Such as a special seed drill or a rolling after sowing, for example.

The lack of equipment adapted to tillage and dry sowing leads most farmers to wait for the rains to set up their crops. At this time, the owners of tractors and agricultural equipment, which provide services to farmers, are becoming very popular. Being in this position of strength, they allow themselves to work the soil in very poor conditions leading to the production of very bad seedbeds.

Soil preparation, whether conventional or at least before sowing, is practiced by 95% of Algerian farmers, the main objective of the latter is to refine the seedbed.

REFERENCES

Abdellaoui Z., H. Teskrat, A. Belhadj and O. Zaghouane, 2011. Étude comparative de l'effet du travail conventionnel, semis direct et travail minimum sur le comportement d'une culture de blé dur dans la zone subhumide. Options Méditerranéennes **96** :71-87.

Adjabi, A. 2011. Etude de la tolérance du blé dur (triticumdurumdesf) aux stress abiotiquessous climat méditerranéen. Thèse de Doctorat des Sciences Agronomiques. ENSA, El-Harrach, Alger, 130 pages.

Benmahammed, A., Nouarh., L. Haddad , Z. Laala, A. Oulmi and H. Et Bouzerzour, 2010-Analyse de la stabilité des performances de rendement du blé dur (*Triticum durum* desf.) Sous conditions semi-arides. Biotechnol. Agron. Soc. Environ.**14**: 177-186.

Benniou, R. and L. Brinis, 2007. Diversités des exploitations agricoles en région semi-aride algérienne. Sécheresse. **17** :399-406.

Bouaziz, A. 1987. Implantation d'un peuplement de bletended en conditions seches. Analyse Physique et modelisation. These de doctorat. Institute Agro- nomique et Veterenaire Hassan II. Rabat, Morroco.

Bouguendouz, A. 2011. Effet de trois itinéraires techniques sur l'élaboration du rendement de l'orge (*Hordeum vulgare* L.) Sous conditions semi-arides des hautes plaines Sétifiennes. Options Méditerranéennes. **96** : 83-89.

Chekli, H. 1991. Eléments du choix des séquences d'installation de la culture du blé dans la région de Meknès. Modification des états structuraux et aspects énergé- tiques. Thèse de Doctorat Es-Sciences Agronomiques, IAV Hassan II, Rabat, Maroc, pp. 229.

Chenaffi H.,A. Aïdaoui,H. Bouzerzour, and A. Saci, 2006- Yield response of durum wheat (*Triticum durum* Desf.) Cultivar Waha to deficit irrigation under semi-arid growth conditions. Asian J. Plant Sci.**5**: 854-860.

Drinkwater, L.E., R.R. Janke, and L. Rossoni-Longnecker, 2000. Effects of tillage intensity on nitrogen dynamics and productivity in legume-based grain systems. Plant Soil, **227**:99–113. Doi:10.1023/A:1026569715168

Ducellier, L 1930. Espèces et variétés de céréales cultivées en Algérie. Direction de l'agricultureet de la colonisation, 130 pages.

Feddal, M. A. 2011 Analyse du comportement du sol sous l'action de deux techniques de mise en place d'une culture de *(Triticum durum).*

Fellahi, Z. A., A. Hannachi, H. Chennafi, M. Makhlouf and H. Bouzerzour,2010. Effet des résidus et du travail du sol sur la cinétique de l'accumulation de la biomasse, le rendement et l'utilisation de l'eau du blé dur (triticumdurumdesf.) Variété MBB sous conditions climatiques des hautes plaines Sétifiennes. Soumis Sciences et Technologie Université Chlef.

Fischer, R.A. and R. Maurer. 1978. Drought resistance in spring wheat cultivars: I. Grain yield responses. Aust. J. Agric. Res., **29**: 897-912.

Hakimi, M. 1993. L'évolution de la culture de l'orge : le calendrier climatique traditionnel et les données agro météorologiques modernes. In theagrometeorology of rainfed barley-based farming systems.Proceeding of an International symposium.Ed. Jones M., Marthys G., Rijks D. 157 – 166.

Hervieu B., R.Capone and S. Abis, 2006. The challenge posed by the cereals sector in the Mediterranean. Ciheamanalytical note, N°9: 14 pages.

Labreuche, J.,T. Viloingt,D. Caboutet, J.P. Daouze,R. Duval,A. Ganteil, L. Jouy,L.Quere,H. Et J.Boizard and Rouger-Estrade, 2007. Evaluation des impacts environnementaux des techniques culturales sans labour (TCSL) en France. Parite1 : la pratique des TCSL en France. ADEME

Lahmar, R. and H. Bouzerzour, 2011. Du malch terreux au mulch organique. Revisiter le dry-farmaing pour assurer une transition vers l'agriculture durable dans les hautes plaines Sétifiennes. Options Méditerranéennes, **96** : 99-106.

Lahmar R. and A. Ruellan,2007. Dégradation des sols et stratégies coopératives en Méditerranée : la pression sur les ressources naturelles et les stratégies de développement durable. Cahiers Agricultures. **16** : 318-323.

Lithourgidis, A.S., I.B. VasilakoglouK.V. Dhima, C.A. Dordas and M.D. Yiakoulaki, 2006. Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios, Field Crop. Res. **99** 106–113.

Monneveux Ph. M. and Et Nemmar , 1986 -Contribution à l'étude de la résistance à la sécheresse chez le blé tendre (Triticum aestivum L.) Et chez le blé dur (Triticum durum Desf.). Etude de l'accumulation de la proline au cours du cycle de développement. Agronomie, **6**(6): 583-590.

Norwood C. 1994. Profile water distribution and grain yield as affected by cropping system and tillage. Agron. J.**86** : 558-563.

Nouar H., L. Haddad, Z. Laala, L. Oulmi, H. Zerargui, A. Benmahammed and H. Bouzerzour, 2010. Performances comparées des variétés de blé dur : Mohammed Ben Bachir, Waha et Boussalem dans la wilaya de Sétif. Céréaliculture, **54**: 23-29.

Panda, R.K.,S.K. Behera and P.S.Etkashyap 2003.Effective management of irrigation water for wheat under stressed conditions.Agricultural Water Management, **63**: 37-56.

Peterson, Ga., Ad. Halvorson, Jl. Havlin, Or. Jones, Dj. Lyon and Dl. Tanak. 1998. Reduced tillage and increasing cropping intensity in the Great Plains conserves soil C. Soil Tillage Res. J. **47**: 207-218.

Watts, D.G. and M. El Mourid, 1988 Rainfall patterns and probabilities in the semi-arid cereal production region of Morocco. I.N.R.A/MIAC. Settat.

Rec. on 10.2.2020 & Acc. on 20.02.2020