

Full Length Research Paper

Agro-morphologic variations among eleven potato (*Solanum tuberosum* L.) cultivars

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In this work, we studied agro-morphological parameters that could be used to define variation among early, mid-early, mid-late and late potato cultivars, cropped in the main season by quantitative and qualitative parameters (characters of mother tubers, vegetation cover, height of plants, number of leaves, number of true leaves, number of stems, number of stolons, length of first stolon, median diameter of first stolon, caliber of first tuber, final number of tubers per plant and final yield per plant). For the main agro-morphological characters, there were a great variation compared to the control Spunta. Challenger and Fabula showed the highest caliber of mother tubers (49.16 mm), while highest weight of seed tubers was determined on cv. Alegria (125.7 g). Among other characters, challenger produced the largest leaf area (9940.3 mm²). Panamera cultivar has considerable plant height (13.77 cm), the highest number of leaves per plant (63.33) and also the highest number of true leaves (48.48). Moreover, Panamera has the largest length of first stolon with 8.66 cm, (6.16 cm for Spunta). It has also the largest value of median diameter of first stolon with 2.17 mm and followed by Mondial (2.23 mm), Bellini (1.63 mm) and Liseta (2.01 mm). The difference among the cultivars in terms of median diameter of first stolon was statistically significant ($P \leq 0.05$). Liseta has the largest value of caliber of first tuber (37.4 mm), followed by Bellini (37.71 mm), while, Spunta has presented the lowest measures (13.36 mm). For final yield per plant, Bellini outyielded other cultivars with 0.96 kg per plant.

Key words: Potato cultivars, earliness character, variation, agro-morphology, main season.

INTRODUCTION

Potato (*Solanum tuberosum* L.), perennial herb belongs to the Solanaceae family, and shares the genus *Solanum* with at least 1000 other species (Rousselle et al., 1996;

Milbourne et al., 2007). It ranks as the most important crop in the world after wheat, rice and maize (Cromme et al., 2010), with a global production of 325 million tonnes

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(Barat et al., 2012). In Tunisia, potato is an important horticultural crop. In 2012, 23 200 ha were cropped with potato, gave a production of 340 000 tonnes. By 2014, an area of 26 200 ha were cultivated and a maximum of 385 000 tonnes was reached (FAOSTAT, 2014). The crop is grown throughout the year, except for a brief period in early August, the possible growing seasons are early (crop is planted in the northeast coastal areas from November through mid-January and harvest occurs from early March through mid-May), medium-early (crop is planted in the frost-free coastal areas from October to november and harvested from January through mid-March), medium-late or main season (crop is planted in all potato producing areas from mid-January to mid-March, with harvest from mid-May though mid-July) and late (crop is planted from mid-August through mid-October and harvested from mid-November through the end of February).

Potato is known by a high diversity of crop population which is due to genotypic and environmental factors (Smith and Smith, 1989). Martins et al. (2006), demonstrated morphological and agronomic traits are very useful in characterization of plant population, as well as is the first step in description and classification of plant. In the same context, morphological parameters have been used in combined analysis to evaluate potato cultivars for diversity studies (Jaime et al., 2007). Those parameters come forward to the growth processes in different organs according to the stage of development of plants which affect the final size of tubers (Struik et al., 1990). Bielek (1974) showed tuberization, which is a physiological phenomenon marked by the transformation of the mother tuber to a sprouts plant with leafy stems, is depending on a large number of factors including; disease, nutrition, leaf area, environment, mother tubers and genetics. The growth rates of the individual tubers of a plant differ (Mares and Marschner, 1980). Thus, differences must exist in the ability of individual tuber to compete for the limited supply of photosynthate. This process is thought to be controlled by the interaction between genotype and environmental factors. Photoperiod, light quality, temperature and mineral nutrition. However, the influence of these varies factors depending on the cultivar (Barani et al., 2013).

Potato crop have already been studied by assessing soil and climate factors, yield level and yield limiting. However there is a scarce on determining the distribution of cultivars by seasons and regions according to their earliness character and their adaptative characters.

