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Biodiversity of pearl millet *Pennisetum glaucum* (L) R. Br. (Poales Poaceae) in southern Algeria (Tidikelt region)

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ABSTRACT The study aims to identify the *Pennisetum glaucum* (L) R. Br. (Poales Poaceae) phenotypes cultivated in Tidikelt region. We conducted field visits during the plant maturity stage, to evaluate these patterns, based on the descriptive study of the International Crop Research Institute for the Semi-Arid Tropics. The results showed significant differences between plant height, the number of nodes and leaves, seed color, and main stem length. Whereas, we recorded only slight differences for the dimensions of the third upper leaf and panicle. It was also found that the best groups of locally cultivated millet were pearly and yellow millet, due to the morphological characteristics of their panicles, unlike wild millet (MLT.VN, MLT.VNP) and domesticated (MDT.Sepl, MDT.Sepc, and MDT.Smix) which are used as feed. On this basis, this type of cereal culture could play a leading role in promoting the cultivation of local millet groups in this region.

KEY WORDS Biodiversity; Morphology; Panicle; Pearl millet; Tidikelt.

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INTRODUCTION

More than one-third of the Earth's population lives in semi-arid regions, poor soils, and low nutrient availability (FAO-ICRISAT, 1996; Vadez et al., 2012) where millet is a staple food for most people, particularly, in Africa and Asia (Pernès, 1984, 1987; Hanna, 1987; Dave, 1987; Vietmeyer, 1996; Rai et al., 1997; Hanelt, 2001; Yadav & Rai, 2013).

Many authors have described the Pearl millet biodiversity in West Africa and proved that there is a similarity between the millets found in the Sahel region. (Bono, 1973; Brunken et al., 1977; Marchais, 1982). *Pennisetum glaucum* (L) R.Br.) (Poales Poaceae), is characterized as being resistant to most pests and diseases (Singh et al., 1990), having a growing season, and being highly productive compared to major cereals under harsh weather conditions such as drought (Leonard & Martin, 1963; Pernès, 1984; Hanna, 1987; Dave, 1987; Vietmeyer, 1996; Devi et al., 2011). This plant has been cultivated in North Africa since the 8th century with the aim of producing grains and fodder (Tostain, 1998; Yadav et al., 2007).

The south of Algeria has a typical desert climate, with rare rainfall of 1.20 mm; in addition, the aridity is extreme and the average temperature is very high (ONM, 2016). Despite these harsh local climatic and environmental conditions, millet has managed to adapt and maintain its original morphological diversity over the centuries. In the local dialect, pearl millet is called Buschnnat (Lemgharbi et al., 2016; 2017).

The agro-morphological traits have been applied as a tool for assessing and classifying millet lines by many researchers in West Africa (Beggi et al., 2014), in Tunisia (FAO-ICRISAT, 1996; Pistrick et al., 1994; Radhouane, 2004), in Morocco (Marmouzi et al., 2016), in South Algeria (Lemgharbi et al., 2016; 2017). These morphological characters help determine the variability of millet phenotype and the correlation with several agricultural and environmental factors (Milan & Cubero, 1995; Van Beuningen & Busch, 1997). The description and evaluation of the phenotypic diversity of crops depend on the variance in quantitative characteristics (Vega, 1993; Schut et al., 1997) which do not require sophisticated equipment of measuring.

Farmers are interested in selecting the finest groups of varieties (as Pearly and yellow) and storing them in a special place called Matmurat (landfill for storing grain crops) away from external influences, to re-sow them. Due to the small size of millet seeds, it is necessary to provide some special agricultural conditions, as well as preparing the soil by adding compost of domestic animal waste, and organizing it in the form of rows as waterways, called locally "Abadou" (surface waterways used for watering fields in the Tidikelt region) where millet seeds are sown at the edges of these waterways with depth about 5–10 cm. Seedlings will emerge in 2–5 days and the optimal temperature for growth ranges from 30–40 °C (Newman et al., 2010).

The planting (May-August) coincides with the water shortage season (Lee et al., 2004) and with the temperature rises and is accompanied by a sharp decrease in the moisture soil, which requires watering it day after day to ensure maximum humidity. Millet has fast-growing and deep roots, making it more adaptive to the harsh environmental conditions of the characteristic water shortage (Newman et al., 2010) and does not require providing large quantities of organic fertiliser but only a little animal manure (Myers, 2002). Most herbicides for grass damage pearl millet, but some are less harmful when used at lower rates. During the millet vegetative growth stage, farmers usually cut the lower leaves of the stem for a increased vegetative growth (Hancock Seed, 2014).

The pearl millet life cycle is estimated between 48–80 days for early and very late varieties, respectively, autumn millet is planted in summer (May and June) and the crop ripens at the end of October and early November. Millet is also grown in the spring to ripen in the summer (summer millet). Clement (1985) confirmed that most varieties of pearl millet are grown in the Sahel and Sahara region, where precipitation rates less than 60 mm belong to early and medium species and their life cycle is limited to 70–90 days.

Millet is characterized by a large production of the vegetative system and represents about 70% of the total plant biomass (Azam et al., 1984). Cross-pollination of pearl millet by wind, where the female organs mature early compared to the male (pollen) of the hermaphrodite, and sometimes self-pollination may occur. The pills begin to grow after fertilization (20 to 30 days) and become fully mature after only 40 days of fertilization (Boston, 1996). Millet grows in three stages; the germination stage and the appearance of the primary leaves (Beginning of May - mid-July) which represents the vegetative growth, then the stage of growth and the emergence of panicles, which varies between 40 and 50 days after germination, and, finally, the third stage represents flowering and grain fullness and ripening and takes between 75 to 85 days after germination.

Knowledge concerning the morphological and genetic diversity of pearl millet grown in the south of Algeria region is very limited, despite the richness of this region in millet populations which are distinguished by varied morphological and genetic characteristics. They can be an important source of strategic materials in high demand in food industries and animal alimentation (Murty & Kumar, 1995; Li et al., 2008; Nambiar et al., 2011; Lemgharbi et al., 2016; 2017).

