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Agronomic and Chemical Evaluation of Seven Hot Pepper (*Capsicum annuum* L.) Populations Grown in an Open Field

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ABSTRACT

The morphology, marketable yield, main flowering and fruiting parameters, and the capsaicinoid content in different parts of mature green and red fruits of seven local hot pepper (*Capsicum annuum* L.) populations has been studied. Morphological characters and productivity values were estimated by agronomic analysis. Capsaicinoid content was determined by HPLC. Plants from these populations showed uniform development and uniform height ranging from 53-58 cm. Based on the ability to flower and on fruit setting, local pepper populations could be divided into two homogenous groups having an average of 120-160 flowers/plant. Cultivars 'Chaabani' and 'Baklouti Kairouan' produced an important marketable yield (863 and 752 g/plant, respectively). Total capsaicinoid content varied according to the population, and within the same population according to the stage of maturity and different parts of the fruit. Capsaicinoid content was higher in green pepper fruits than in red ones, higher in the placental part than in other parts, but lowest in seeds as well as in green and red fruit. 'Piment Sesseb', 'M'sarreh' and 'Rouge Long' populations had the highest total capsaicinoid contents in green and red pepper fruit and are recommended for pepper fruit production in season crops destined for the fresh market and as a spice (pepper powder).

Keywords: capsaicinoid, fruit quality, hot pepper accessions, plant growth

INTRODUCTION

In Tunisia, pepper is the most cultivated vegetable crop and is mainly consumed for its fruits, used either fresh or dry. In the late harvest season peppers are frequently exposed to high temperature that often prevails during the end of spring and the beginning of summer. These conditions have a considerable negative effect on pepper flower growth and fruit set (Aloni *et al.* 1999). Low productivity is attributed to poor flowering and fruit set resulting in a high abortion rate due to high temperature. High temperature has been shown to reduce the number of flowers and fruit of some Solanaceous vegetables (Erickson and Markhart 2002; Russo 2003). However, this sensitivity varies according to the type of pepper (hot or sweet pepper) and, within the same type, according to the cultivar (Tarchoun *et al*. 2003).

Peppers (*Capsicum annuum*) present an important genetic variability of wild and cultivated accessions that differ in their vegetative growth (determined, sympodial, fascicular, etc.), their criteria of fruit quality (shape, weight, length, color, taste, etc.) and their marketable output (Pikersgill 1997; Lester 1998). This variability is not largely appreciated in pepper improvement programs (Paran *et al*. 1998).

The nutritional composition in pepper fruits differs, depending on the variety and stage of maturity. Fruits are considered an excellent source of various nutritional compounds such as flavonoids, carotenoids, vitamins C, E and ascorbic acid (Daood *et al.* 1996; Lee *et al.* 2005; Matsufugi *et al.* 2007; Oboh and Rocha 2007; Chuah *et al.* 2008; Jarret *et al.* 2009). These anti-oxidant vitamins have a very important function to protect the human body against oxidative damage and to prevent various diseases such as cancer and cardiovascular diseases (Matsufugi *et al.* 2007; Oboh and Rocha 2007; Chuah *et al.* 2008).

Hot pepper is a well known spice. Fruits are used in various pharmacological preparations and biologically active compounds, especially capsaicinoids (lipophylic alkaloids at different concentrations), are produced by glands situated in the placenta. These capsaicinoids are one of the most important criteria of hot pepper fruit quality. Among them, capsaicin constitutes the most pungent alkaloid (Sathiyamurthy *et al*. 2002) and is largely conditioned by several factors: endogenous (genotype), ecological (geographical origin, pedoclimatic and cultivation conditions) and technological (processing and storage of material). Their synthesis is especially associated with the stage of fruit development (Estrada *et al*. 2002). Estrada *et al*. (2000) reported that these compounds are detected 14 days after flowering and their level continues to increase with an increase in the age of the fruits until the end of their development (physiological stage). The Cap Bon, Kairouan and Sahel regions in Tunisia are representative zones of pepper growth and production; they are characterized by traditional populations of *C. annuum* ssp. In order to protect biodiversity and preserve local germplasm, various landraces have to be characterized using morphological characters, whose expression can vary depending on environmental factors and production conditions (Estrada *et al*. 2002), assessed by molecular markers (PCR, RAPD) (Pikersgill 1997; Lester 1998; Paran *et al*. 1998).