Here we provide a comprehensive developmental study that profiles morphological characters of eleven potato cultivars (*Solanum tuberosum*) in order to discriminate between behaviours of early, mid-early, mid-late and late cultivars cropped and harvested in the same date, to study the effect of cultivar in the growth and yield of potato and to define differences in performance of cultivars with different earliness character.

MATERIALS AND METHODS

A total of eleven potato cultivars was obtained by a certified seed production of Technical Center of Potato and Artichoc, Tunisia (TCPA). The tuber seeds were allowed to sprout and later a number of 180 tubers per cultivar were planted to define agromorphological variation among themselves. Study site was located at the experimental field of the Higher Agronomic Institute of Chott Meriem (ISA-CH-M), the region of Sousse, east coast of Tunisia. The climate characterizes this region is a typical mediterranean climate, with an average temperature of 18.5°C. Annual rainfall is about 300 mm. The irrigation water used is characterized by a salinity of 1.02 g/l and a pH of 8.08. The experiment was laid out in a Completely Randomized Block design (RCBD), with three replications. Tubers were planted with 0.4 m inter row and 1 m intra row spacing. Each plot was 38 m² wide consisting of six rows, which accommodated 30 plants per row and thus 180 plants per plot, the spacing between plots and adjacent replication were 1 m. There was a total of 1245 m² area for experiment site. Six plants from each block for each cultivar were taken, gave a total of 18 plants per cultivar for each date of measure (three dates of measure for the whole experiment). Other characteristics of the field trial is shown in Table 1.

Treatments

Operations of soil preparation, weeding, irrigation and disease control were performed on time equally for all treatments. Plot received water from rainfall and irrigation (rainfall : 187 mm, total water supply : 278 mm). Irrigation system was twice a week for the first four weeks, and thrice a week for the rest of the growing cycle.

Measurements

Quantitative and qualitative parameters of seed tubers

Assessment of these parameters was performed on 12 samples of mother tubers for each cultivar (4 samples for each block). Measurements consist on calibers of mother tubers, weight of mother tubers, weight of mother tubers without sprouts, weight of sprouts, number of sprouts and mean length of sprouts.

Vegetative growth parameters

Leaf area: Leaf area was determined 78 DAP on adult leaves on a random sample with three replicates in blocks. Measurements were made using a leaf area meter. Monitoring of rest of quantitative and qualitative parameters of plants was carried out on three dates: 44, 55 and 81 DAP. Strong and healthy plants are chosen in each block and for each cultivar for the various measures, samples are then transported to the Horticultural laboratory (ISA-CM).

Vegetation cover: Measurement of this parameter was carried out with a grid dimension of 0.8 * 1 m and composed of 80 sections of 10 cm². To estimate vegetation cover, we consider only sections are at least half covered by vegetation and applying the following formula:

% Recovery of soil = number of sections completely or half covered by vegetation * 100 / total number of sections.

Height of plants: Height of plants was determined referring to the height of the longest stem (distance from the soil surface up to the insertion of the petiole of 'uppermost' leaf).

Number of leaves per plant: It is determined by a count of leaves

Table 1. Field trial characteristics.

Cutivars	Field trial										
	Spunta (M-E, control)	Fabula (M-L)	Evora (M-L)	Bellini (M-L)	Dounia (M-L)	Panamera (M-L)	Challenger (ML)	Eden (M-L)	Alegria (E)	Mondial (L)	Liseta (E)
Sprouting	20 days before planting at a temperature range of 8 to 10°C										
Sprouts characters measerments	5 times before planting (every 3 days)										
Date of planting	04 March 2015 DAP										
Fertilization		7	14	21	28	35	42	49	56	63	70
	Ammonitrate (Kg)	9	9	9	9	6	6	3	3	3	3
	Phosphoric Acid (l)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
	Soil potassium (Kg)	4	4	4	4	4	4	7	7	7	7
	Tattoo-C (Chlorothalonil + Propamocarb) (250 ml / hl), 30 DAP										
	Ridanebe (80% Manebe), (350 g / hl), 51 DAP										
Chemical control	Penncozeb (Mancozebe), (300 g / hl), 92 DAP										
	DAP										
Samples harvest	44, 55 and 81										
Leaf area measerment	78										
Hilling	21										
Weeding	as needed										
Topkill	76										
Tuber harvest	113										

E, M-E, M-L and L: Early, mid-early, mid-late and late; DAP: Day after planting.

per plant on the main stem.

