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Study of Production and Adaptation Characters of Some Newly Obtained Genotypes of Durum Wheat (Triticum Durum Desf.) in Sub-Humid Region (El Harrouch North-Eastern of Algeria)

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STUDY OF PRODUCTION AND ADAPTATION CHARACTERS OF SOME NEWLY OBTAINED GENOTYPES OF DURUM WHEAT (*TRITICUM DURUM* DESF.) IN SUB-HUMID REGION (EL HARROUCH NORTH-EASTERN OF ALGERIA)

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ABSTRACT

The experiment was carried out at DAOUDI Larbi pilot farm in El Harrouch, during the 2021/2022 crop year, under sub-humid weather conditions. The main objective of this research is based on the study of production and adaptation characters of seven durum wheat newly obtained genotypes (*Triticum durum* Desf.). The results of descriptive sheets according to UPOV recommendations (2014-2017), showed diversity between the varieties studied, such as: plant height, straw section, awns (presence, disposition, anthocyanin pigmentation, color, and length), ear (density, color, shape, length and glaucescence), lower glume (shape, color, weight and shape of shoulder, length and curvature of beak), neck glaucescence, length of rachis… According to the results obtained of production and adaptation characters we find that Numidia presented the high value of number of Plant/m^2 (350 ± 4.58), Emilio Lepido showed a high level of Number of Herbaceous tillers/Plant (2.70 ± 0.52), number of Grains/Ear (37.1 ± 6.85), and Harvest index (35.62 Qunitals/Acres). While, the number of Ears tillering/Plant, number of Ears/m^2, thousand grains weight, grain yield, biomass aerial, and economic yield (1.67 ± 0.31, 423.33 ± 15.95, 48.6 g, 62.13 ± 2.34 Qunitals/Acres, 184.6 ± 1.7 Qunitals/Acres and 98.88 ± 2.01 Qunitals/Acres). According to the results obtained the Shannon and Weaver relative diversity index showed a low diversity in all accessions studied (H'_{Mean}=0.41). Finally, we concluded that the creation of descriptive sheets, the knowledge of production and adaptation parameters are considered as precursors of high yield, they allow us to better exploit these species according to economic needs, agro-ecological conditions, and mastery of production techniques in improvement programs.

Key words: Genotypes, *Triticum durum* Desf., production, adaptation, El Harrouch.

INTRODUCTION

Wheat is one of the major cereals cultivated and exported globally. It has been cultivated for more than 10 000 years and is eaten daily by the world's population in all its forms. This fundamental food is an important dietary fiber-containing an ample amount of energy, starch, and other vital vitamins, amino acids, minerals, and other components that are beneficial for health (Tradologie, 2021).

The global wheat market is segmented into different groups of countries that have different wheat production and consumption capacities,

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making this market more conducive to price volatility. Only 20 % of world wheat production is traded and this is a surplus and surplus market. However, this global wheat trade has increased threefold between 1961 and 2005, and wheat thus consolidates its place as the “most traded” cereal in the world (Charvet, 2012). In 2022, world wheat production reached 780.96 million tons compared to 774 million tons in 2021 (IGC, 2023). The war in Ukraine has shaken commodity markets and severely undermined world food security. Despite efforts to alleviate the impact of the crisis, especially the partial reopening of food shipments from Ukraine's Black Sea ports, several risks remain mostly in the areas of Ukraine's storage, processing and transport capacities, international trade policy measures, and food price levels and volatility (AMIS, 2023). North African agriculture is likely to be among the most affected, not only because of its high dependence on rainfall, but also and especially because of its low ability to adapt to climate change (Mertz et al., 2009).

In Algeria, Cereals, dominated by durum wheat, represent 85 % of the area of agricultural use and are located in semi-arid areas, characterized by variable, random and water deficit (Bessaoud, 2019). Cereal production in Algeria is highly dependent on climatic conditions. This is reflected from year to year in significant variations in the area of agricultural use, production and yield. Thus, the lack of rainfall, but also the poor distribution of rainfall during the year largely explains the large variation in cereal production (Djermoun, 2009).

Productivity is defined as the ability to produce more. It’s a relative notion. In breeding, it often refers to grain yield. A productive variety is, in fact, only in relation to another variety it replaces and to which it is compared. The latter is then used as a reference (Reynolds et al., 2007; Adjabi et al., 2007).

Grain yield is a genetically complex trait, and its improvement requires the joint selection of productivity and adaptive traits to biotic and abiotic environments. Genetic improvement of yield is progressive and continuous, following modification of components (Doré et Varoquaux 2006).

In this optical the objective of this study is the evaluation of the production and adaptation characters of seven genotypes of new durum wheat varieties (*Triticum durum* Desf.) on the basis of morpho-physiological characters according to the international standards of the Union for the Protection of Plant Varieties (UPOV, 2014-2017) in sub-humid conditions in the region of El Harrouch in the wilaya of Skikda (North-eastern of Algeria).

MATERIALS AND METHODS

a) *Plant Material*

The plant material used comes from the AXIUM Agro Multi Investment and Services SPA (Ain Smara, Constantine) and Technical Institute of Field Crops (TIFC) of El Khroub (Constantine). A total of 7 durum wheat genotypes (*Triticum durum* Desf.) were the subject of this study (Table 1).

b) *Description of the study site*

The test was carried out during the season of 2021/2022 at the pilot farm Daoudi Larbi of El Harrouch located in the wilaya of Skikda (North East of Algeria) (Figure 1) at 36°39’08” N and 6°49’12” E, above142 m sea level.

According to the Köppen-Geiger classification, the climate of El Harrouch province is mediterranean type Csa. The average temperature at El Harrouch is 17.4 °C. It falls on average 704 mm of rain per year. The driest month is July with only 5 mm. With an average of 126 mm, January recorded the highest precipitation. With an average temperature of 26.0 °C,

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the month of August is the warmest of the year. With an average temperature of 10.0 °C, the month of January is the coldest of the year (DSAS, 2020).

The soil is very heavy in clay texture (52 % clay, 32 % silt and 16 % sand) with very high fertility, unsalty, and an alkaline pH (8.1) (PFDL, 2020).

Table 1: Origin of the genotypes studied.

Genotypes	Name	Pedigree	Origin
G1	Ovidio	Svevo/Claudio	Italy
G2	Emilio Lepido	Orobel//Acrcobaleno/Svevo	Italy
G3	Ancomarzio	Stotka//Altar84/Ald	Italy
G4	Moulet Eddar	Unavailable	Algeria
G5	Numidia	Unavailable	Algeria
G6	Bouhamenna	Unavailable	Algeria
G7	El Tayeb	Mexicali75× Ofanto	Algeria

