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Agronomic evaluation of Tunisian accessions of chili pepper (*Capsicum frutescens* L.)

Kaouther ZHANI[1], Wissem HAMDI [1], Sami SEDRAOUI [2], Rami FENDRI [1] ,Oula LAJIMI [1], Chérif HANNACHI [1]

[1] *Higher Institute of Agronomy, 4042, Chott Mariem, Tunisia, Sousse University,*

[2]*Faculty of Sciences of Bizerte, Tunisia, Carthage University*

Abstract - *Five local accessions of chili pepper (Capsicum frutescens L.): Tébourba, Somâa, Korba, Awled Haffouz and Souk Jedid, were cultivated in the experimental station of Higher Institute of Agronomy, Chott Mariem, Sousse (Tunisia) for their agronomic evaluation. Results showed that the pepper accessions were significantly different ($p<0.05$). Korba accession had the superior vegetative characters (stem height, stem width, leaf area, plant height, number of bifurcations) and produced the highest number of flowers (356), fruits (211) and yield (22 t/ha). Fruits of Tébourba accession are the longest (118 mm), the widest (15 mm), the heaviest (12 g) and have the thickest (2 mm) pericarp, the longest (96 mm) placenta and the biggest number of seeds (127 seeds).*

Key Words: Capsicum frutescens, fruits, genotypes, quality, yield.

1. Introduction

Pepper *(Solanaceae* family and *Capsicum* genus) is an important agricultural crop. It is an annual plant grown for its berries extensively used as spice and in medicine. Its fruits, used as spice, vegetable and herbal remedy, are kwon by their highest vitamin C content among all vegetables [1] and their antioxidant characteristics [2]. It plays an important role in the economy of many countries. It is the world's second important vegetable, ranking after tomatoes and it is the most produced type of spice flavouring and colouring for food while providing essential vitamins and minerals. In 2013, Food and Agriculture Organization (FAO) statistics estimated world production of Capsicum peppers at 21.3 million tonnes from a harvested area of 1.6 million ha (i.e. an average yield of 13.4 t/ha) [3]. Comparatively, yield in the developing countries is about 10 – 30% of that in developed countries [4]. However, Tunisia is known to be one of the major producers of pepper in the world.

In fact, in Tunisia, pepper is widely grown in all regions both on open air and under greenhouse and occupies the fourth largest area planted by gardening. In 2014, the area allocated to this crop reached 21,200 ha with a national yield of 18.1 t/ha [5]. Pepper is very appreciated by Tunisian consumer's especially pungent varieties which are used fresh to prepare different dishes, dried (spice) or pickled.

Pepper production in Tunisia is not unconnected with the climatic condition and day length while the moisture content of the soil and the prevailing temperature has important effects on the growth and yield of the crop. In general, the maximum growth and production of pepper occur between a temperature range of 18°C and 30°C [4], in a loam or silt loam soil with good water-holding capacity (but also on many soil types as long as the soil is well drained) and the soil pH between 5.5 and 6.8 [6]. The majority of cultivated varieties are hybrids belonging to the genus *Capsicum annuum* and estimated to be 34, all are officially allowed by Agriculture Minister [71]. The varieties belonging to *Capsicum frutescens* or Chili pepper are local varieties, named "Baarbid". The most production of this species in Tunisia is localized in the region of Korba. Nevertheless, this type of pepper is cultivated in other regions and no study was done about the production of the accessions cultivated there.

Therefore, for the first time, the present research studies the agronomic performance of local Tunisian chili pepper. Thus, five accessions of chili pepper (*Capsicum frutescens* L.) are cultivated under greenhouse in Chott Meriem (Sousse, Tunisia) in order to select the best performing accession(s).

2. Materials and methods

2.1. Experimental protocol

Research was conducted in the experimental station of Higher Institute of Agriculture of Chott Mariem (Tunisia). Five local accessions of chili pepper were included in this study. They were collected from three Tunisian regions: Manouba, Cap Bon and Sidi Bouzid. Two of them came from two locations in Cap Bon; Somâa (Sm) and Korba (Kb), two were from the state of Sidi Bouzid:

Awled Haffouz (Az) and Souk Jedid (Sj) and the fifth was collected from Tébourba (Tb) in Manouba.