Number of true leaves per plant: Subject to counting the number of adult leaves per sample.

Number of stems per plant : Provinding by counting the number of stems per plant.

Production parameters

Number of stolons: It consist in a simple counting of the number of stolon for each plant.

Length of first stolon: Since the plant contains several stolons, we just measured the length of first stolon.

Median diameter of the first stolon: Measuring median diameter of first stolon by means of a caliper square.

Caliber of first tuber: This parameter was determined referring to the first tuber of the first stolon using a caliper square.

Number of tubers per plant: Total number of tubers was counting per plant on the shosen samples (this parameter was measured 117 DAP).

Final yeild per plant: This parameter was determined as 117 DAP

by weighting the total yield of potato tubers per plant. It was calculated as kg/plant.

Statistical analysis

Statistical analysis of the various measures was performed by means of the SAS version 6 software, according to the analysis of variance using a General Linear Model (GLM). Effect of cultivars and date of measure on various characters were analyzed using two-way analysis of variance (ANOVA). A Duncan test was used to identify homogenous group. Statistical analysis were conducted using the probability of 0.001. Data for each of characters were recorded at different dates of measure and subjected to statistical analysis and found to be statistically significant at the level of 1%. Correlation coefficients were also calculated using SAS.

RESULTS

Quantitative and qualitative parameters of seed tubers

The result (Table 2) showed the heighest caliber of mother tubers presented by Challenger and Fabula (49.16 mm) which was statistically different compared to Eden (40.00 mm). Statistical analysis for weight of

Table 2. Average effects of cultivars on various characters of mother tubers.

Cultivars	Calibers of mother tubers (mm)	Weight of mother tubers (g)	Weight of mother tubers without sprouts (g)	Weight of sprouts (g)
Spunta	46.66 ^a ±2.07	105.63 ^{bdc} ±16.59	103.65 ^{bdc} ±16.11	1.93 ^{ba} ±0.56
Fabula	49.16 ^a ±2.60	115.45 ^{bac} ±19.78	113.68 ^{bac} ±19.41	1.80 ^{ba} ±0.40
Evora	46.66 ^a ±1.67	119.49 ^{ba} ±16.59	117.65 ^{ba} ±16.26	1.80 ^{ba} ±0.63
Bellini	48.33 ^a ±2.84	76.67 ^f ±9.04	75.72 ^e ±8.93	0.84 ^c ±0.12
Dounia	46.66 ^a ±1.67	119.49 ^{ba} ±16.59	117.65 ^{ba} ±16.26	1.80 ^{ba} ±0.36
Panamera	48.33 ^a ±1.88	95.30 ^{ed} ±11.12	93.19 ^{ed} ±10.84	2.15 ^a ±0.29
Challenger	49.16 ^a ±2.29	113.4b ^{ac} ±12.78	111.95 ^{bac} ±12.53	1.44 ^{bc} ±0.27
Eden	40.00 ^b ±1.51	79.19 ^{ef} ±8.61	77.83 ^e ±8.46	1.33 ^{bc} ±0.18
Alegria	44.09 ^a ±3.45	125.74 ^a ±15.49	123.84 ^a ±15.26	1.86 ^{ba} ±0.24
Mondial	47.50 ^a ±2.18	98.39 ^{dc} ±13.02	97.15 ^{dc} ±12.85	1.15 ^c ±0.22
Liseta	45.88 ^a ±2.29	91.42 ^{edf} ±13.87	90.01 ^{ed} ±13.65	1.35 ^{bc} ±0.26
CV	17.17	19.74	19.63	44.02

Means followed by the same letters are not significantly different ($P < 0.01$) according to Duncan's test.

Table 3. Mean effects of cultivars on individual characters of sprouts of mother tubers.