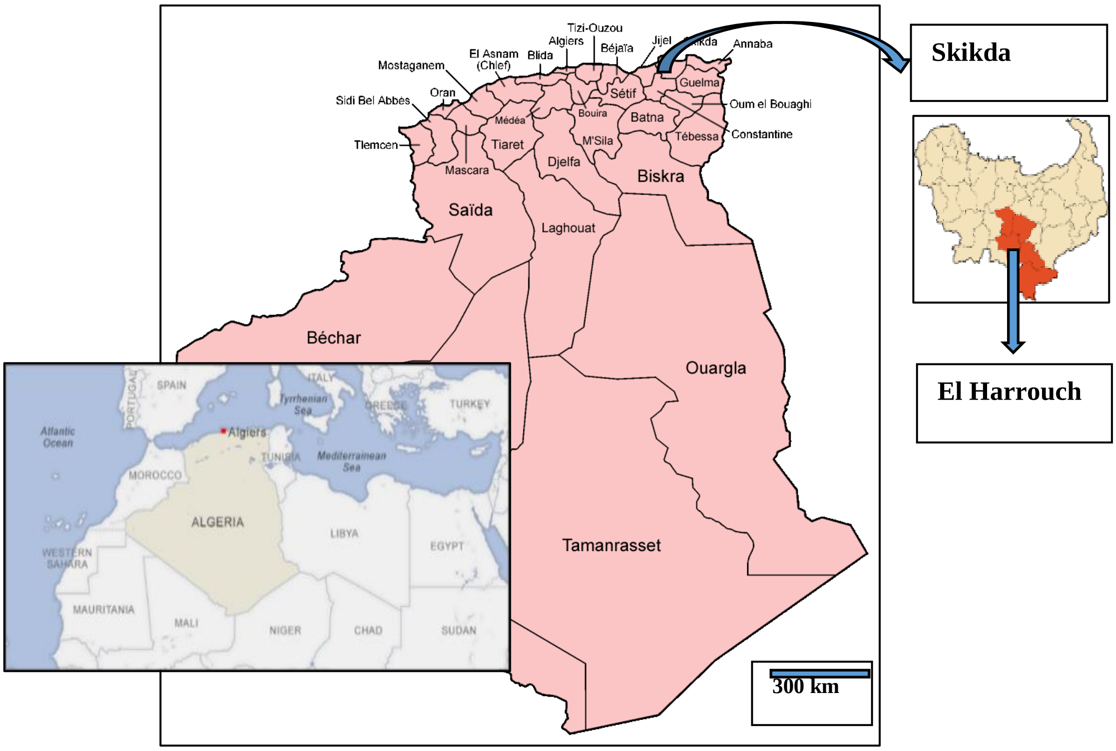

Figure 1: Localisation of El Harrouch (Wilaya de Skikda)

c) *Study Methods*

In the field, a trial of seven genotypes was installed according to an experimental device of completely randomized blocks with three replications; each elementary plot is 1 m x 1 m and consists of 5 rows spaced 20 cm apart with a spacing of 50 cm between each genotype. Sowing is carried out manually on November, 2021 with a sowing density of 350 Seeds/m^2.

d) *Parameters Studied*

i. *Study of morphological characteristics of descriptive sheets*

The morphological characterization of the genotypes was carried out according to the International Union for the Protection of New Varieties of Plants (UPOV, 2014-2017), using 28 characters (Table 2). 12 samples/plant /genotypes were measured at maturity.

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Table 2: Phenotypic classes and nature of the characters studied

N	Studied Characters	Observation and notation	Nature
1	Plant: Length (stem, ear and awns)	Very short: <60 cm (1), Short: 60-75 cm (3), Medium: 75.1-90 cm (5), Long: 90.1-115 cm (7), Very long: >115 cm (9)	Qualitative
2	Straw: Pith in cross section (half way between base of ear and stem node below)	Thin (1), Medium (3), Thick (5)	Qualitative
3	Ear: Presence or absence des awns	Presence (1), Absence (2)	Qualitative
4	Ear : Distribution of awns	Awnless (1), Tip owned (2), Half owned (3), Fully owned (4)	Qualitative
5	Ear : Disposition of awns	Not divergent (1), Weakly divergent (3), Half divergent (5), Divergent (7), Very divergent (9)	Qualitative
6	Ear : Pigmentation of awns	None or very weak (1), Weak (3), Medium (5), Strong (7), Very strong (9)	Qualitative
7	Ear : Color of awns	White (1), Light brown (2), Medium purple (3), Dark purple (4)	Qualitative
8	Ear: Length of awns	Very short: <50 mm (1), Short: 50-80 mm (3), Medium: 80.1-100 mm (5), Long: 110.1-120 mm (7), Very long: >120 mm (9)	Qualitative
9	Ear: Length of awns at tip relative to length of ear	Shorter (1), Equal (2), Longer (3)	Qualitative
10	Ear : Density (Compactness)	Very lax: D<20 (1), Lax: 20<D<23 (2), Medium: 23<D<26 (3), Dense: 26<D<29 (4), Very dense: D>29 (5) D = 10 x N / L D: Density, N: Number of spikelets, L: Spine length (mm)	Qualitative
11	Ear : Color (at maturity)	White (1), Slightly colored (2), Strongly colored (3)	Qualitative
12	Ear : Shape in profile view	Tapering (1), Parallel-sided (2), Semi clavate (3), Clavate (4), Fusiform (5)	Qualitative
13	Ear : Length of ear (excluding awns)	Very short: <50 mm (1), Short: 50-60 mm (3), Medium: 60.1-80 mm (5), Long: 80.1-110 mm (7), Very long: >110 mm (9)	Quantitative
14	Ear: Length of first article	Very short (1), Short (3), Medium (5), Long (7), Very long (9)	Qualitative
15	Ear: hairiness of margin of first rachis segment	Absent or very weak (1), Weak (3), Medium (5), Strong (7), Very strong (9)	Qualitative
16	Ear: neck glaucescence	None or very weak (1), Weak (3), Medium (5), Strongly colored (7), Very strong (9)	Qualitative
17	Ear: glaucescence	None or very weak (1), Weak (3), Medium (5), Strongly colored (7), Very strong (9)	Qualitative
18	Ear : Length of rachis	Very short (1), Short (3), Medium (5), Long (7), Very long (9)	Qualitative
19	Lower glume: shape	Ovoid (1), Medium oblong (2), Narrow oblong (3)	Qualitative
20	Lower glume: color	Yellowish white (1), Pale red (3), Red (5), Brown (7), Black (9)	
21	Lower glume: shape of shoulder	Sloping (1), Rounded (2), Straight (3), Elevated (4), Elevated with a 2^{nd} beak (5)	Qualitative
22	Lower glume: width of shoulder	Very narrow (1), Narrow (3), Medium (5), Broad (7)	Qualitative
23	Lower glume: length of beak	Very short: <1mm (1), Short: 1-2mm (3), Medium: 2-5mm (5), Long: 5-10mm (7), Very long: >10mm (9)	Qualitative
24	Lower glume: Curvature of beak	Absent (1), Weak (3), Moderate (5), Strong (7)	Qualitative
25	Lower glume: Hairiness of external	Absent (1), Present (9)	Qualitative