The work lasted from January to October 2011. In January 5th seeds of the five accessions were sown in alveolar containers consisting of 104 cells and containing fertilized peat (N-P-K, 12-24-12). These containers were covered by white plastic to accelerate seeds germination and emergence and put under greenhouse until the plants were ready for transplanting. Watering was done based on climatic condition with a fine watering can and hand weeded. Fungicide (Proplant: 200 ml/hl) was applied before the fungal devastation as preventive activity. Before transplanting, farmyard manure (7 t/ha) was dispersed into the soil and land preparation was done mechanically.

At five leaves stage, plants were transplanted on March 3rd under monotunnel greenhouse covered with polyethylene low density plastic. The plants are arranged, randomly with 5 repetitions, in a single line at a density of two plants/m². They were vertically dressed, irrigated regularly using system drip irrigation and fertilized according to the crop needs. Fungicides were used to protect plants against aphids (Talastar: 80 ml/hl), moths and leaf miners (Lannate: 200 ml/hl) and powdery mildew (Solfo: 500 g/hl).

2.2. Data collection

A number of 18 agronomic traits (Table 1) are used to study of the growth and the production of the plant. 60 plants, 30 leaves and 30 fruits within each accession were used to characterize the five genotypes.

2.3. Soil analysis

Soil samples were collected annually from the 0 to 20 cm depth. Soil pH was determined potentiometrically in 1:2 soil/distilled water suspensions after shaking. Soil organic matter was measured using the walkley and black method. The Kjeldahl method was used to determine the soil nitrogen (N). Phosphorus (P) was determined using Olsen's method. Potassium (K) was determined using a flame photometer. Calcium and Mg were determined using anatomic absorption spectrophotometer

2.4. Data Analysis

SPSS software 13.00" was used to analyze the data and Duncan's multiple range test was used to separate the means at 5% ($p<0.05$).

Table 1. Agronomic characters in study

Characters studied
Plant Height (PH) (at red ripening): measured in cm from soil level to the top most growth point of above ground plant
Stem Height (SH)
Time of beginning of flowering (BF): number of days from plantation to the appearance of the first flower on second flowering nods.
Time of maturity : number of days from plantation to apparition of the first mature fruit)
Leaf area (LA)(cm²): determined by planimeter (Metter 3100)
Stem width (SW): measured in cm at widest point
Number of bifurcations (NB) : counted 120 days after plantation
Number of flowers per plant (NF): determinate 120 days after transplantation
Number of fruits per plant (Nbfr)
Yield per plant (Yp) and per hectare (Yh)
Fruit weight (WF) (g) : determinate on SHIMAZDOU A×200 digital scales
Fruit Length (LF): measured in mm with Digital Caliper
Fruit Diameter (DF) : measured in mm with Digital Caliper
Thickness of flesh (Tf): measured in mm with Digital Caliper
Stalk length (Sl): measured in mm with Digital Caliper
Placenta length (Pl) (mm)
Number of seeds per fruit (SN)
100-seed-wight (100 sw) in g

2. Results

Initial soil physicochemical characteristic were show in the Table 2. The value of pH is 7.8 indicated that is a weakly alkaline soil. Soil analyses gave values of 2.7% organic matter (OM), and nutrients 27 (N), 412 (P), 816 (K), 193 (Ca) and 22 (Mg) ($mg.kg^{-1}$ soil) and it have a sandy loam texture soil.

Table 2. Soil proprieties

Chemical proprieties ($mgkg^{-1}$)						
pH	OM (%)	N	P	K	Mg	Ca
7.8	2.7	27	412	816	22	193
Physical proprieties (%)						
Clay	Sand	loam	Field capacity		Wilting point	
23	62	15	7.5-14.2		3.2-8.6	

Examination of agronomic performance in the vegetative stage (Table 3) showed a significant difference ($p<0.05$) in stem diameter (10.36 to 16.6 cm), leaf area (46.81 to 69.68 cm²) and plant height (56.16 to 114.83 cm). Kb *cv* demonstrated the best values while Sj *cv* had the lowest ones. The number of bifurcations, counted 120 DAP, was measured only in Kb, Az, Sm and Tb *cv* and it was ranging between 168.12 (Az *cv*) and 228.3 (Kb *cv*) bifurcations.

Significant variability in flowering time (DAP to the appearance of the first flower) and the total number of flowers per plant was observed (Table 3) and the range was respectively 44 to 58 DAP and 212.7 to 356.5 flowers. Tébourba *cv* was the earliest to flowering with 44 days while Sm *cv* took the longest days (58 days). Kb *cv* had the highest number of flowers per plant (356.5) whereas Tb *cv* had the lowest number (212.7 flowers).