Cultivars	Number of sprouts	Length of sprouts
Spunta	3.8 ^{bac} ±0.64	7.83 ^c ±1.43
Fabula	3.28 ^{dc} ±0.68	6.08 ^d ±1.37
Evora	3.83 ^{bac} ±0.63	7.14 ^{dc} ±1.10
Bellini	2.86 ^{ed} ±0.52	8.06 ^c ±1.14
Dounia	3.83 ^{bac} ±0.63	7.14 ^{dc} ±1.10
Panamera	3.93 ^{ba} ±0.50	8.18 ^c ±1.25
Challenger	2.26 ^f ±0.39	7.91 ^c ±1.63
Eden	2.36 ^{ef} ±0.28	10.67 ^a ±1.36
Alegria	4.08 ^{ba} ±0.62	9.54 ^b ±1.39
Mondial	3.65 ^{bc} ±0.67	9.54 ^b ±1.62
Liseta	4.3 ^a ±0.68	7.66 ^c ±1.08
CV	41.78	35.86

Means followed by the same letters are not significantly different ($P < 0.01$) according to Duncan's test.

mother tubers presented a significant difference between cultivars ($P \leq 0.01$). The highest weight of seed tubers was that of Alegria (125.74 g), followed by Evora and Dounia (119.49). Bellini presented the lowest weight with 76.67 g. Analysis of variance of weight of mother tubers without sprouts showed a significant difference between cultivars. The most important value was that of Alegria (123.84 g), followed by Evora and Dounia (117.65 g). Eden and Bellini presented the lowest weight of seed tubers without sprouts with 77.83 and 75.72 g respectively. There was also a difference among cultivars regarding weight of sprouts. The highest weight of sprouts was that of Panamera with 2.15 g, followed by Alegria (1.86g). The lowest value was that of Mondial and Bellini with 1.15 and 0.84 g respectively.

Statistical analysis of number of sprouts presented a highly significant difference between cultivars ($P \leq 0.01$) (Table 3). Liseta showed the highest number of sprouts (4.3), followed by Alegria (4.08) and Panamera (3.93). The lowest number of sprouts was that of Challenger (2.26).

Table 3 showed also the highest length of sprouts that was produced by Eden 10.67 mm, which was significantly different compared to Alegria and Mondial (9.45 mm). The lowest length was that of Fabula with 6.08 mm.

Analysis of variance of number of sprouts revealed a highly significant difference between dates ($P \leq 0.01$) which is showed in Table 3. Figure 1 showed number of sprouts increased from date to date for all cultivars from 3.64 (date 1) to 13.5 (date 2).

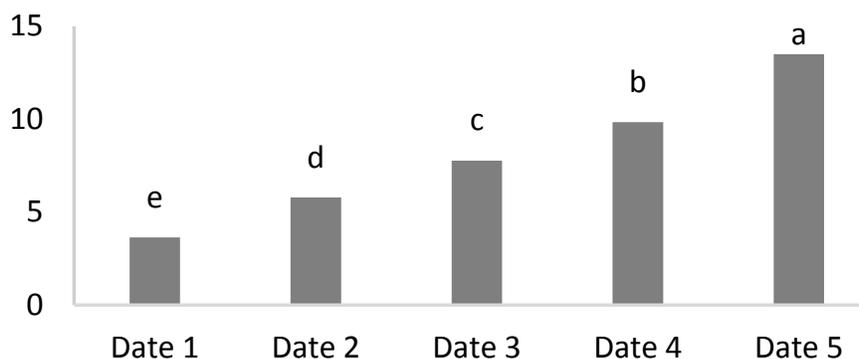


Figure 1. Mean effect of date on number of sprouts.