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	surface		
26	Grain: Length of brush hair in dorsal view	Short (1), Medium (3), Long (5)	Qualitative
27	Grain: Shape	Slightly elongated (1), Moderately elongated (2), Strongly elongated (3)	Qualitative
28	Grain: Color	Whitish yellow (1), Yellow orange (2), Slightly brown (3)	Qualitative

ii. Production and adaptation characters

- ***Number of Plants/m²:*** we count all the plants lifted/variety/repetition. We then deduce the average of the plants raised/m^2.
- ***Number of herbaceous tillers/plant:*** we count 12 plants/genotype, from the 4-leaf stage until the end of tillering. We then deduce the average herbaceous tillers/plant.
- ***Number of ears/plant tillering:*** we count 12 plants/genotype, from the four leaf stage until the end of tillering. The average of the ear tillers/plant is then deduced.
- ***Efficiency of transformation of herbaceous tillers into ear tillers (%)***.
- ***Number of ears/m²:*** we count all the ears formed/genotype/repetition. We then deduce the average of Ears/m^2.
- ***Number of grains/ear:*** we count 10 Ears/Genotype.
- ***1000 grain weight (TGW):*** It is obtained by direct weighing on a precision balance (Metter-P.C 400), of 1000 Grains/Genotype. It is expressed in grams.
- ***Grain yield (GY):*** The grain yield is estimated by the calculation according to the components of the yield by the following formula (expressed in g/m^2 then in Quintals/Acres):
  GY= [Number of Ears/m² x Number of Grains/Ear x 1000 Grain weight] / 100
- ***Aerial biomass (ABIO):*** The aerial biomass is determined from the harvesting of a sample of vegetation from a row segment 1 linear meter long. The weight of the sample is reconverted into Quintals/Acres and represents the parcel value of this variable
- ***Straw yield (SY):*** The straw yield was estimated by the difference, between the aerial biomass and the grain yield, derived from the mown bundle of vegetation of a one m long row segment per elementary plot. Expressed in Quintals/Acres. It is calculated by the formula: ***SY = ABIO – GY***
  ABIO: Aerial biomass (Quintals/Acres) and **GY**: Grain yield (Quintals/Acres).
- ***Economic yield (E_{eco} Y):*** The economic yield is calculated as the sum of the grain yield plus 30 % of the straw yield. Expressed in Quintals/Acres. It is calculated by the formula of Annicchiarico et al., (2005):
  $E_{eco}Y = GY + 0.3\ SY$
  GY: Grain yield and **SY**: Straw yield

- ***Harvest index (HI):*** The harvest index (%) is determined using the plot values of grain yield and aboveground biomass estimated from the vegetation sample harvested from a 1 m long row segment. Expressed in percent (%). It is calculated by the following formula:
  HI % = GY / ABIO
  GY: Grain yield (Quintals/Acres) and **ABIO:** Aerial biomass (Quintals/Acres).

iii. Shannon and Weaver Relative Diversity Index

The Shannon and Weaver relative diversity index (Shannon and Weaver, 1949), as described by Spellerberg & Fedor (2003), was calculated with the aim of determining the phenotypic diversity of the durum wheat collection studied, to

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reveal the degree of polymorphism of the 26 traits analyzed. It is worth noting that each character state is defined as a distinct phenotypic class. The Shannon and Weaver index was calculated using the following formula:

$$\mathbf{H} = -\sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{p_{i^*Ln}p_i}$$

H = Shannon and Weaver diversity index
Pi = Frequency of each phenotypic class i of a given trait
n = Number of phenotypic classes of each trait

The index (H) is converted to the relative index of phenotypic diversity (H') by dividing it by its maximum value H_{max} (Ln (n)) in order to obtain values between 0 and 1.

$$\mathbf{H'} = -\sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{p_{i^*Ln}p_{i/\,Ln(n)}}$$

The relative index of diversity (H') reaches its minimum value which is equal to zero for monomorphic characters. Moreover, the value of this index increases with the degree of polymorphism and reaches a maximum value (1) when all the phenotypic classes present equal frequencies.

iv. *Sanitary State of Plants*

Visual notation of the various diseases (foliar, stem and ear) and physiological accidents.

v. Statistical

Statistical analysis was done by Excel stat 2020 and IBM SPSS Statistics 25.

RESULTS AND DISCUSSION

a) Morphological Characteristics of Descriptive Sheets

- ***Plant Height***

According to the results obtained, the height of the plants studied varies between 50.78 cm to 63.15 cm in the varieties " Moulet Eddar and Ancomarzio ", respectively. We note the presence of an average phenotypic variability which classifies the genotypes according to the characteristics of varietal identification of the UPOV in two groups: very short with a rate of 85.74 % in the varieties "Ovidio, Emilio Lepido, Moulet Eddar, Numidia, Bouhamenna, and El tayeb, ", and short with a percentage of 14.28 % in the variety of "Ancomarzio” (Table 3). Annicchiarico et al., (2005) show that stem length is considered a key trait in adaptation to terminal drought stress. Selectors have long assumed that the most drought-tolerant cereal varieties are tall-strawed varieties, because there is a positive relationship between plant height and drought tolerance can be explained by the ability of high-straw genotypes to fill the grain in case of terminal water deficit by the quantity of assimilate stored in the stem and the ability to remobilize these reserves towards the grains (Annicchiarico et al., 2005 ; Bahlouli et al., 2005).

- ***Straw Section***

The majority of the genotypes studied "Ovidio, Emelio Lepido, Ancomarzio, Moulet Eddar, " have a moderately thick stem with a rate of 57.14 %, while 42.86 % of the genotypes have a thin stem " Numidia, Bouhamema, and El Tayeb, Wahbi " (Table 3). According to these results, it can be concluded that the majority of genotypes studied show good resistance to lodging except the " Numidia, Bouhamema, and El Tayeb " genotype which have a thick stem and may show

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sensitivity to lodging. The severity of lodging depends upon both plant characteristics and many environmental factors. Genetic improvement of the stem or root properties provides one promising strategy for lodging resistance (Hai et al., 2005; Huang et al., 2006; Kashiwagi and Ishimaru 2004). However, lodging in crops is a complex event and is typically inherited quantitatively

- ***Presence of Awns***

Our research shows that all genotypes show awns and this character is often considered in case of water deficit. Indeed, the presence of awns, by their upright habit and their position in the immediate neighbourhood of the seed, increases the possibility of using water and the development of dry matter during the grain formation phase, especially after the senescence of flag leaves.

- ***Distribution of Awns***

The distribution of awns of the genotypes studied is 100 % over the entire length of the ears (fully owned) (Table 3).

- ***Disposition of Awns***

All the genotypes studied present awns with different dimensions and notations, which classify them according to the UPOV criteria into four main groups: We note that the genotypes "Ovidio, Emilio Lepido, Ancomarizo, Moulet Eddar, and Bouhamenna " have divergent beards with a rate of 71.42 %, the variety " Numidia " have weackly divergent awns with a percentage of 14.29 %, while the "El Tayeb " genotype shows no divergent beards (14.29 %) (Table 3). According to Teresa et al. (2009), bearded genotypes are sought especially in areas where the climate is hot and dry, while beardless genotypes are predominant in temperate and humid regions.

- ***Anthocyanin pigmentation of awns***

All genotypes show none or very weack (100 %) awns pigmentation (Table 3). According to Coulomb et al. (2004), anthocyanin pigmentations are indicators of senescence but also of stress: a plant can, when attacked, increase its production of foliar anthocyanins.

- ***Awns Color***

Almost all of the genotypes (100 %) have white awns (Table 3).

- ***Awns Length***

The length of the beards varies between 5.25 cm in the " Ancomarizo " variety and 6.96 cm in the " Ovidio " variety (Table 3), and according to the UPOV criteria all the genotypes are considered as varieties with short beards (100 %). Bouzerzour (2004), shows that the presence of long beards in certain situations is linked to tolerance to water stress, because the beards continue to ensure photosynthesis well after the senescence of the flag leaf, and its presence contributes for more than 7 % increase in yields under water stress.

- ***Length of the Awns at the Tip Relative to Length of Ear***

The length of the awns at the tip relative to length of ears varies between 12.23 cm in the " Ancomarizo " variety and 14.38 cm in the " Emilio Lepido " variety. These results show the existence of phenotypic variability which arranges the genotypes into two classes: shorter for six varieties with a percentage of 85.71 % (Ovidio, Emilio Lepido, Ancomarzio, Moulet Eddar, Numidia, Bouhamenna) and longer for "Oued El Bared" variety (14.28 %) (Table 3). Awns length in wheat can increase water utilization and the elaboration of the dry matter during the maturation phase. According to Blottière (2003), the length of the awn also contributes to limiting water loss. This morphological parameter seems closely

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linked to tolerance to terminal water deficit, at least in durum wheat (Slama et al., 2005).