Table 3. Vegetative parameters of five Tunisian chili pepper accessions

	Tb	Sm	Kb	Az	Sj
SH (cm)	12.30 b	12.73 b	12.89 b	13.74 b	41.40 a
SW (cm)	14.30 b	14.70 b	16.60 a	13.90 b	10.36 c
LA(cm²)	62.09 b	52.82 c	69.70 a	70.47 a	46.81 d
P H (cm)	102.96 b	104.73 b	114.83 a	90.60 c	56.16 d
NB	207.90 b	194.50 c	228.30 a	168.12 d	-
BF	44.00 b	58.00 a	48.00 b	52.00 b	54.00 a
NF	212.69 d	308.48 b	356.50 a	285.80 c	268.61 c

(a-c): Means in the same line followed by the same letter are not significantly different at 5% level according to Duncan test.

The difference in yield between the five accessions was significant; it is demonstrated in Table 4. The highest fruit yield per plant was obtained from Kb *cv* with 210.95 fruits while Tb *cv* had the least fruit yield with 101.28 fruits. The estimation of yield in g per plant showed that Kb *cv* was the most performing accession (870.61 g) while Sj *cv* produce the lowest yield per plant (406.8 g). Thus, the yield per hectare ranged from 10.16 (Sj *cv*) to 21.76 t (Kb *cv*). Therefore, Kb *cv* is the most performing accession and it is probably due to its best responses in vegetative growth in terms of height of plant, diameter stem, leaf area, number of bifurcation, fruits number, flowers number. The positive correlation study between yield and vegetative and productive parameters (Table 5) confirm this.

Table 4. Productivity of five Tunisian chili pepper accessions

	Tb	Sm	Kb	Az	Sj
NbFr	101.28 e	195.24 b	210.95 a	168.12 c	149.23 d
Yp (g)	600.4 c	758.5 b	870.61 a	617.26 c	406.78 d
Yh (t)	15.01 c	18.96 b	21.76 a	15.43 c	10.16 d

(a-e): Means in the same line followed by the same letter are not significantly different at 5% level according to Duncan test.

Fruit characteristics showed also a significant difference among the pepper accessions with respect to all the parameters measured (Table 6). Fruits of Tb *cv* had the highest length (117.9 mm), weight (11.72 g) and placenta length (95.89 mm). Az *cv* produced the largest (14.67 mm) fruits with the thickest pericarp (2.14 mm). Kb *cv* had the pedicel with the biggest length (40.23 mm). Sj *cv* recorded the lowest values in all traits studied. Finally, the number and weight of seeds are studied and a significant difference was moreover recorded. Tb *cv* produced the higher number of seeds (126.8) while Sj *cv* produced the lowest one (63.26). Again Tb *cv* had the highest weight of seeds (0.570 g) whereas Sj *cv* had the lowest weight (0.432).

Correlation between fruit parameters were also studied (Table 7) and higher positive correlation was observed between weight and length fruit (r=0,814), between weight and diameter fruit (r=0,739), between placenta length and fruit length (r=0,571) and between pericarp thickness and diameter of fruit (r=0.511)

Table 5. Correlation coefficients among growth parameters in Tunisian hot pepper

	PH	SH	SW	LA	NB	NF	NbFr	Yp
PH	1							
SH	0,021*	1						
SW	0,094*	0,077	1					
LA	0,052	0,186	0,222*	1				
NB	0.16**	-0.033	0.065	-0.043	1			
NF	0.45**	0.59**	0.150	0.140	0.25**	1		
NbFr	0.547**	0.084	0.267*	-0.184	0.174**	0.052*	1	
Yp	0,246**	0,535*	0,097	0,115	0,099**	0,431*	0.47**	1

Table 6. Fruit characteristics of five Tunisian chili pepper accessions

	Tb	Sm	Kb	Az	Sj
LF (mm)	117.9a	98.38c	82.95d	102.7b	53.51e
DF (mm)	14.67a	12.01b	11.68c	15.63a	8.90d
WF (g)	11.72a	6.04cd	5.57d	10.18b	2.36e
Tf(mm)	2.15ab	1.39c	1.36c	2.42a	1.14d
Pl(mm)	95.89a	72.95c	51.97d	87.66b	39.74e
Sl (mm)	38.18b	37.48c	40.23a	38.78b	35.38d
SN	126.8a	75.23d	95.53c	106.73b	63.26e
sw (g)	0.533b	0.521b	0.452c	0.570a	0.432d

(a-e) Means in the same line followed by the same letter are not significantly different at 5% level according to Duncan test.