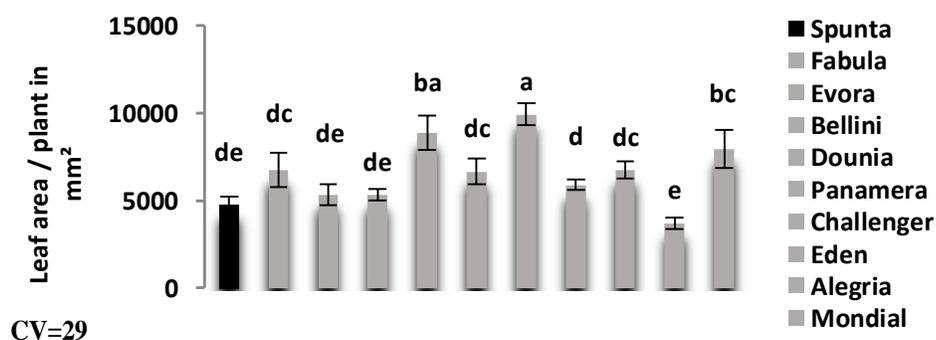


Figure 2. Leaf area per plant depending on cultivar.

Vegetative growth parameters

Leaf area

Challenger produced the largest leaf area (9940.3 mm²), which was statistically significant compared to Mondial (3707.4mm²) (Figure 2).

Vegetation cover

Statistical analysis of vegetation cover revealed a highly significant difference between cultivars (Table 4). Dounia and Mondial showed the most important values that were respectively (18.44%) and (17.55%). The control has a very low soil cover about 11.66%, followed by Fabula (10.77%). There was a significant cultivar-by-date interaction for this parameter (Figure 3), Spunta (control), Fabula, Evora, Bellini, Dounia, Panamera, Challenger and Eden had an increasing trend for three measurement dates. By cons Alegria, Mondial and Bellini are characterized by a decreasing behaviour beyond 55 DAP.

DISCUSSION

Height of plants

Analysis of variance of average plant height, revealed a highly significant difference at level of 1% (Table 4). Panamera cultivar has the highest average height (32.74 cm). While Spunta cultivar presented the lowest height (13.77 cm). There was a significant cultivar*date interaction for this parameter ($P \leq 0.01$), Figure 4 showed evolution of average plant height, studied cultivars showed an increasing trend up to 81 DAP, except Liseta which showed a decrease in plant height in end of vegetative cycle. This figure showed also Panamera has the largest average height during all measurement dates.

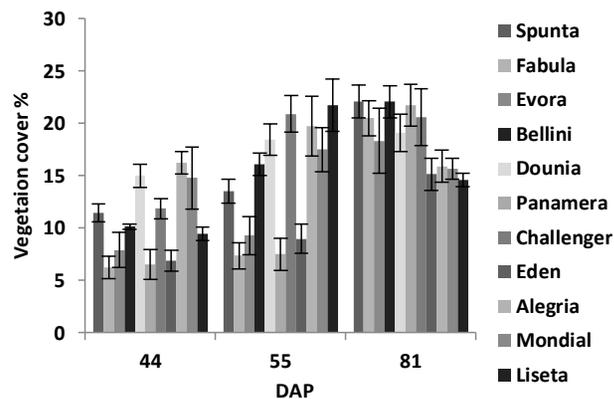
Number of leaves per plant

Table 4 showed Panamera produced more number of total leaves (63.33) which was significantly different ($P \leq 0.01$) compared to Dounia. There was a significant cultivar* date interaction for total number of leaves

Table 4. Average effects of cultivars on various characters.