The purpose of this work was thus to identify and assess the biodiversity of Pearl millet groups grown in the Tidikelt region with the aim of valuing and preserving the natural resources of local cereals.

MATERIAL AND METHODS

Study area

Tidikelt region is located at 1274 km south of the Algerian capital, Algiers. The area measures approximately 100000 km^2, and is located between 27°15'N and 2°31'E. It includes the Salah town and its surroundings: Zaouia, Western Sahla, Foggarat Ezzoua, and In Ghar (Fig. 1).

The geology of Tidikelt has a flat topography with deposits of mid-Cretaceous (Albian Barremian) and a layer of sandy loam surface of Quaternary age (Flamand, 1900). Hydrographic and climatic analysis has revealed that the entire area of this region is rain dependent on its groundwater recharge and drinking water. This water is harvested locally in low-lying areas or dug-out ponds called "foggara" (Foggara: underground drainage galleries with well, used for irrigation and drinking water flowing in Tidikelt region) (Ruffi et al., 1963).

Tidikelt is one of the hottest deserts in Algiers and it is classified as a very arid zone according to Köppen (1900); rainfall is exceptional with an annual average of less than 1.18 mm, and the temperature is very high with an average from 27 to 47 °C min/max monthly during 2000–2022. The mean summer temperature (June to August) is 45.2 °C with highs exceeding 52 °C (Global Climatology, 2016).

The vegetation in the Tidikelt region (Oasis) is composed of Date palm *Phoenix dactylifera* L., *Acacia raddiana* Savi, *Vachellia nilotica* (L.) P.J.H. Hurter & Mabb, *Tamarix aphylla* (L.) H. Karst., some cereals such as *Triticum turgidum* L. subsp. *durum* (Desf.) Husn., *T. aestivum* L., *Hordeum vulgare* L., as well as *Gossypium* sp., *Medicago sativa* L., *Ficus carica* (L.), *Punica granatum* L. and *Mentha spicata* L., which are very well adapted to the extreme seasonal temperatures and arid conditions. Millet populations can survive under extremely difficult environmental conditions, such as drought and salinity; therefore they have a high reproductive capacity and quick dispersal (Anonym, 2010).

Experimental material

The exploration of millet groups was done from the Northeast of In Salah (Foggarat Ezzoua town, 45 Km) to the South of the region (In Ghar, 70 km).We visited the important sites in the region which are the fields of Zaouia 3 km to the west, and Sahla, 12 km to the north. Six traditional and modern fields devoted to millet cultivation with a total distance of about 130 km were surveyed during three consecutive harvest seasons during the plant's maturation. There are two types of fields: traditional

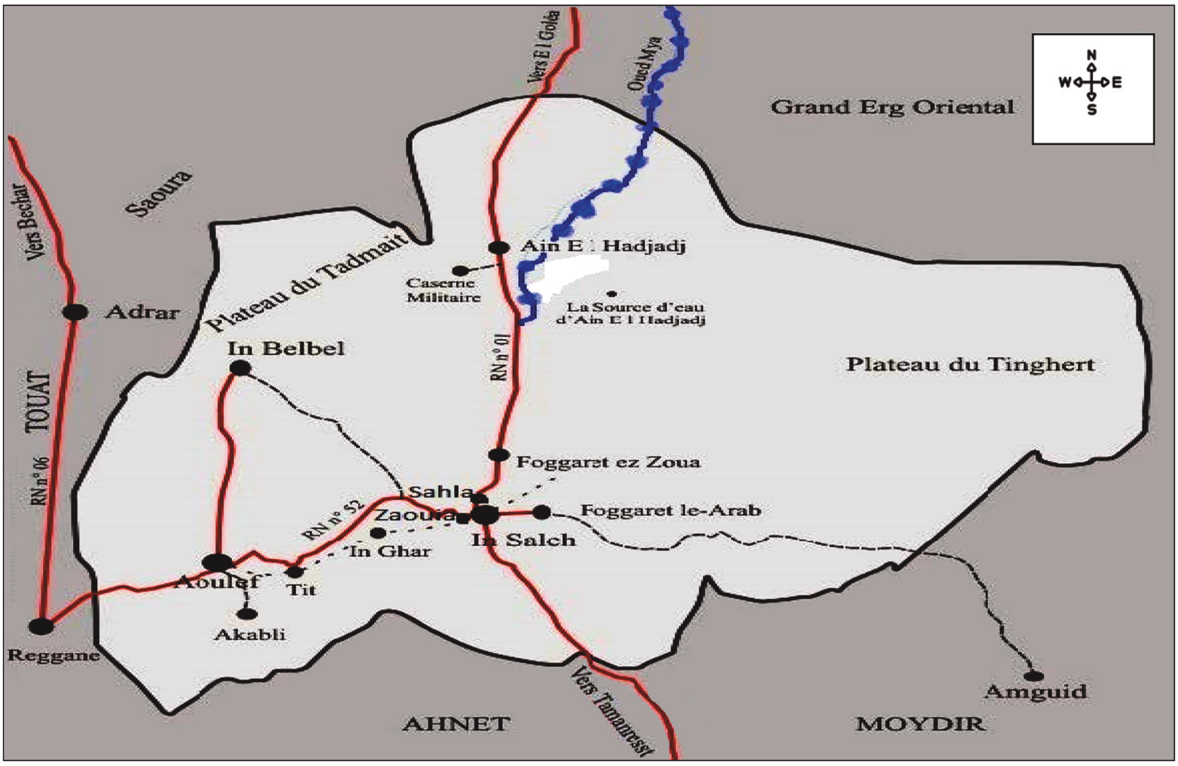


Figure 1. Tidikelt map (from Ruffié et al., 1963 modified). Red = route (road), blue = Oued (valley), black = piste (track).