Table 7. Correlation coefficients among production parameters in Tunisian hot pepper

	WF	DF	LF	Pl	Tf	SN
WF	1					
DF	0,739**	1				
LF	0,814**	0,70**	1			
Pl	-0,621**	-0,44**	0,565**	1		
Tf	-0,594**	0,511**	-0,43**	0,81**	1	
SN	-0,671**	-0,59**	-0,62**	0,57**	0,568**	1

3. Discussion

The review of the agronomic performance of the studied accessions showed a significant difference in the stem height, collar diameter, leaf area and plant height. These results agrees with the findings of many others works on pepper [8,7,10]. The determination of leaf area is an indicator of the power plant since it is directly related to the photosynthetic capacity and chlorophyll synthesis [11], while the diameter of the stem reflects the plant vigor [12] because larger is the diameter better is the plant in supporting best vegetative part and then the fruit load. The height of plant is an important growth character directly linked with the productive potential of plant. An optimum plant height is claimed to be positively correlated with productivity of plant [13,14].

According to the literature, the difference in height of the plant is mainly attributed to the genetic potential [15] but also to environmental factors, especially temperature which must be in order of 25°C to ensure good vegetative growth to plant pepper[16]. Also, The capacity of genotype to absorb soil nutrients from the soil [17] could be a cause in this difference in plant height,

especially nitrogen [18]) and phosphorus [19] which have enhancing effect on the vegetative growth of plants by increasing cell division and elongation.

Our result indicates also significant variations in number of bifurcations. This trait was also used to separate accessions of *Capsicum* and similar variability was observed confirming our results [20]. Generally, this difference is related to a genetic make-up of the crop [21] and/or influence of organic and inorganic nutrients in the soil [17]. The growth temperature can also control the formation of branches as it was confirmed in 10 Tunisian varieties of pepper [22].

Similarly, there was a variation in flowering time and total number of flowers. Analogous result was obtained on 10 local ecotypes in Tunisia [20]. In fact, earliness in flowering is an important parameter to explore because it

The significant difference in yield between the five accessions found in this study agrees with the results of other researchers on pepper [28,29] and other crops like tomato [30], rapeseed [31] and white[32]. The recorded variations of varieties in marketable yield could be due to their differences in genetic make-up and/or agro ecological adaptations compared to the locations in which they had evaluated [33].

With regards to relationship between vegetative growth and yield and yield components of hot pepper, researchers confirmed our results and proved that there is a positive and highly significant correlation between yield and number of branches [34], yield and plant height [35], yield and height and diameter of stem[36] and yield and fruit number [37,38]. High temperatures strongly influence also reproductive development of chili pepper [39]because elevated temperature during post-pollinisation reduced fruit number of pepper [40].

In this study, it was also observed that Tunisian chili peppers accessions are significantly different in their sizes. Similar significant heterogeneity between pepper was discovered in fruits with regards to length and weight [41], diameter[21], pericarp thickness [42], placenta length[20] and pedicel length[43], number of seeds [44] .

In our study, a positive correlation has been found between fruit weight and length, and between fruit weight and diameter [42]. Similarly, pericarp thickness is positively correlated with the diameter [34] and weight [46] of fruit. In fact, the fruit weight variability is mostly genetic linked to chromosome 2 [47]. However, it was confirmed[48] that the weight of pepper fruit is controlled by several loci, some with a large effect (locus *2.2 fw* on chromosome 2) and others with a small effect (locus *fw4* on chromosome 4). Also, temperature [49], plant growth[50], plant nutrition [51], agricultural practices [52] and competition between fruits that are developing simultaneously on the plant [53] may also affect the growth and the size of pepper fruits.

For seeds, the difference in their number and weight is related to the cultivar [54] on the first hand, to temperature [55]on second hand and to the positive correlation with fruit size on the third hand [56] especially weight [57] and length[35]. In literature, the choice of these characters in the selection of fruits in pepper is related to many reasons. Fruits with thickest pericarp are the most withstand to transportation shocks and have the highest dry matter) [36]. Larger pepper fruits are the most attractive by consumer [58] and so get premium prices. Also, higher is the size of fruits greater is the capability for storage of photosynthates and lower is the rate transpiration [59].

4. Conclusion

Thus, from this study, agronomic variations observed between the five Tunisian *Capsicum frutescens* accessions allow us to identify Korba (Kb) accession as the most performing in production and Tébourba (Tb) as the accession with highest quality of fruits. Then these accessions could be good parents in breeding for improvement programs of pepper.

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