The aim of the present study was to agronomically characterize some local populations, among the best known and most widely consumed in Tunisia, grown in an open field exposed to high temperature. The aim of classifying the morphological characters and capsaicinoid content of different parts of mature green and red fruits was to select the best landraces for productivity and fruit quality.

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MATERIALS AND METHODS

Plant material and growth conditions

Seven local populations of hot pepper were used as representative landraces of three regions, Cap Bon, Kairouan and Sahel, each considered a separate population (**Table 1**): 'Baklouti Essahel', 'Rouge Long', 'Chaabani', 'M'sarreh', 'Fort de Korba', 'Baklouti Kairouan' and 'Piment de Sesseb'. Seeds of those materials were sown in alveolar containers consisting of 180 cells and containing fertilized peat (nitrogen, phosphorus and potassium, N-P-K, 12-14-24). When the 6-8th leaves emerged, 50 plants were transplanted on April, 25th 2005, to on open field at a density of 3 plants/m² after soil fertilization with N, P and K according to Chaux and Foury (1994). The experiment was a completely randomized design with four replications of each treatment/plot. Only a single season was assessed.

Irrigation and fertilization were applied as needed. Climatic factors, namely day and night temperatures, and daily relative humidity, were recorded using a thermohydrograph Temperature/Humidity Recorder (Enercorp Instrument Ltd). Monthly averages are illustrated in **Table 2**.

Table 1 Seven landraces of hot pepper used in this study.

Population designation	Place of origin (Province)
Baklouti Essahel	Sahel (Bekalta)
Rouge Long	Sahel (Teboulba)
Chaabani	Kairouan (Chebika)
M'sarreh	Kairouan (Chebika)
Baklouti Kairouan	Kairouan (Sbikha)
Piment de Sesseb	Kairouan (Sesseb)
Fort de Korba	Cap Bon (Korba)

Table 2 Environmental conditions during the period of the experiment in an open field in 2005.

	June	July	August	September
Day temp. (°C)	31.5	35.8	34.8	33.04
Night temp. (°C)	19.8	20.27	20.44	19.31
Relative humidity (%)	64.12	66.22	63.89	62.14

Plant growth and flowering

120 days after plantation, corresponding to the highest temperature period of the year, some vegetative parameters were recorded on 30 plants within each population. The height of the first bifurcation, an indicator of pepper earliness (Pochard *et al*. 1992; Tarchoun *et al*. 2003), the date of the first visible flower (expressed by number of days from plantation to the appearance of the first flower), plant height (from the cotyledonary leaves to the highest shoot), number of bifurcations/plant, leaf area, number of flowers and fruits/plant, percentage fruit set and total marketable yield/plant were assessed and recorded. 30 fruits (1st and 2nd harvest) were harvested for each population at green maturity to determine the main parameters: weight, length, diameter, thickness of the pulp, length of the placenta and number of seeds.

Data analysis for agronomic characters was performed using SAS v. 6.0. One-way analysis of variance (ANOVA) was used to separate the means, which were compared by Duncan's multiple range test at $P = 0.05$.

Capsaicinoid analysis

Simultaneously, 10 mature fruits (collected for each population) were harvested at the green and red stages. They were cut into three equal parts: upper, median and lower. In separate samples also with 10 fruits, we extracted the placenta, the seeds, the placenta + seeds and the pulp from green and red mature fruits for every population. All parts of the fruit were oven-dried at 60°C until constant weight (2 to 3 days) and then ground by a mini-grinder for capsaicinoid analysis. Capsaicinoids were extracted and analyzed by HPLC (Hewlett Pachard Ti-series 1050) according to the method of Collins *et al*. (1995) with some modification as indicated next. 2 g of each pepper sample ground was mixed with 20 ml of acetonitrile and kept for 4 h at 80°C in a water bath with constant shaking and without reflux. Then, after cooling, the supernatant of each extract was further filtered through a 0.45 µm nylon filter before the HPLC analysis. A waters HPLC (Hewlett Pachard Ti-series 1050) equipped with a Nova-pack C18 reverse phase column ODS of 4 × 250 mm was used. The mobile phase was isocratic, methanol/water at a ratio of 82:18, and the flow rate was 0.7 ml/min and run for a total of 10 min. The HPLC instrument was equipped with fluorescence detectors at 280 nm excitation and emission at 338 nm. 5 µl of any filtrate was injected at the HPLC in order to determine the total capsaicinoid content in every part of pepper fruit. The procedure was repeated three times for each sample; data was presented as means ± standard errors.