(in Zaouia), where the soil is very old and irrigated with a traditional system called locally "Foggara" and new fields such as El-Maleh, Javo (in Sahla) which consist of new fertile soil that depends on a modern irrigation system (drip system). The data for the site is shown in Table 1. The material consisted of 13 millet characters according to the morphology of the plant and the panicle color in the maturity stage in fields (Table 2).

We collected data on millet cultivation in the region using different methods to assess rural participation, which included visits to millet fields, identification of problems, and organization of meetings with local farmers interested in millet cultiva-

Sites	**Distance (km) (From In Salah center)**	**Geographical Position**	**Altitude (m)**	**Site characteristics**
Zaouia	3 km West	27°12'37N 02°27'26E	260 m	Traditional fields
Sahla	12 km Nord-est	27°19'33N 02°49'17E	873 m	New fields (El-Maleh, Javo)
Foggarat Ezzoua	45 km Nord-west	36°28'14N 02°50'30E	874 m	New fields (Emttiaze, 500ha)
In Ghar	70 km South-west	27°10'41N 02°03'27E	266 m	New fields (Mohamed Boudiaff)

Table 1. Sites visited in Tidikelt region during three cropping seasons.

N°	**Code**	**Locality**	**Status**
1	MLT.Saf K	Zaouia	Local Millet
2	MLT.SafT	Sahla (Javo)	""
3	MLT.Saf P	Zaouia / Foggarat Ezzoua (500 h)	""
4	MLT.Kha1	Sahla (Javo)	""
5	MLT.Ham	Sahla (Javo)	""
6	MLT.P	Foggarat Ezzoua (El-mtiaze)	""
7	MLT.PP	Foggarat Ezzoua (500 h)	""
8	MLT.Kha2	In Ghar (Taghbara)	Domesticated†
9	MDT.Sepl	Sahla (El-Maleh)	""
10	MDT.Sepc	Sahla (El-Maleh)/ Foggarat Ezzoua	""
11	MDT.Smix	Sahla (El-Maleh)/ Zaouia	
12	MLT.VN	Zaouia/ Sahla (El-Maleh)	Wild millet
13	MLT.VNP	Zaouia/ Sahla (El-Maleh)	""

Table 2. Pearl millet accessions, and local name with their collection site. MLT.Saf K: Yellow. Short millet. MLT.SafT: Yellow. Tall millet. MLT.Saf P: Yellow, Hairy millet. MLT.Kha1: Black millet n.1. MLT.Kha2: Black millet n. 2. MLT.P: Pearly millet. MLT.PP: Hairy millet. MDT.Sepl: Sudan tall panicle millet. MDT.Sepc: Sudan short, panicle millet. MDT.Smix: Sudan mix millet. MLT.VN and MLT.VNP: Violet-Black, Wild and hairy millet. †Domesticated: introduced from neighboring countries; Mali, Nigre.

tion through formal discussions and using a questionnaire on millet cultivation and production with preferred characteristics, economic activities in rural areas and uses/importance (Lelo et al., 1995).

In addition, we have relied on data collection technology, field observations, and consultation of workers in the field of agricultural extension for the interests of the agricultural sector in the governorate in order to better understand the cultivation system and methods of exploiting the millet crop, which allowed us to achieve high accuracy in data collection. We organized field visits to more than 20 fields at different agricultural sites in the area during the panicle maturity stage (Singh, 2003).

The descriptive study of the qualitative characteristics and quantitative measures of the morphological characteristics of the different groups of millet was carried out according to Andrews & Kumar (1996) and Christinck et al. (2000) of millet descriptors, for example; PH, NN, and LN, the third leaf dimensions (LL, LW) and PC at maturation (Table 3).

We have determined the panicle and grain colors based on Royal Horticultural Society (RHS) color codes (IBPGR - ICRISAT, 1993). The descriptive and cytological study of the millet seed was carried out in a laboratory, and was based on the descriptive parameters of IBPGR & ICRISAT (1993) such as; Setae of Panicle (PS), Seed Envelop style (SE), Seed Form (SF) and Proportion of Floury Endosperm (PFE). The PFE was estimated using the percentage of corneous and floury endosperm, this percentage was determined by the examination of seed sections using a stereomicroscope and was then compared to sorghum standards (Taylor & Taylor, 2008). On this basis, the various millet grain groups are classified into corneous, intermediate, or floury according to the International Association of Cereal Science and Technology (ICC, 2008). The moisture analysis content of seeds millet groups was carried out in the laboratory according to method 44 15 A of the American Association of Cereal Chemists (AACC) (2000).

The quantitative and qualitative data were organized into groups of four replicates (n = 4), then analyzed using the Analyze of Variance (ANOVA) and the Principal Component Analysis (PCA). As a result, we calculated the differences in mean values at the 0.05 probability level depending on the least significant difference (LSD) method SPSS. Statistic version 17.0 software.

RESULTS

Field visit data

Based on field visits concurrent with millet cul-

Characters	Code	Description
Plant Height (cm)	PH	Height of the Plant from the ground to the tip of the main panicle
Number of Nodes (count)	NN	Number of nodes on the main stem (Plant)
Leafs Number (count)	LN	Number of leaves on the main stem(Plant)
Stem Diameter (cm)	SD	The diameter measured on the third inter node from the ground
Panicle Length (cm)	PL	Length of the panicle from its base to tip
Panicle Width (cm)	PW	Width of panicle in a natural position at the widest part
Leaf Length (cm)	L.3L	Length of the third upper leaf from the top
Leaf Width (cm)	W.3L	Width of the third upperleaf from the top
Panicle Color	PC	The color of the panicles on the main stem of the plant at maturity
Panicle Form	PF	Form of panicle in maturity
Panicle Setae	PS	Setae on the main panicle in maturity

Table 3. Field millet morphological characters with their codes and descriptions.