- ***Compactness of Ears***

The compactness of the ears in the varieties studied varies between the value of 27.1 for the variety “Numidia” and the value of 31.1 for the variety "Bouhamenna". These results show a bit important diversity, which divides the genotypes into two groups: very dense density with a rate of 42.86 %, in the following genotypes: "Ancomarzio, Moulet Eddar, and Bouhamenna" and dense density with a rate of 57.14 % in the following varieties: "Ovidio, Emilio Lepido, Numidia, and El tayeb" (Table 3). This character is linked to the importance of the spacing between the spikelets and the length of the articles. According to the results obtained, all the genotypes studied show a genetic source of adaptation to frost given their very compact and compact density of the ears. It is generally admitted that a good yield is based on a good compactness of the ear (Boudour, 2006).

- ***Color of Ears***

Among the seven varieties studied, there are four varieties with a rate of 57.14 % (Ovidio, Emilio Lepido, Ancomarzio, and El Tayeb) present slightly colored ears and three varieties (42.86 %) have white ears (Moulet Eddar, Numidia, and Bouhamenna) (Table 3). According to Teresa et al. (2009), cultivars from regions with high light density have a tendency to develop coloration on extremity of the tips of the ears.

- ***Shape of Ears***

According to the results obtained, we note that four genotypes present ears with a tapering shape (57.15 %) which are: "Ovidio, Emilio Lepido, Moulet Eddar, and El Tayeb", and two varieties (28.57 %) have fusiform ears "Numidia and Bouhamenna", and "Ancomarzio" with a semi clavate shape (14.28 %) (Table 3). According the results obtained by Motzo and Giunta (2002), triangular shape awns can provide a potentially large photosynthetic surface comprising up to 60 % of the total ear surface area, and their location above the canopy where light and CO_2 are non-limiting permits the potential for maximal assimilation.

- ***Length of Ear (Excluding Awns)***

According to UPOV criteria, the length of the ears of all the genotypes is average, varies between 6.03 cm in the "Bouhamenna" variety and 7.22 cm in the "Numidia" variety (Table 3). Djekoune et al. (2002), have also shown that the significant length of the ear is a predictive parameter of a harvest index and high yield potential.

- ***Length of First Article***

The length of the first article presents a significant diversity which classifies the genotypes in three classes: medium in three varieties with a rate of 42.86 % (Moulet Eddar, Numidia, and El Tayeb), long in Bouhamenna variety with a rate of 14.28 %, and very long in the following three varieties: "Ovidio, Emilio Lepido and Ancomarzio" with a percentage of 42.86 % (Table 3).

- ***Hairiness of Margin of First Rachis Segment***

The presence of hairiness at the lateral edges of the first segment of the rachis presents a phenotypic diversity of three classes: weak in two varieties with a rate of 28.57 % (Numidia and Bouhamenna), medium in a single variety of "Ancomarzio" (14.28 %), strong in four varieties with a percentage of 57.15 % (Ovidio, Emilio Lepido, Moulet Eddar, and El Tayeb) (Table 3). According to Boudour (2006), the strong hairiness of the

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rachis is a criterion of adaptation to water deficit. So we can conclude that the genotypes having a strong and very strong hairiness of the rachis are considered as varieties resistant to water stress.

- ***Neck Glaucescence***

The glaucescence of the neck of the ear shows significant variability between the varieties studied which classifies them into two groups: weak in two varieties with a percentage of 28.57 % for "Ovidio and Emilio Lepido" and medium in five varieties with a rate 71.43 % for "Ancomarzio, Moulet Eddar, Numidia, Bouhamenna, El Tayeb" (Table 3).

- ***Glaucescence of Ear***

The glaucescence of the ear presents a specific diversity which classifies the genotypes into two groups: weak in five varieties (71.43 %) for "Ovidio, Ancomarzio, Moulet Eddar, Numidia, and El Tayeb", and medium in two varieties for "Ancomarzio and Bouhamenna" (28.57 %) (Table 3). According to the results obtained, we can consider that the varieties "Ancomarzio and Bouhamenna" are moderately resistant to water stress because of its high glaucescence compared to other genotypes. Souilah (2009), also considers that glaucescence is a morphological parameter of adaptation to water deficit.

- ***Length of Rachis***

The length of the rachis varies between 5.33 cm for the “Bouhamenna" variety and 6.75 cm for the "Emilio Lepido" genotype. These results show the presence of a strong phenotypic diversity which classifies the genotypes into three classes: medium with 57.14 % in four genotypes (Ancomarzio, Moulet Eddar, Ovidio, and Bouhamenna), long with 14.29 % in "El Tayeb" and very long with a rate of 28.57 % in the genotypes "Emilio Lepido and Numidia" (Table 3).

- ***Shape of the Lower Glume***

The glume of the ear has a medium oblong shape for 85.71 % in six varieties which are: "Ovidio, Emilio Lepido, Ancomarzio, Moulet Eddar, Bouhamenna, and El Tayeb" and a narrow oblong shape in "Bousselam" variety (14.29 %) (Table 3).

- ***Color of the Lower Glume***

All genotypes studied show a yellowish-white lower glume color (Table 3). According to Flag leaves of wheat (*Triticum aestivum* L.), regarded in crop production as the "functional leaves", are the main organs for photosynthesis, and contribute 45–58 % of photosynthetic performance during the grain-filling stage (Khaliq et al., 2008).

- ***Shape of Shoulder of the Lower Glume***

The shape of the shoulder of the glume is very variable with the presence of three classes distributed as follows: Sloping in Ovidio variety, elevated in "Emilio Lepido, Moulet Eddar, and El Tayeb" varieties, rounded in "Bouhamenna" variety and straight in "Ancomarzio and Numidia" varieties (Table 3).

- ***Width of Shoulder of the Lower Glume***

The width of the shoulder of the lower glume shows significant diversity with the presence of 3 phenotypic classes: very narrow with 42.86 % in three varieties "Ovidio, Moulet Eddar, and El Tayeb", narrow with 42.86 % in three varieties "Emilio Lepido, Ancomarzio, and Bouhamenna" and broad with 14.28 % in "Numidia" (Table 3).

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- ***Length of Beak of the Lower Glume***

The length of the beak of the lower glume is long in the following four genotypes (57.14 %): "Ancomarzio, Moulat Eddar, Numidia, and El Tayeb", and medium for the following three genotypes (42.86 %): "Ovidio, Emilio Lepido, and Bouhamenna" (Table 3).

- ***Curvature of Beak of the Lower Glume***

The curvature of the beak of the lower glume shows a significant diversity which classifies the genotypes into three groups: group without curvature in three genotypes with a rate of 42.86 % "Emilio Lepido, Ancomarzio, and Bouhamenna", group of weak curvature in three varieties with a rate of 42.86 % "Ovidio, Moulet Eddar, and Numidia", and group of moderate curvature with a rate of 14.28 % in "El Tayeb" (Table 3).

- ***Hairiness of External Surface of the Lower Glume***

For the hairiness of external surface of the lower glume, we note that 42.86 % of the genotypes do not have external hairiness, such as: "Ancomarzio, Moulet Eddar, and Numida", while the rest of the varieties (57.14 %) have hairiness "Ovidio, Emilio Lepido, Bouhamenna, El Tayeb" (Table 3). The role of glume hairiness in wheat adaptation is not well understood, but some authors consider this parameter as a criterion of adaptation to water deficit (Boudour, 2006).