Standards of capsaicin and dihydrocapsaicin were obteined from Sigma Chemical Co. (St Louis, MO) and were used for verification of retention-time and instrument calibration. The mean retention-time of capsaicin and dihydrocapsaicin under these conditions were 4.58 and 5.21 min, respectively.

RESULTS AND DISCUSSION

Growth parameters

Table 3 presents three growth parameters of seven hot pepper landraces: height, total number of bifurcations/plant and leaf area.

Plant height

120 days after plantation, plant height differed depending on the population. 'Chaabani' plants were tallest (72 cm) while 'Baklouti Kairouan' plants were shortest (52 cm) (**Table 3**); 'Rouge long', 'M'ssareh', 'Piment de Sesseb', 'Baklouti Essahel' and 'Fort de Korba' had a narrow plant height ranging from 53 to 58 cm without significant differences. Taller 'Chaabani' plants from the Kairouan population would partly justify its high production (**Table 4**).

Working on hot pepper populations grown on open field, Alegbejo and Orakwue (2002) found about 42 pepper cultivars with an average of 63 cm in plant height. Differences could be attributed differences in performance of local populations and environmental conditions. High temperature (> 30°C) during the vegetative stage negatively affects the development of leaves and is considered to be the temperature threshold for growth in pepper (Aloni *et al*. 1999).

Number of bifurcations

A high number of bifurcations or branching nodes/plant, the potential site of flowering in pepper, was observed in 'Baklouti Essahel', 'Chaabani', 'M'sarreh and 'Fort of Korba', which grouped together with an average of 247 bifurcations/plant; 'Rouge long', 'Baklouti Kairouan' and 'Piment de Sesseb' developed 182, 205 and 169 bifurcations, respectively (**Table 3**).

Differences in the number of bifurcations can be attributed to genetic differences and to sensitivity to high temperature during the growth phase. Some studies have shown that environmental conditions influence pepper growth, particularly bifurcation number, thus limiting productivity. In

Table 3 Growth parameters of seven local pepper populations grown in an open field.

Growth parameters	PH	NTB	LA (mm²)
Baklouti Essahel	54.64 cbd	267.05 a	1436.4 d
Rouge Long	58.37 b	182.1 c	2204 bc
Chaabani	71.57 a	242.5 ba	2548.5 ba
M'sarreh	58.27 b	242 ba	2051.6 c
Baklouti Kairouan	51.62 d	205.25 bc	2587.7 a
Piment de Sesseb	56.81 cb	169.56 c	2325.8 bac
Fort de Korba	52.49 cd	238.7 ba	2454.7 ba

PH: plant height, NTB: Number of total bifurcations/plant; LA: leaf area.
Means within the same column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

Table 4 Earliness of flowering, level of the first bifurcation, Number of flowers and fruits/plant, fruit set percent and total yield/plant for seven hot pepper accessions grown in an open field.

Flowering parameters	DAP	H1B (cm)	NFl	NFr	Fruit set (%)	Yield (g)
Baklouti Essahel	30.85 cb	12.19 d	172..25 a	40.65 b	24.033 cb	506.09 de
Rouge Long	38.4 a	15.77 a	125.75 b	45.05 ba	35.33 a	718.68 dc
Chaabani	31. 8 b	12.93 dc	184 a	49.8 a	28.64 b	863.27 a
M'sarreh	28.5 d	14. 21 bc	176.2 a	45.2 ba	26.56 cb	640.06 bc
Baklouti Kairouan	32.2 b	14.32 bc	129.6 b	28.9 c	23.23 cb	752.03 ba
Piment de Sesseb	29.5 cd	15.16 ba	110.4 b	40.55 b	36.56 a	598.71 bc
Fort de Korba	25.85 e	12.02 d	165.75 a	37.85 b	22.61 c	420.83 e

DAP: Earliness of flowering, H1B: height of the first bifurcation, NFl,: Number of flowers/plant; NFr: Number of fruits/plant.
Means within the same column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

Table 5 Fruit characteristics, weight, length, diameter, length of placenta, pulp thickness and number seed/fruit of seven pepper accessions grown in an open field.