Qualitative characters	Code	Description
Seed Number in Spikelet	SNS	Number of seeds in Spikelet in panicle maturated
Seed Envelop	SE	Natural Position of seed envelop
Seed Form	SF	Form of seed in maturity
Seed Collor	SC	Color of seed in maturity
Seed Weight 1 Litre (Gram)	SW1L(g)	Weight of one - liter volume of seeds in gram
Thousand Seed Weight	TSW(g)	Weight (g) of 1000 seeds taken from matured panicle at 20°C
The Proportion of the Floury Endosperm	PFE	Proportion (%) of floury endosperm in seed (section)

Table 4. Millet cytological characters recorded in the laboratory (Laboratoire de Biochimie, Ecole Normale Supérieure, Kouba, BP N° 92. Algiers, Algeria).

tivation and maturation, as well as conversations and questionnaires, we can elucidate the following findings regarding millet phenotypic variation in the area (Figs. 2–14).

Local millet. Its plants are generally distinguished by their short height and abundance of leaves compared to the domesticated plants, in addition to the quality of their panicles, especially known locally as "El maghroude" (designation of local millet panicle variety used as treatment food for fracture of bones) (MLT.P) and Safra (yellow) (MLT. SafT, MLT. SafK) (Figs. 2, 3, 8, 9). This local millet is also characterized by good production of compact panicles, with medium-length and large seeds. Due to these distinctive characteristics, this crop is more desirable by local farmers; it accounts for a high percentage of crops (85–90%) in almost all of the sites studied (Appa-Raos, 1980; Lemgharbi et al., 2016; 2017).

Domesticated millet. It was introduced from neighboring countries (Mali, Niger) and hence it is locally called "Beechnut Soudan" (in Arabic) meaning Sudan millet. It is characterized by a long height, less foliage, and deeper roots, compared to local millet. Domesticated millet provides good fodder for its long stems, but it usually has long panicles, which are poorly filled with small seeds. As a result, domesticated millet is present in low proportions which account for less than 10% of the fields from this region (Figs. 10, 11, 12).

Wild millet. This group represents a very small proportion of fields (0–1%). It is characterized by abundant setae and very little to no seeds (Teklehaimanot et al., 1998; Ivancich et al., 2012). These characteristics make it undesirable and it is locally called "Barria" (in Arabic) meaning wild millet or Beechnut El Farr (dialect) which means "rat ear" (Figs. 13, 14).

Millet morphological characters

From a statistical perspective, we can eliminate the wild millet group (Figs. 13, 14) as it represents a very low percentage in all studied fields. In addition, most of its panicles and leaves fall spontaneously when the plant matures which makes it difficult to describe, and measure during the descriptive evaluation process in general; local farmers consider wild millet as a weed in fields.

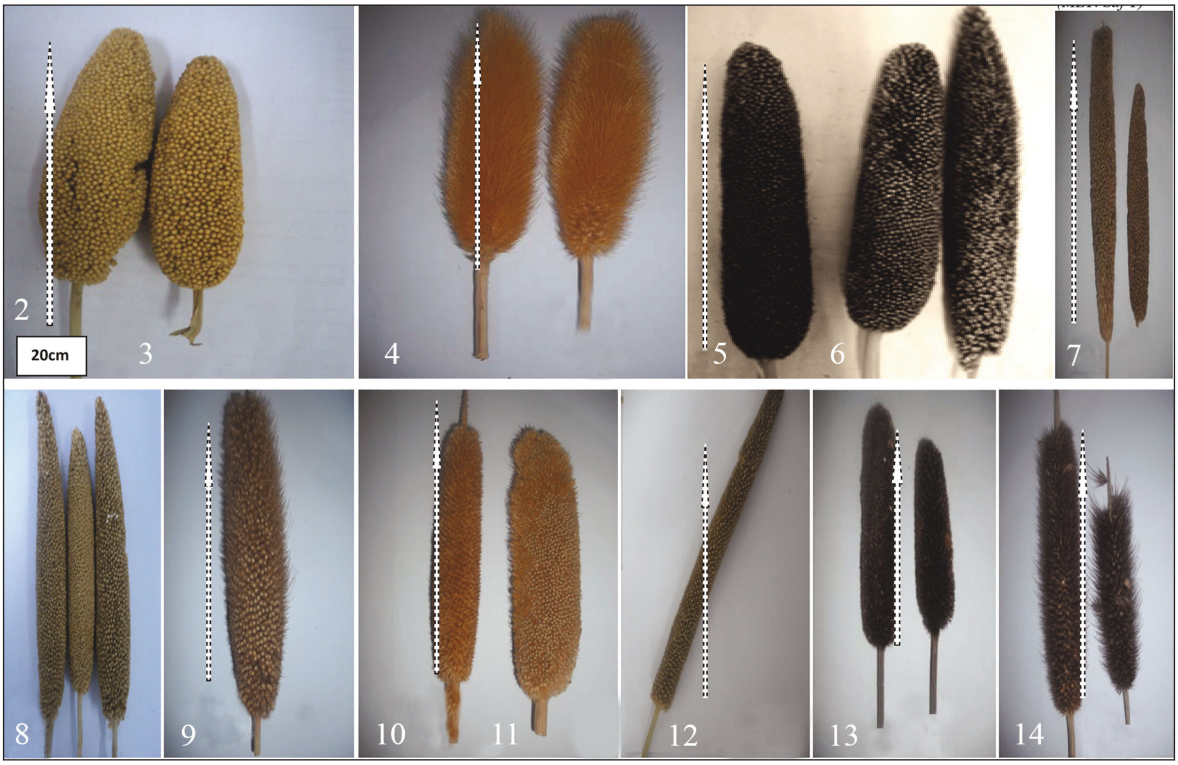
Concerning the remaining eleven millet groups cultivated, they showed clear phenotype diversity, with significant differences recorded in HP, SD, LN, and NN on the main stem. For example: HP of domesticated millet ranges from 225±0.01 to 245±0.07, cm (MDT.Sepc, MDT.Smix, and MDT.Sepl) compared to local millet from 188±0.08 to 204±0.11 cm (MLT.Kha2, MLT.SafT), The NN and LN were greater in local millet: 14±0.7, node and 14±0.01, leaf (MLT.Ham, MLT.PP) respectively, compared with domesticated millet: 11±0.77, node and 11±1.11, leaf (MDT.Sepl, MDT.Sepc) respectively (Figs. 15, 16).