Cultivars	Vegetation cover (%)	Average height of plants (cm)	Total number of leaves	Number of mature leaves	Number of main stems	Number of stolons	Length of first stolon (cm)	Median diameter of first stolon (mm)	Caliber of first tuber (mm)
Spunta	11.66 ^{fe} ±2.37	13.77 ^f ±6.55	44.55 ^c ±7.37	30.44 ^c ±9.17	4.66 ^a ±0.91	6.88 ^c ±1.27	6.16 ^{bc} ±2.54	1.22 ^d ±0.32	13.36 ^d ±9.71
Fabula	10.77 ^f ±3.30	20.66 ^e ±4.67	37.29 ^d ±6.65	20.91 ^d ±5.79	2.51 ^b ±0.37	8.14 ^{bac} ±2.62	6.67 ^{bac} ±2.05	1.64 ^{bdc} ±0.40	27.01 ^{bc} ±7.98
Evora	15.00 ^{cd} ±3.96	20.44 ^e ±3.73	37.44 ^d ±5.01	21.77 ^d ±5.07	2.94 ^b ±0.67	9.88 ^a ±1.85	4.50 ^c ±1.67	1.48 ^{dc} ±0.50	27.56 ^{bc} ±12.57
Bellini	15.33 ^{cb} ±2.26	24.88 ^d ±7.09	42.81 ^{dc} ±8.71	30.00 ^c ±5.49	3.00 ^b ±0.77	8.22 ^{bac} ±2.15	6.25 ^{bc} ±1.75	1.63 ^{bdc} ±0.35	31.73 ^{ba} ±12.82
Dounia	18.44 ^a ±1.82	24.81 ^d ±5.48	50.63 ^b ±8.60	31.40 ^c ±8.26	2.74 ^b ±0.38	7.40 ^{bc} ±1.58	7.04 ^{ba} ±1.81	1.36 ^d ±0.31	20.43 ^{dc} ±9.46
Panamera	16.00 ^{cb} ±4.06	32.74 ^a ±5.46	63.33 ^a ±12.20	48.48 ^a ±11.68	2.88 ^b ±0.58	7.70 ^{bc} ±2.07	8.66 ^a ±3.02	2.17 ^a ±0.42	27.05 ^{bc} ±10.12
Challenger	12.22 ^e ±1.83	30.44 ^{ba} ±6.50	40.00 ^{dc} ±6.83	29.77 ^c ±5.01	4.51 ^a ±0.76	9.29 ^{ba} ±1.55	4.90 ^{bc} ±1.31	1.51 ^{dc} ±0.34	27.90 ^{bc} ±8.37
Eden	14.11 ^d ±3.25	21.37 ^e ±5.27	26.14 ^e ±3.80	15.44 ^e ±3.10	2.44 ^b ±0.43	7.81 ^{bc} ±1.93	4.83 ^{bc} ±2.05	1.57 ^{bdc} ±0.50	21.73 ^c ±7.43
Alegria	16.16 ^b ±1.17	31.11 ^{ba} ±6.22	50.50 ^b ±6.97	40.27 ^b ±6.36	3.00 ^b ±0.69	8.33 ^{bac} ±2.15	6.27 ^{bc} ±2.91	1.89 ^{bac} ±0.46	26.81 ^{bc} ±10.68
Mondial	17.55 ^a ±2.19	29.25 ^{bc} ±7.30	41.11 ^{dc} ±6.03	31.25 ^c ±6.46	2.62 ^b ±0.62	7.88 ^c ±1.61	5.25 ^{bc} ±1.74	2.23 ^a ±0.40	26.73 ^{bc} ±10.77
Liseta	15.55 ^{cb} ±3.17	27.51 ^{dc} ±4.89	37.81 ^d ±9.33	21.63 ^d ±4.66	3.00 ^b ±0.72	7.00 ^c ±1.78	6.20 ^{bc} ±1.95	2.01 ^{ba} ±0.53	37.40 ^a ±9.63
CV	11.12	17.28	21.15	27.69	34	34	54	41	44

Means followed by the same letters are not significantly different ($P < 0.01$) according to Duncan's test.

**Figure 3.** Changes in vegetation cover per plant.

($P < 0.01$), Figure 5 showed cultivars had evolved differently from one to other. Spunta (control), Fabula, Evora, Bellini, Dounia and Panamera had

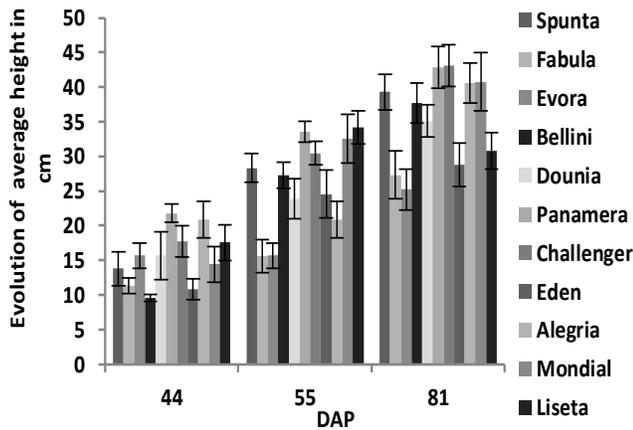


Figure 4. Evolution of average height per plant.