- ***Length of Brush Hair in Dorsal view of the Grain***

The length of grain hairs shows a significant diversity which divides the genotypes into two classes: Class of medium hairs with a rate of 42.86 % in three varieties "Moulet Eddar, Numidia, and El Tayeb" and class of long hairs with a rate of 57.14 % in the varieties "Ovidio, Emilio Lepido, Ancomarzio, and Bouhamenna" (Table 3).

- ***Shape of Grain***

Regarding the shape of the grain, the varieties studied show significant variability with the presence of two classes: moderately elongated class in five genotypes with 71.43 % (Emilio Lepido, Ancomarzio, Moulet Eddar, Numidia, and El Tayeb) and strongly elongated class in two varieties with 28.57 % (Ovidio and Bouhamenna) (Table 3).

- ***Color of Grain***

The color of the grain shows a significant diversity with the presence of two groups: group of yellow orange color in six genotypes (85.71 %) "Ovidio, Emilio Lepido, Ancomarzion, Moulet Eddar, Numidia and Bouhamenna" and slightly brown color group in "El Tayeb" variety (14.29 %) (Table 3).

Table 3: Descriptive sheets, relative index of diversity (H and H’), classes and frequency of different characters studied.

N	Studied characters	G1	G2	G3	G4	G5	G6	G7	H	H’	Classe	Percent
1	**Plant: Length (stem, ear and awns)**	1	1	3	1	1	1	1	0.42	0.33	**-Very short:** G1, G2, G4, G5, G6 and G7 **-Short:** G3	85 % 15 %
2	**Straw: Pith in cross section**	3	3	3	3	1	1	1	0.68	0.54	**-Thin:** G5, G6 and G7 **-Medium:** G1, G2, G3 and G4	43 % 57 %
3	**Ear :**	4	4	4	4	4	4	4	0	0	**-Fully awend :**	100 %

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	Distribution of awns										All genotypes	
4	**Ear : Disposition of awns**	7	7	7	7	3	7	1	0.79	0.62	**-Divergent:** G1, G2, G3, G4 and G6 **-Weakly divergent:** G5 **-Not divergent:** G7	72 % 14 % 14 %
5	**Ear : Pigmentation of awns**	1	1	1	1	1	1	1	0	0	**-None or very weak:** All genotypes	100 %
6	**Ear: Presence or absence des awns**	1	1	1	1	1	1	1	0	0	**-Presence :** All genotypes	100 %
7	**Ear : Color of awns**	1	1	1	1	1	1	1	0	0	**-White :** All genotypes	100 %
8	**Ear: Length of awns**	3	3	3	3	3	3	3	0	0	**-Short :** All genotypes	100 %
9	**Ear: Length of awns at tip relative to length of ear**	1	1	1	1	1	1	1	0	0	**-Shorter :** All genotypes	100 %
10	**Ear : Compactness**	4	4	5	5	4	5	4	0.68	0.54	**-Very dense:** G3, G4 and G6 **-Dense:** G1, G2, G5 and G7	43 % 57 %
11	**Ear : Color**	2	2	2	1	1	1	2	0.68	0.54	**-Slightly colored :** G1, G2, G3 and G7 **-White:** G4, G5 and G6	57 % 43 %
12	**Ear : Shape in profile view (Figure 2 to 8)**	1	1	3	1	5	5	1	0.95	0.75	**-Tapering:** G1, G2, G4 and G7 **-Semi clavate:** G3 **-Fusiform:** G5 and G6	57 % 14 % 29 %
13	**Ear: Length of ear (excluding awns)**	5	5	5	5	5	5	5	0	0	**-Meduim :** All genotypes	100 %
14	**Ear: Length of first article**	9	9	9	5	5	7	5	1	0.79	**-Very long :** G1, G2 and G3 **-Medium:** G4, G5 and G7 **-Long:** G6	43 % 14 % 43 %
15	**Ear: Neck glaucescence**	3	3	5	5	5	5	5	0.58	0.47	**-Weak :** G1 and G2 **-Medium:** G3, G4, G5, G6 et G7	29 % 71 %
16	**Ear: Glaucescence**	3	3	5	3	3	5	3	0.6	0.47	**-Weak :** G1, G2, G4, G5 and G7 **-Medium**: G3 and G6	71 % 29 %
17	**Ear:**	7	7	5	7	3	3	7	0.95	0.75	**-Strong :** G1,	57 %

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	Hairiness of margin of first rachis segment										G2, G4 and G7 **-Medium:** G3 **-Weak:** G5 and G6	14 % 29 %
18	**Ear : Lenght of rachis**	5	9	5	5	9	7	5	0.95	0.75	**-Medium :** G1, G3, G4 and G7 **-Long:** G6 **-Very long:** G2 and G5	57 % 14 % 29 %
19	**Lower glume: Shape**	2	2	2	2	2	2	2	0	0	**-Medium oblong :** All genotypes	100 %
20	**Lower glume: Color**	1	1	1	1	1	1	1	0	0	**-Yellowish white :** All genotypes	100 %
21	**Lower glume: Shape of shoulder**	1	4	3	4	3	2	4	1.28	1	**-Sloping :** G1 **-Elevated :** G2, G4 and G7 **-Straight:** G3 and G5 **-Rounded:** G6	14 % 43 % 29 % 14 %
22	**Lower glume: Width of shoulder**	1	3	3	1	5	3	1	1	0.79	**-Very narrow :** G1, G4 and G7 **-Narrow:** G2, G3 and G6 **-Broad:** G5	43 % 43 % 14 %
23	**Lower glume: Length of beak**	5	5	7	7	7	5	7	0.68	0.54	**-Medium :** G1, G2 and G6 **-Long:** G3, G4, G5 and G7	43 % 57 %
24	**Lower glume: Curvature of beak**	3	1	1	3	3	1	5	1	0.79	**-Weak :** G1, G4 and G5 **-Absent:** G2, G3 and G6 **-Moderate:** G7	43 % 43 % 14 %
25	**Lower glume: Hairiness of external surface**	9	9	1	1	1	9	9	0.68	0.54	**-Present :** G1, G2, G6 and G7 **-Absent:** G3, G4 and G5	57 % 43 %
26	**Grain: Length of brush hair in dorsal view**	5	5	5	3	3	5	3	0.68	0.54	**-Long :** G1, G2, G3 and G6 **-Medium:** G4, G5 and G7	57 % 43 %
27	**Grain : Shape (Figure 2 to 8)**	3	2	2	2	2	3	2	0.6	0.47	**-Strongly elongated :** G1 and G6 **-Moderately elongated:** G2, G3, G4 and G6	14 % 86 %
28	**Grain : Color**	2	2	2	2	2	2	3	0.4	0.32	**-Yellow orange:** G1, G2, G3, G4, G5 and G6 **-Slightly brown:** G7	71.43% 28.57%
									H=0.52	**H'=0.41**		

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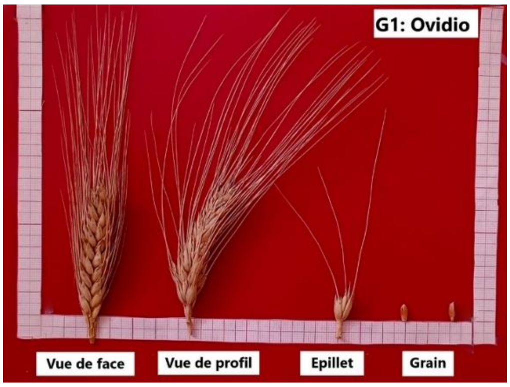

Figure 2: Morphology of ear, spikelet and seed of Ovidio (G1)

Figure 3: Morphology of ear, spikelet and seed of Emilio Lepido (G2).