Seed characters

Significant variations were recorded in seed characteristics; the natural position of the SE allowed us to classify the seeds into three categories: exposed, intermediate and closed, with the exception of wild millet (MLT.VN, MLT.VNP) (Lemgharbi et al., 2016). Usually, there are two seeds in the spikelet of the ripe panicle with the exception of the introduced millet. MDT. Smix was characterized by 2 to 3 seeds, whereas this criterion was absent in wild millet spikelet (MLT.VN, MLT.NVP) (Table 5).

The morphological and cytological characteristics of the millet panicle and seed presented in Table 5 can be used to identify and select the distinct groups of millet. For example, MDT.Sepl, and MDT.Smix was the only group having elongated and hexagonal seed forms respectively, while the rest of the groups had oblanceolate (38.46 %), obovate (30.77 %) and globular forms (15.38 %). Seed millet colors were classified into three groups: yellow (27.27 %), grey (36.36 %), and black (18.18 %), except for MDT.Sepc, which possessed ivory color (Kumar et al., 1993). Clear differences in the values of TSW (g), were recorded between the local and domesticated millet groups, as the local seeds were characterized by relatively higher weights ranging between 9.10–9.50 g, while the values of its domesticated counterpart were estimated between 6.20–6.86 g, but there are no values for wild millet (MLT.VN, MLT.VNP), due to the scattering of its spikes at the start of ripening (Fig. 17). Concerning the SW1L (g), we recorded values between 778.00 –782.60 g/L for all millet groups with a slight decrease in the weight of domesticated millet seeds (778.00 g/L), however, a lower value was recorded for the wild millet MLT.VN (350.00 g/L) and SW1L (g) of MLT.VN group was not available (Fig. 17).

The seed cytological results confirmed that the seeds of Pearl millet groups which are characterized



Figures 2–14. Pearl millet panicles types in plant maturation stage of Tidikelt region. Fig. 2: Saffra Toulla (MLT.Saf T). Fig. 3: Saffra ksira (MLT.Saf K). Fig. 4: Saffra Lemchaara (Hairy) (MLT.Saf P): Fig. 5: Khahla (Black) (In Ghar) (MLT.Kha2). Fig. 6: Khahla (Sahla.Javo) (MLT.Kha1). Fig. 7: Hamra (Red) (MLT.Ham). Fig. 8: El-Maghroud (Pearl) (MLT.P). Fig. 9: El-Maghroud Lemchaara (MLT.PP). Fig. 10: Sudan Mkhalta (Mixt) (MDT.Smix). Fig. 11: Sudan Ksira (Short) (MDT.Sepc). Fig. 12: Sudan Touila (Tall Panicle) (MDT.Sepl). Fig. 13: Violet-Noir (MLT.VN). Fig. 14: (MLT.VNP).

by a high percentage (93–96%) of starchy (MLT.SafP, MLT.SafT, and MLT.SafK) or corneous endosperm (MLT.P, MLT.Ham, MLT.Kh1 and MLT.Kh2), represent the most cultivated local millet groups, and are favoured by local farmers (Figs. 18–21).

	Local millet								Domesticate millet			Wild millet	
	MLT. SafK	MLT. SafT	MLT. Saf P	MLT.Kh1	MLT. Ham	MLT. P	MLT. PP	MLT. Kh2	MDS. epl	MDS. epc	MDS. mix	MLT.VN	MLT.VNP
PC	Yellow (7B)	Yellow (1B)	Yellow (13A)	Black (189A)	N (167A)	Green (146B)	Creen (152C)	Black (202A)	Green (144A)	Yellow (17B)	Yellow (13A)	Black (203D)	Black (N200A)
PF	Globose	Globose	Candle	Candle/Semi-cylindrical	Candle/Semi-cylindrical	Candle /Semi-cylindrical	Candle	Candle	Semi-cylindrical	Semi-cylindrical	cylindrical	Candle	Candle
PS	-	-	++	+	+	-	++	+	+	-	-	+	++
SNS	02	02	02	02	02	02	02	02	02	02	02 -- 03	NA	NA
SE	Naked (3)	Naked (3)	Interme-diate (5)	Interme-diate (5)	Interme-diate (5)	Naked (3)	Interme-diate (5)	Interme-diate (5)	Covered (7)	Naked (3)	Naked (3)	Covered (7)	NA
SF	Oblan-ceolate	Oblan-ceolate	Oblan-ceolate	Obovate	Oblan-ceolate	Globular/ Obovate	Oblan-ceolate	Globular/ Obovate	Elongated	Obovate	Hexagonal	NA	NA
SC	Yellow (8C)	Yellow (8C)	Yellow (8C)	Black (194A)	Brown (200)	Grey (201)	Grey (201)	Black (N200B)	Ivory (158A)	Grey brown (199)	Grey brown (199)	NA	NA

Table 5. Panicle and seed characters of pearl millet groups in plant maturity stage of Tidikelt region. PC: Panicle Color, PF: Panicle Form, PS: Panicle Setae, (-): Panicle Without setae, (+): Panicle with setae, (++): with long setae, SNS: Seed Number in Spikelet, SE: Position of Seed Envelop, SF: Seed Form, SC: Seed Color.