Fruit characteristics	BE	RL	CH	M	BK	PS	FK
Weight (g)	22.75 c	20.62 c	33.30 a	22.87 c	29.9 b	21.0 c	21.31 c
Length (cm)	5.91 d	10.09 b	12.25 a	9.21 c	9.05 c	10.13 b	9.74 cb
Diameter (cm)	3.58 a	2.61 dc	3.26 b	2.78 c	3.64 a	2.64 dc	2.35 d
Placenta length (cm)	3.94 d	7.89 c	10.40 a	7.50 c	7.25 c	7.79 c	8.77 b
Pulp thickness (cm)	0.27 b	0.23 cbd	0.31 a	0.24 cb	0.23 cd	0.21 cd	0.20 d
Number of seeds	162.75 b	167.85 b	170.55 b	172.20 b	189.05 a	166.10 b	161.55 b

BE: Baklouti Essahl, RL: Rouge Long, CH: Chaabani, M: M'sarreh, BK: Baklouti Kairouan, PS:Piment de Sesseb; FK: Fort de Korba.
Means within the same column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

fact, it was found that high soil and night temperature reduced the number of leaves that developed from the cotyledon stage until flowering (Rylski 1986). Yaping and Heins (1996) showed that seedling stem, length, and internode length were primarily functions of average daily temperature. Comparing 10 local pepper varieties, Tarchoun (2001) found that the number of bifurcations was negatively affected by an average low temperature regime of 22/7°C.

Leaf area

'Baklouti Kairouan', 'Chaabani', 'Fort de Korba', 'Piment de Sesseb' and 'Rouge Long' had similar leaf area ranging from 2200 to 2600 mm²; 'M'sarreh' and 'Baklouti Essahel' had the smallest leaves (< 2000 mm²) (**Table 3**). De swart *et al.* (2004) found that average leaf area ranged from 188 to 548 cm² in four *C. annuum* accessions grown under glasshouse conditions at 22.5/18°C. Studies by Agrawal *et al.* (1993) indicated that *Cucumis sativus* ('Poinsett and 'Ashly') plant growth under negative difference of day-night temperature (DIF) produced one half to one third less growth than those grown under positive DIF based on stem height, leaf area and suggested that this reduction is likely related to reduce photosynthesis associated with less chlorophyll.

Flowering and fruiting characteristics

The position of the first flower, expressed by the number of days after plantation (DAP) to the first visible flower, and the level of the first bifurcation, the potential site of the first flower, showed variability between the different local accessions. 'Fort de Korba' showed earliest flowering, while 'Rouge Long' was the latest (**Table 4**).

The ability to flower and set fruit divided local pepper accessions into two groups: 1) 'Chaabani', 'M'sarreh', 'Baklouti Essahel' and 'Fort de Korba' had the highest number of flowers (> 160 flowers/plant); 2) fewer flowers in 'Baklouti Kairouan', 'Rouge Long' and 'Piment de Sesseb' (110-130 flowers/plant). 'Chaabani', 'Rouge Long' and 'M'sarreh' developed the most fruit: 45-50 fruits/plant; 'Baklouti Kairouan' formed the fewest. The production of all other accessions was intermediate (38-41 fruits/plant). Fruit set percentage did not exceed 37% for all landraces. Despite their low percentage fruit set, 'Chaabani' and 'Baklouti Kairouan' produced a good marketable yield (863 and 752 g/plant, respectively); 'Fort de Koorba' yielded the least, 421 g; the remaining accessions yielded 506 to 719 g/plant, corresponding to the two harvests (**Table 4**). These populations/accessions expressed variable behavior under open field conditions (season crop) characterized by elevated temperature. Pepper flowering and fruit set are largely conditioned by several factors: endogenous (genotype), ecological (geographical origin, pedoclimatic and cultivation conditions) (Aloni *et al*. 1991; Usman *et al*. 1999; Aloni *et al*. 2001). According to Ltifi and Harbaoui (1992), who compared some local pepper cultivars grown in an open field, the low productivity of these cultivars was attributed to their sensitivity to high temperature that occurred during the crop season (April to September).

High temperatures strongly influence reproductive development, fruit growth and yield of chili pepper (var. 'Shishito') (Pagamas and Nawato 2008). Erickson and Markhart (2001, 2002) showed that elevated temperature during post-pollination reduced fruit set of bell pepper populations 'Ace' and 'Bell Boy'.