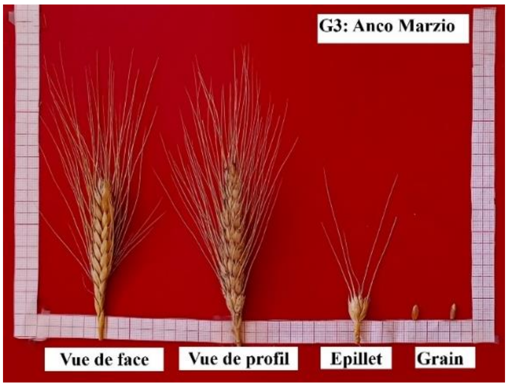

Figure 4: Morphology of ear, spikelet and seed of Emilio AncoMarizo (G3).

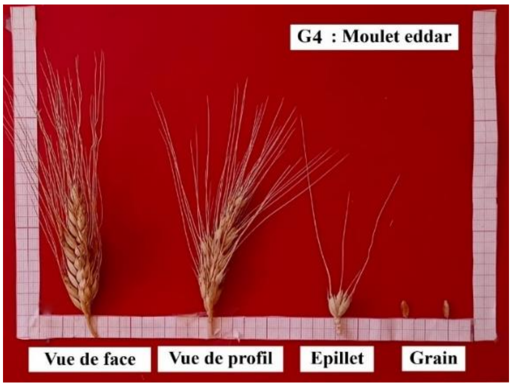

Figure 5: Morphology of ear, spikelet and seed of Moulet Eddar (G4).

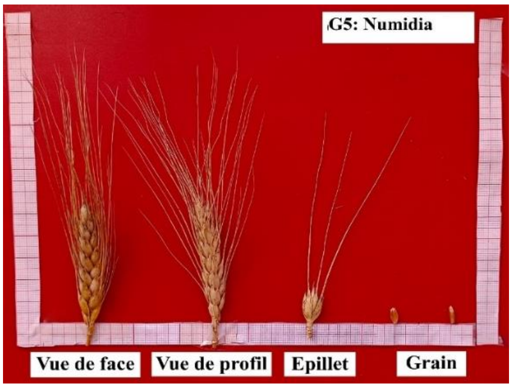

Figure 6: Morphology of ear, spikelet and seed of Numidia (G5).

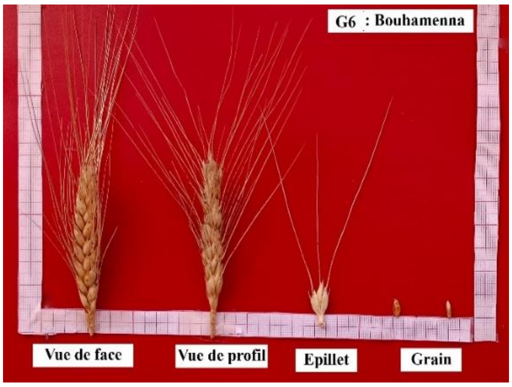

Figure 7: Morphology of ear, spikelet and seed of Bouhamenna (G6).

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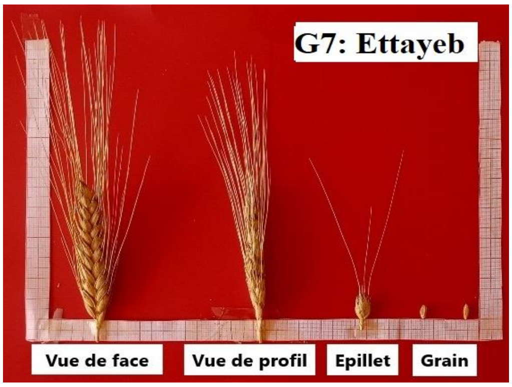

Figure 8: Morphology of ear, spikelet and seed of El Tayeb (G7).

a) Production Characters

- ***Number of Plants/m^2 (NBM)***

The number of Plants/m^2 varies from a maximum of 350 to a minimum of 222.33 Plants/m^2 in the varieties "Numidia and Bouhamena et El Tayeb", respectively (Table 4). According to the variance analysis (Table 5), the value of P (0.000) being well below the significance threshold of 0.05, so we can conclude that the number of Plants/m^2 of the seven genotypes differ significantly with the threshold of significance of 5 %.

Table 5: Variance analysis of number of plants/m^2

Source	SS	DF	MS	F-ration	P-value
Genotype	50880.952	6	8480.159	87.339	0.000
Error	1359.333	14	97.095		
Total	52240.286	20			

***SS :** Sum of squares, **MS:** Mean squares, **P:** Significant.*

- ***Number of Herbaceous Tillers/Plant (NHTP)***

The "Ovidio, Emilio Lepido and Bouhamena" genotypes cover the ground well producing more herbaceous tillers with 2.73, 2.70 and 2.67 herbaceous tillers/Plant, respectively, compared to "Numidia" 1.87 Herbaceous tillers/Plant, respectively (Table 4). According to the variance analysis (Table 6), the value of P (0.185) being well above the significance threshold of 0.05, so we can conclude that the number of herbaceous tillers of the seven genotypes does not differ significantly with the threshold of significance of 5 %. The number of tillers/plant is a component that indirectly explains the dry matter yield. Tillering may affect wheat yield positively or negatively depending on availability of natural resources such as water, light and nutrients (Elhani et al., 2007).

Table 6: Variance analysis of Herbaceous tillers/Plant

Source	SS	DF	MS	F-ration	P-value
Genotype	1.513	6	0.252	1.737	0.185
Error	2.033	14	0.145		
Total	3.547	20			

- ***Number of Ears Tillering/Plant (NETP)***

The highest ear tillering potential is measured in the "Ovidio" variety with 1.67 ear tillers/plant and the lowest is measured in the "Numidia" varieties with 1.10 ear tillers/plant (Table 4). According to the variance analysis (Table 7), the value of P (0.165) being well above the significance threshold of 0.05, so we can conclude that the number of ears Tillering/Plant of the seven genotypes does not differ significantly with the threshold of significance of 5 %. The result obtained agrees with those obtained by Oudjani (2009) which show that there is no relationship between the herbaceous tillering capacity and the number of rising ears per unit area.

Table 7: Variance analysis of Tillering ears/ Plant

Source	SS	DF	MS	F-ration	P-value
Genotype	0.846	6	0.141	1.827	0.165
Error	1.080	14	0.077		
Total	1.926	20			

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- ***Efficiency of transformation of herbaceous tillers into ear tillers (%) (ETHTET)***

The "El Tayeb and Ancomarizo" genotypes shows a higher rate of transformation from herbaceous tillers to ears tillers with 69.55 % and 69.16 %, respectively. And the lowest rate presented By Emilio Lepido with 56.67 % (Table 4). The number of Ears/Plant is dependent on the herbaceous tillering capacity. The effects of competition are relevant in tiller emergence and may affect directly final yield and yield components (Ozturk et al., 2006).