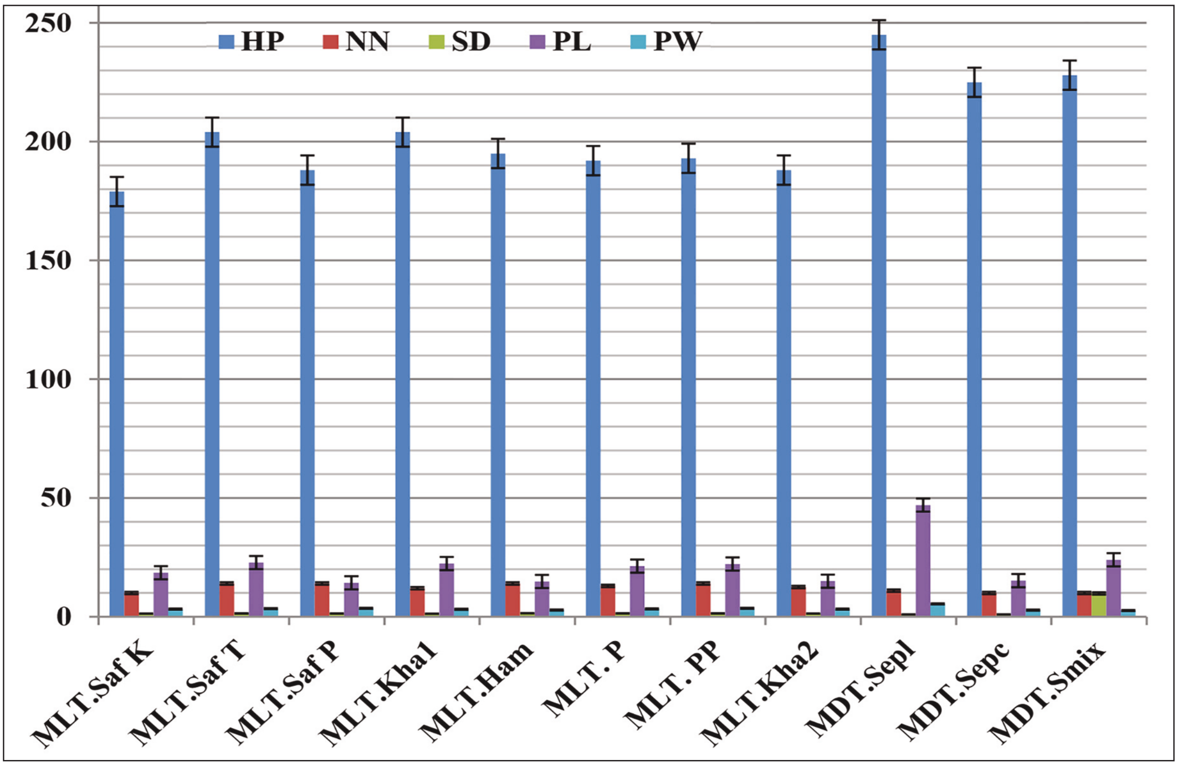


Figure 15. Mean Morphological measurements average ±(SE) for Height Plant (HP)), Nodes Number (NN), Stem Diameter (SD), Panicle Length (PL) and Panicle Width(PW) (cm).

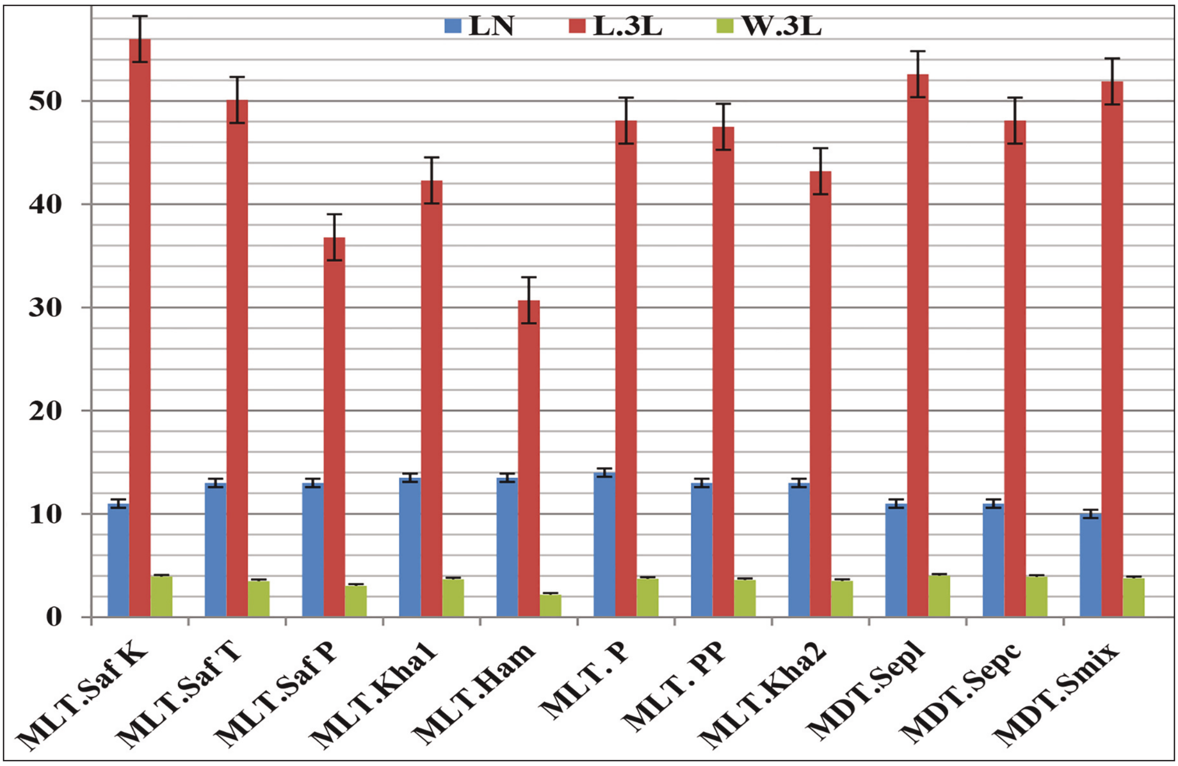


Figure 16. Leaf Number (LN), Length of the third upper leaf (L.3L), and Width of the third upper leaf (W.3L) (cm).