Fruit characteristics

The results of morphological traits of 30 fruits for each population are depicted in **Table 5**. 'Chaabani' developed the heaviest and longest fruits (33.3 g and 12.25 cm, respectively) and is considered the most suitable landrace for fresh market production in an open field. Fruit shape depends largely on the variety but it is also influenced by environmental conditions, especially the temperature regime. Post-anthesis high temperature has various adverse effects on pepper fruit and seed development, such as reduced fruit length and number of seeds/fruits (Pagamas and Nawata 2007, 2008). Pepper fruits developed under temperature stress are usually malformed (Rylski 1986) resulting in low seed set (Kato 1989). The landraces used in our study, however, had a length/diameter ratio of > 3, except for 'Baklouti', indicating that fruit shape was not severely affected by high temperature and that variability was attributed to genotypic differences.

Capsaicinoid analysis

The total amount of capsaicinoids in different parts of fresh mature fruits for all accessions varied according to the stage of maturity and part of the fruit (**Tables 6**, **7**). High total capsaicinoid content was observed in 'Piment Sesseb', 'M'sarreh' and 'Rouge Long'; 'Baklouti Kairouan' had the lowest content. The former three accessions are recommended for season crop (summer period) production; they

Table 6 Total capsaicinoid content (ppm) in different parts of green mature fruit evaluated in seven hot pepper accessions grown in an open field.

	Baklouti Sahel	Rouge Long	Chaabani	M'sarreh	Baklouti Kairouan	Piment Sesseb	Fort de Korba
Upper part	375.21* ± 5.23	1088.43 ± 42.03	225.30 ± 19.12	1197.11 ± 32.75	18.35 ± 0.45	1101.69 ± 80.66	488.86 ± 46.42
Median part	92.00 ± 3.12	362.14 ± 41.78	159.83 ± 19.88	705.77 ± 46.25	13.58 ± 1.10	564.71 ± 28.87	170.36 ± 14.16
Lower part	78.43 ± 14.13	327.56 ± 132.34	126.00 ± 12.09	627.08 ± 145.07	3.43 ± 0.37	259.60 ± 7.36	182.16 ± 16.07
Placenta and seeds	290.53 ± 9.23	1167.92 ± 271.34	254.30 ± 62.03	962.18 ± 34.47	66.67 ± 8.78	1284.01 ± 70.27	734.82 ± 98.01
Placenta	420.00 ± 66.12	2264.21 ± 132.90	460.63 ± 10.12	2273.31 ± 22.95	278.97 ± 1.49	3056.60 ± 46.62	1514.29 ± 54.77
Pulp	82.18 ± 2.04	325.81 ± 12.69	19.88 ± 0.63	348.78 ± 7.88	73.73 ± 0.19	249.27 ± 28.81	140.48 ± 4.51
Seed	45.29 ± 3.15	184. 98 ± 7.32	32.92 ± 17.97	170.62 ± 15.98	38.12 ± 0.79	277.53 ± 7.81	52.84 ± 2.25

* means ± SE (3 replications for each fruit part)

Table 7 Total capsaicinoid content in different parts of red mature fruit evaluated in seven hot pepper populations grown in open field during season culture (ppm).

	Baklouti Sahel	Rouge Long	Chaabani	M'sarreh	Baklouti Kairouan	Piment Sesseb	Fort de Korba
Upper part	304.69 ± 39.73	453.46 ± 66.21	129.96 ± 59.70	475.66 ± 60.61	15.29 ± 0.80	853.05 ± 11.96	165.25 ± 4.30
Median part	64.47 ± 1.57	282.28 ± 11.92	74.06 ± 4.01	396.82 ± 68.67	13.81 ± 0.42	410.06 ± 58.30	104.79 ± 16.36
Lower part	69.77 ± 1.71	179.19 ± 42.39	28.35 ± 8.52	184.87 ± 33.02	3.10 ± 0.12	259.82 ± 49.67	70.93 ± 2.58
Placenta and seeds	156.46 ± 24.37	1083.32 ± 32.25	89.45 ± 37.94	175.92 ± 3.84	57.97 ± 13.75	900.66 ± 18.11	391.75 ± 99.55
Placenta	179.14 ± 15.28	2028.99 ± 84.14	127.93 ± 22.38	607.45 ± 12.66	64.69 ± 10.55	2328.00 ± 57.65	794.17 ± 219.53
Pulp	73.46 ± 2.63	74.28 ± 3.54	57.47 ± 5.72	166.67 ± 5.28	16.36 ± 1.74	196.12 ± 13.09	72.27 ± 2.24
Seed	39.77 ± 6.53	50.64 ± 12.46	19.86 ± 3.85	38.68 ± 6.48	5.02 ± 0.18	171.11 ± 16.44	25.99 ± 1.51

* means ± SE (3 replications for each fruit part)

are usually used as dried pepper as well as for processing of *harissa*, a Tunisian export product.