- ***Number of Ears/m^2 (NEM)***

The "Ovidio" genotype represents the highest number of Ears/m^2 with 423.33 ears/m^2, followed by significant averages of the following varieties: "Ancomarzio, Bouhamenna, Emilo Lepido, El Tayeb and Numidia" which range from 375 to 259.33 Ears/m^2. While the least low values are found in "Moulet Eddar" variety with averages of 245.67 Ears/m^2 (Table 4). According to the variance analysis (Table 8), the value of P (0.000) being well below the significance threshold of 0.05, so we can conclude that the number of Ears/m^2 of the seven genotypes differ significantly with the threshold of significance of 5 %. The number of Ears/m^2 represents the number of tillers having given an ear (Souilah et al., 2014; Hazmoune and Benlaribi, 2004). Zhang et al. (2007), demostrated that high ear number is key to achieving high wheat grain yield in the high rainfall zone.

Table 8: Variance analysis of number of Ears/m^2

Source	SS	DF	MS	F-ration	P-value
Genotype	75483.143	6	12580.524	41.829	0.000
Error	4210.667	14	300.762		
Total	79693.810	20			

- ***Number of Grains/Ear (NGE)***

For the number of Grains/Ears, the "Emilio Lepido" genotype is at the top of the ranking with 38.8 Grains/Ears, followed by "Ancomarzio, Ovidio, Numidia and Bouhamena" with values of 30.3, 30.2, 30.1 and 29.2 Grains/Ear, respectively. While low average is noted in the variety "El Tayeb" with 28.6 Grains/Ear (Table 4). According to the variance analysis (Table 9), the value of P (0.027) being well below the significance threshold of 0.05, so we can conclude that the number of grains/ear of the seven genotypes differ significantly with the threshold of significance of 5 %. These results agree with those of Souilah (2009), who shows that the number of grains/ear varies from 23 to 58 and also depends on the fertility of the ear of each genotype. The yield gain in the mainly comes from an increased grain number per area rather than a higher grain size (Shearman et al., 2005).

Table 9: Variance analysis of Grains/Ear

Source	SS	DF	MS	F-ration	P-value
Genotype	515.943	6	85.990	2.577	0.027
Error	2102.400	63	33.371		
Total	2618.343	69			

- ***1000 Grains Weight (TGW)***

The genotypes that record high thousand grains weight (TGW) values is "Ovidio and Ancomarzio" with 48.6 g and 48.19, respectively. While the other values range between 45.75 g and 44.35 g, while the variety of "Emilio Lepido" is represented the lowest value with 43.94g (Table 4). The values obtained are higher than those obtained by Oudjani (2009) on 25 genotypes of durum wheat which shows that the TGW varies from 49.72 g to 39.8 g. A high TGW will imply a high specific weight of the genotypes, which will favor a high yield when the conditions

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are optimal (Benmounah and Brinis, 2018).

- ***Grain Yield (GY)***

The grain yield is the product of three components: the number of Ears/m^2, the number of grains/ear and the TGW. It is noticed a compensation between these three parameters according to genotype and culture conditions. The highest grain yield is recorded by the genotype "Ovidio" with 62.13 Quintals/Acres, after it comes "Emilio Lepido" with 57.22 Quintals/Acres, followed by "Ancomarzio, Bouhamena and El Tayeb", with 57.22, 54.76, 48.45 and 44.37 Quintals/Acres, respectively. While the lowest yield is recorded by the "Numidia and Moulet Edar" genotype with 34.62 and 32.12 Quintals/Acres, respectively (Table 4). According to the variance analysis (Table 10), the value of P (0.000) being well below the significance threshold of 0.05, so we can conclude that the grains yield of the seven genotypes differ significantly with the threshold of significance of 5 %. These results obtained do not agree with those of Oudjani (2009), which show a yield varying between 38.82 and 16.06 Quintals/Acres. Grain yield is a polygenic, complex and low heritable trait, the improvement of this trait can be approached indirectly through the traits that are strongly linked to it and less influenced by the environment (Fellahi et al., 2017, 2018, 2020).

Table 10: Variance analysis of grain yield (Quintals/Acres)

Source	SS	DF	MS	F-ration	P-value
Genotype	2326.598	6	387.766	68.239	0.000
Error	79.554	14	5.682		
Total	2406.153	20			

- ***Aerial Biomass (AB)***

The "Ovidio" genotype recorded the best aerial biomass values with 184.62 q/ha. While "Moulet Eddar" had the lowest value with 103.767 Quintals/Acres (Table 4). According to the variance analysis (Table 11), the value of P (0.073) being well above the significance threshold of 0.05, so we can conclude that the aerial biomass of the seven genotypes does not differ significantly with the threshold of significance of 5 %. According to Mebarkani (2012), the ability to make a high aerial biomass is a characteristic of adaptation to variable environments. Belkherchouche (2015), suggests that to maximize the assimilates to the grain, selection should take into account ear size, glume lifetime, awn length and density, yield per m² and per ear, 1000 grain weight, specific weight and length of the last internode and the neck of the ear. The selection of such traits contributes to accumulating in the identified genotypes the yield potential and adaptation to dry Mediterranean conditions.

- ***Straw Yield (SY)***

The highest straw yield is recorded by the "Bouhamena" genotype with 129.78 Quintals/Acres, While the others genotypes (Ovidio, Ancomarizo, Emilio Lepido, El Tayeb and Numidia) show values averages between 122.94 and 94.25 Quintals/Acres. Whereas the "Moulet Eddar" variety is ranked last with 81.72 Quintals/Acres (Table 4).

Table 11: Variance analysis of aerial biomass (Quintals/Acres)

Source	SS	DF	MS	F-ration	P-value
Genotype	9796.151	6	1632.692	2.512	0.073
Error	9099.412	14	649.958		
Total	18895.564	20			

According to the variance analysis (Table 12), the value of P (0.346) being very well above the significance threshold of 0.05, so we can conclude that the straw yield of the seven genotypes does not differ significantly with the threshold of significance of 5 %. Morphological characters such as straw yield and plant

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height have been identified as morphological markers of drought tolerance (Salmi et al., 2021). Morphological markers are effective ways to study wheat genetic diversity (Al Khanjari et al., 2008; Kirouani et al., 2019).

Table 12: Variance analysis of straw yield (q/ha)

Source	SS	DF	MS	F-ration	P-value
Genotype	4324.784	6	720.797	1.235	0.346
Error	8169.354	14	583.525		
Total	12494.138	20			

- ***Harvest Index (HI)***

Regarding the harvest index, the "Emilio Lepido, Ancomarzio and ovidio" genotypes have the best values with 35.62 %, 34.81 % and 33.65 %, respectively. While, the "Bouhamenna" genotype represent the lowest value with 24.57 %, respectively (Table 4). According to the variance analysis (Table 13), the value of P (0.271) being very well above the significance threshold of 0.05, so we can conclude that the straw yield of the seven genotypes does not differ significantly with the threshold of significance of 5 %. The harvest index is the report of grain on straw. The factors that act on this parameter are the height of the plant, drought and early heat (Oudjani, 2009). The improvement of the harvest index follows the reduction of the height of the plant because this criterea is important for adaptation to the constraints of the environment. A high height induces the production of a significant biomass, which is desirable, but this to the detriment of grain yield, following a low harvest index. Conversely, a significant reduction in the height of the plant certainly improves the number of ears, and the yield, but this is done to the detriment of the length of the root system and the production of straw (Subira et al., 2016; Rabti et al., 2020; Rabti, 2021).