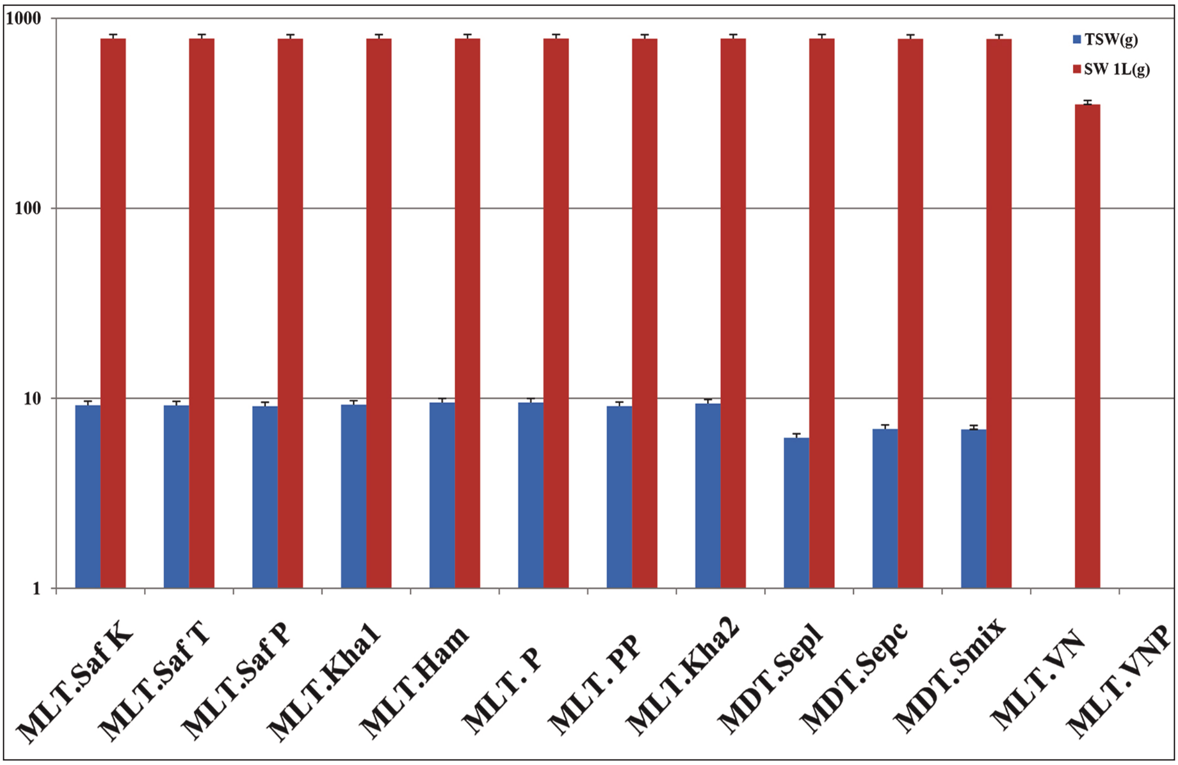


Figure 17. Physical properties of millet seed; TSW (g): Thousand Seed Weight, SW1L (g): Seed Weight 1L (g), NA: Not Available.

While the opposite was recorded for the groups of pearl millet, which are characterized by a relatively high proportion of intermediate endosperm (MLT.PP) (Fig. 22).

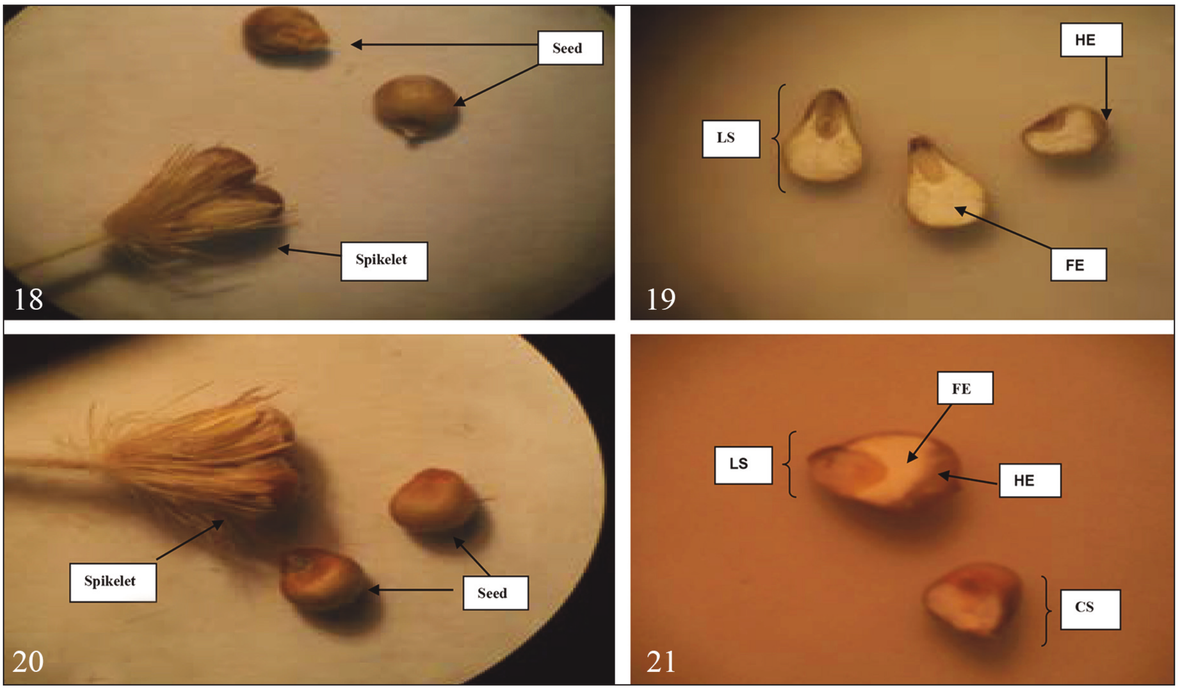
DISCUSSION

Due to the lack of water needed for irrigation, pearl millet cultivation takes place in limited areas and in a traditional manner (Zaouia). Indeed, it is difficult to reclaim large agricultural areas in this region due to its peculiarities such as high soil salinity, lack of groundwater and rain; in addition, pearl millet generally grows from May to August in the Tidikelt region, just like other summer crops (Li et al., 2004) and this coincides with high temperature and severe drought.