Differences in the level of capsaicinoids have been reported by many authors working on hot pepper and under the same conditions (i.e., open field production). Our findings are in agreement with those of Estrada *et al*. (2002) who showed that the variation of capsaicinoid content in 11 red pepper varieties ranged from 0.78 $mg.g^{-1}$ dry weight (DW) to 1.09 $mg.g^{-1}$ DW for the basal fruit and the apical fruit, respectively. Choi *et al*. (2006) found 3.53 $mg.g^{-1}$ DW for whole dry pepper fruit (chili powder) and 0.43 $mg.g^{-1}$ DW for red pepper powder. De Masi *et al*. (2007), using eight pepper varieties, found the capsaicinoid content to range from 0.66 to 3.69 $mg.g^{-1}$ DW for dry fruit. Sanatombi and Sharma (2008) showed the influence of genotype on capsaicin content and pungency level of six chilli cultivars: 'Umorok' was most pungent with 329.100 Scoville Heat Unit (SHU), and 'Haomorok' had the lowest, with 26.000 SHU.

Capsaicinoid content also differed significantly in different parts of green fruits, highest in the placenta, lowest in seeds for both green and red parts (**Table 7**). De Masi *et al*. (2007) found similar results when comparing fresh fruit (0.38-1.46 $mg.g^{-1}$ FW) and seed (0.08-2.72 $mg.g^{-1}$) of 8 hot pepper genotypes.

Capsaicinoids are accumulated preferentially in the placenta rather than in the pericarp and seeds (Sung *et al.* 2005; Cisneros-Pineda *et al.* 2007; Ornelas-Paz *et al*. 2010). Two pathways are involved in the biosynthesis of capsaicinoids: fatty acid metabolism and the phenylpropanoid pathway. They are synthesized exclusively in the epidermal cells of the placenta in *Capsicum* fruit and are accumulated in blisters along the epidermis (Sung *et al.* 2005).

Estrada *et al*. (2002) reported a higher capsaicinoid content in the placenta than in the pulp since the placenta represents the site of capsaicinoid synthesis and accumulation (Bosland 1994). Zewdie and Bosland (2001), assessing 200 accessions of *Capsicum* spp. by HPLC, noted inconsistent capsaicinoid profiles within a single species, suggesting that it could not be used as a reliable chemotaxonomic indicator for this genus; they also noted that capsaicin and dihydrocapsaicin, the main lipophylic alkaloids in hot pepper, were not always the major capsaicinoids.

Capsaicinoid content in red fruit parts were lower than in green parts (**Table 7**), the difference being as much as 43%. Capsaicin and dihydrocapsaicin accumulate progressively from the 14^{th} day after flowering and continue to increase throughout fruit development to reach a maximum after 42 days (Estrada *et al.* 2000). According to Contreras-Padella and Yahia (1998) capsaicinoid content begins to decrease gradually 45 to 50 days after anthesis. These authors suggested that the degradation of capsaicinoids was correlated with an increase in the activity of peroxidases, which oxidise capsaicin in pepper fruits (Sung *et al.* 2005). Robi and Sreelathakumary (2004) noted that capsaicinoid content varies according to the fruit maturity stage. Significant variation was observed among 10 genotypes of *C. annuum* for capsaicin content at the colour-changing stages (1.26 to 3.02%), at the red ripe stage (1.32 to 3.18%) and at the withering stage (1.48 to 3.36%). De Masi *et al*. (2007) found a high capsaicinoid content in the dried fruit (red stage) more than in the fresh fruit and seeds of 16 Calabrian populations of *C. annuum* ssp.

CONCLUSIONS AND RECOMMENDATIONS

In this study pepper populations were heterogeneous based on growth characteristics, yield and capsaicinoid content. 'Chaabani' showed the highest growth parameters associated with highest yield, while the capsaicinoid level was intermediate and would be recommended for culture in the Kairouan region in an open field season. For Cap Bon, 'Fort de Korba' could be recommended because it has moderate capsaicin content compared to other varieties. For the Sahel, 'Rouge Long' showed the best precocity, high yield and elevated capasaicinoid content.

Based on pungency and agronomic performance the pungent taste of these varieties can be improved by a genetic cross between the best varieties selected. In this sense the parent with the highest average performance would be useful to produce a better genotype for improved capsaicin content in hot peppers.

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