Table 13: Variance analysis of harvest index (%)

Source	SS	DF	MS	F-ration	P-value
Genotype	161.907	6	26.985	1.430	0.271
Error	264.177	14	18.870		
Total	426.084	20			

a) *Shannon-Weaver Diversity Index (H) and Relative Index (H') of Different Characters*

The relative diversity index (H'_{Mean}) of all the genotypes studied is around 0.41 (Table 3), reflecting the low morphological diversity of the ears in this study. This diversity is not equal to that obtained by the teams of Belhadj et al. (2015) and Khanjari et al. (2008), on indigenous populations of southern Tunisia and durum wheat from Oman with an index of 0.51 and 0.52, respectively.

The highest polymorphic diversity of the studied collection is due in the shape of the shoulder of the lower glume (H'=1). The other traits studied were mainly represented by a class of significant phenotypic diversity that varies from a value of H'=0.79 to H'=0.32 (Table 3). For the characters related to the ears the genotypes studied show a high diversity morphologic for the length of the first article, the lower glume of shoulder for the width and curvate beak (H'=0.79, for each one), hairiness of margin of first rachis segment, length of rachis and shape in profile view (H'=0.75, for each one). These results obtained do not agree with the work carried out by Belhadj et al. (2015), of the length of the first article (H'=0.19), the hairiness of the first article of the rachis of the ear (H'=0.19), and the curvature of the beak of the lower glume (H'=0.53).

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Table 4: Studied characters of production

Genotypes	NBM	NHTP	NETP	ETHTET	NEM	NGE	TGW	GY	AB	SY	EY	HI
Ovidio	252.33±2.52	2.73±0.42	1.67±0.31	61.17	423.33±15.95	30.2±5.031	48.6	62.13±2.34	184.6±1.7	122.94±1.77	98.88±2.01	33.65
Emilio Lepido	240.67±8.50	2.70±0.52	1.53±0.23	56.67	351±4	37.1±6.85	43.94	57.22±0.65	162.31±21.14	105.88±20.49	88.74±6.80	35.62
Ancomarzio	339±7.81	2.27±0.31	1.57±0.47	69.16	375±25	30.3±5.89	48.19	54.76±3.65	161.53±37.34	106.77±33.69	86.78±13.75	34.81
Moulet Eddar	333.33±20.82	2.03±0.40	1.33±0.15	65.52	245.67±17.47	28.9±6.95	45.23	32.12±2.22	103.77±11.35	81.72±9.66	56.62±4.76	28.3
Numidia	350±4.58	1.87±0.31	1.10±0.1	58.82	259.33±12.22	30.1±5.34	44.35	34.62±1.63	128.87±16.46	94.25±15.35	62.89±5.8	27.08
Bouhamenna	222.33±8.74	2.67±0.31	1.63±0.25	61.05	362.67±11.68	29.2±4.80	45.75	48.45±1.56	178.22±40.89	129.78±40.33	87.38±12.71	24.57
Ettayeb	222.33±3.06	2.20±0.1	1.53±0.23	69.55	341±3	28.6±4.88	45.5	44.37±0.39	145.18±24.64	100.81±24.83	74.61±7.26	31.18

NBM: *Number of Plant/m^2*, ***NHTP:*** *Number of Herbaceous tillers/Plant*, ***NETP=*** *Number of Ears tillering/Plant*, ***ETHTET:*** *Efficiency of transformation of herbaceous tillers into ear tillers (%)*, ***NEM=*** *Number of Ears/m^2*, ***NGE=*** *Number of Grains/Ear*, ***TGW=*** *1000 Grain weight (g)*, ***GY=*** *Grain yield (quintals/Acres)*, ***AB=*** *Aerial biomass (quintals/Acres)*, ***SY=*** *Straw yield (quintals/Acres)*, ***EY=*** *Economic yield (quintals/Acres), and* ***HI=*** *Harvest index (quintals/Acres)*

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In addition, the moderately diversity polymorphic characters are presented on the disposition of awns (H'= 0.62), on four characters of ear (length of awns at tip relative to length with H'=0.54, compactness with H'=0.54, glaucescence with H'= 0.47, and neck glaucescence with H'= 0.47), on pith in cross section of straw with H'= 0.54, on some lower glume characters (length of beak and hairiness of external surface with H'=0.54, for each one), and on two characters of grain (length of brush hair in dorsal view of grain with H'=0.54 and grain shape with H'= 0.47) (Table 3).

The very lowest characters of polymorphism are noted for the plant length and grain color with H'= 0.33 and 0.32, respectively (Table 3). The work on wheat from southern Tunisia carried out by Belhadj et al. (2015) and on Ethiopian wheat by Bechere et al. (1996), show that the character of the compactness of the ears is the least polymorphic with a diversity of H'=0.33 and 0.24, respectively. In addition, Othmani et al. (2015) and Zarkti et al. (2012) reported that the pyramidal shape of the ears is the most abundant in Tunisian and Moroccan collection of durum wheat. Al Khanjari et al. (2008), noticed a higher frequency of glumes hairy in the durum wheat collection from Oman.

Concerning the characters related to the grains, the studied genotypes showed a dominance for the moderately elongated shape for five genotypes (Emilio Lepido, Ancomarzio, Moulet Eddar, Bouhamenna and Numidia) and a weak dominance for strongly elongated for two genotypes (Ovidio and Ettayeb) with H'=0.47. The color of the grains of the varieties studied has a strong dominance of the yellow orange color (Ovidio, Emilio Lepido, Ancomarzio, Moulet Eddar, Numidia and Bouhamenna) and weak dominance of the slightly brown color (Ettayeb) with H'=0.32 (Table 3). These results agree with the work carried out by Belhadj et al. (2015) and Bechere et al. (1996), who concluded that grain shape is the most polymorphic character with H'= 0.98 in southern Tunisian wheats and H'= 0.96 in Ethiopian durum wheats, respectively. Al Khanjari et al. (2008), found reddish-brown grains to be the most expected in the Oman collection, while Bechere et al. (1996) noted the presence of all phenotypic classes in a collection of Ethiopian durum wheat, from yellow color to purple color. The predominance of these colors could depend on the subsequent use of these wheats. This has also been explained Whan et al. (2014) who noticed the existence of a close association between the color of wheat and barley grains and human consumption.

Concerning the monomorphism characters of our series studied, they are found in: five characters of awns of ear (presence or absence, distribution, pigmentation, color, and length), one character of length of ear, and two characters of lower glume (shape and color) with an index H'=0 (Table 3). This difference in results can be explained by the expression of hereditary characteristics according to the nature of the genes and the study environment.

CONCLUSION

The development of descriptive sheets and the study of the yield characters of seven durum wheat varieties studied show the presence of great intra-specific variability due to the agro-climatic conditions of the environment. The criteria that allow us to choose new, more efficient genotypes are numerous, and possess parameters of tolerance and adaptation to environmental constraints. The morpho-physiological characters studied also allow us to classify these genotypes into 3 classes: class of varieties resistant to water deficit (Ovidio and Emilio Lepido), class

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of non-resistant varieties to water deficit (El Tayeb) and class of intermediate varieties (Ancomarzio, Moulet Eddar, Numidia, and Bouhamenna). Finally, the establishment of descriptive sheets, knowledge of the diversity index and production and adaptation parameters are essential mechanisms that constitute the starting point of any program for the creation of new variability. They remain a powerful factor for improving yield, preserving genetic resources against erosion and enriching them through crossbreeding.

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CONFLICT OF INTEREST

The authors report no conflict of interest.

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