We applied the method of ANOVA and PCA to evaluate and compare pearl millet groups cultivated in this region (Table 2). Many authors have used the Hierarchical Classification Method to describe the millet phenotypic variability in order to classify according to different characteristics (Hayward et al. 1982; Falcinelli et al., 1987; Peeters & Martinelli, 1989; Charmet et al., 1990; Balfourier & Charmet, 1991; Reddy et al., 1996; Fox et al., 1997; Kindt et al., 2004, 2005).

We can easily observe and identify the main colors and shapes of panicles in the field. Principally, there are three dominant colors of panicles: yellow with a rate of 38.46% (MLT.SafT, MLT.Saf K, MLT.Saf P, MDT.Sepc, and MDT.Smix), Black by 38.46 % too (MLT.Kha2, MLT.Kha1, MLT.Ham) and green by 20.00 % (MLT.P, MLT.PP, and MDT.Sepl). The last two groups of millet are characterized by globose candle, semi-cylindrical shape (Table 5) and compact panicles (especially the local group named "El maghroude", which is preferred by local farmers) and finally, wild millet (MLT.VN, MLT.VNP) represent less than 1%. These panicle qualitative characteristics enable us to select well for specific genetic strains (Gupta et al., 2011).

While we recorded very slight differences for the third leave dimensions L.3L, W.3L, and PW (Fig. 16), we did not record a significant difference between local and domesticated millet. The presence of the PS can be observed in MLT.Saf P, MLT.PP and MLT.VNP or its absence in MLT. Saf T, MLT.Saf K and MLT.P (Table 5), this criterion



Figures 18-21. Grain and Spikelet of pearl millet. Fig. 18: Spikelet and Seed of local millet (MLT.P). Fig. 19: Cross and longitudinal section in the seed of local millet (MLT.P). Fig. 20: Spikelet and Seed of domesticated millet (MDS.Sepl). Fig. 21: Cross (cs) and longitudinal (ls) section in the seed of domesticated millet (MDS.Sepl).

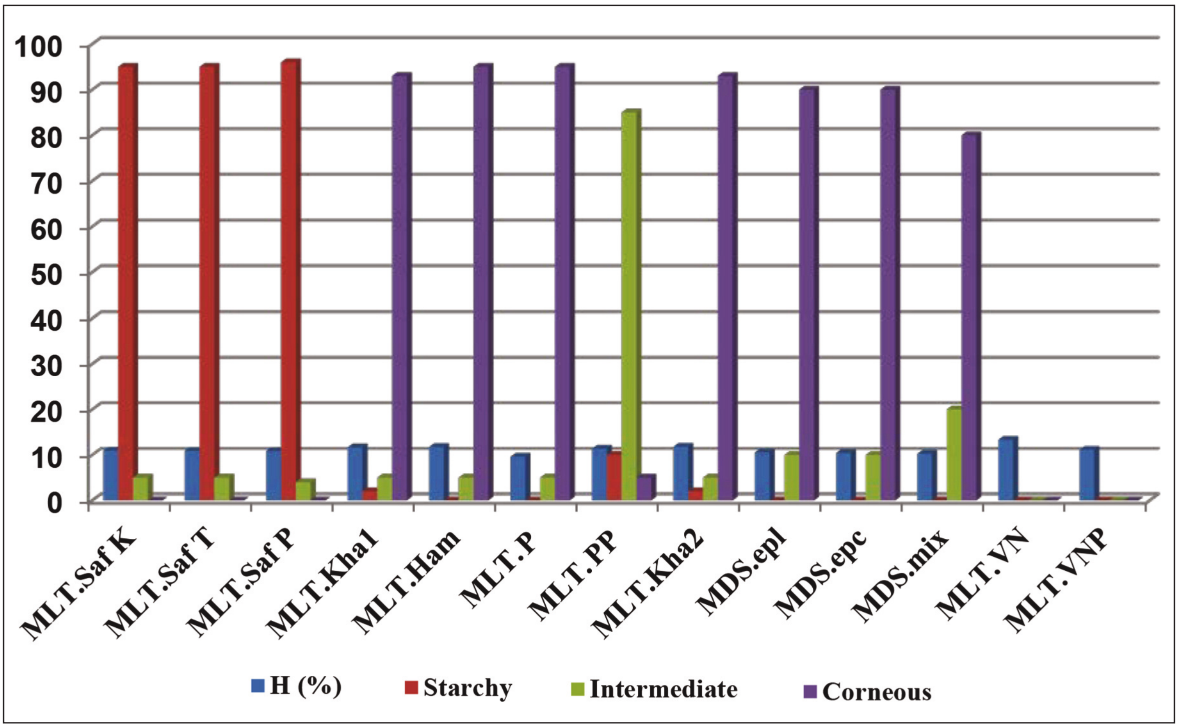


Figure 22. Seed endosperm texture and moisture of pearl millet cultivated in Tidikelt region.

helps us to differentiate the phenotypes of pearl millet and has been adopted by Tunisian farmers as an indicator of millet resistance against bird attack (Mohamed, 1998).

Despite the seed quality of some groups of millet: MLT.P, MLT.SafK, and MLT.SafT compared to the common local cereal, we record that the local people do not depend on these cereals as food and resort to wheat as an alternative, on the contrary, in the Hoggar region (Tamanrasset) where they are used as popular meals.

To understand the pearl millet cultivation system and techniques in the region, the agricultural study on the selection of local seed strains should be developed in order to create a database on pearl millet seeds in order to improve and expand the grain yield, which is characterized by good adaptation to the local environmental conditions.

According to the results of this study, there is a very interesting biodiversity of pearl millet and most of them can be compared to those cultivated in the world, which requires an in-depth study to preserve these natural resources with modern programmers for the future development of local cereals.

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