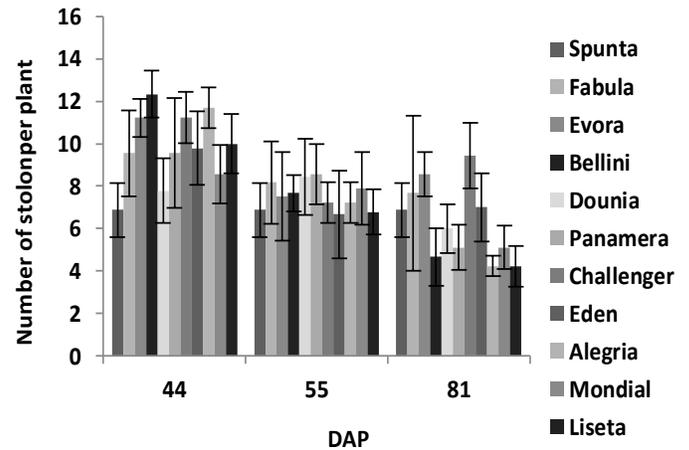


Figure 7. Evolution of number of stolons per plant.

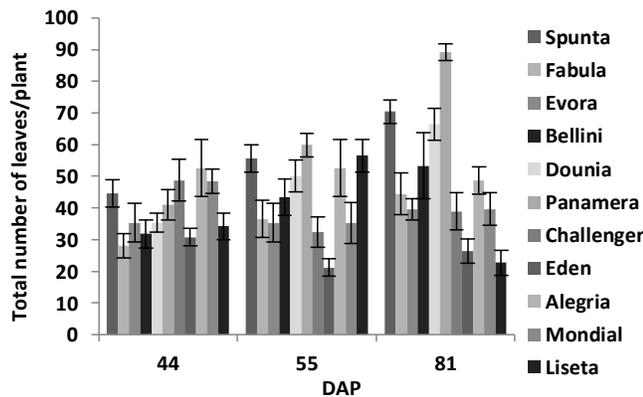


Figure 5. Evolution of total number of leaves per plant.

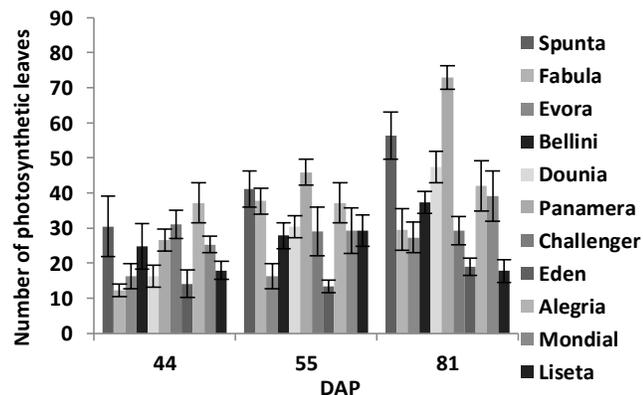


Figure 6. Interaction cultivar*date for number of true leaves.

a steady increase up to 81 DAP. By cons cultivars Challenger, Eden, Alegria, and Liseta suffered a decrease in total number of leaves beyond 55 DAP.

Number of true leaves per plant

Table 4 showed also Panamera cultivar has the highest number of true leaves (48.48), followed by Alegria (40.27). Eden presented the lowest number of adult leaves (15.44). Evolution of average number of true leaves per plant (Figure 6) was different from one cultivar to another. Cultivars Spunta (control), Evora, Dounia, Panamera, Eden and Mondial had an increase in number of photosynthetic leaves up to 81 DAP. Remaining cultivars had a decrease in this parameter during last measurement. Analysis of variance of interaction cultivar*date showed a highly significant difference at level of 1%.

Number of stems per plant

For number of main stems (Table 4), analysis of variance provided a highly significant effect of cultivar on this parameter ($P \leq 0.01$). Spunta and Challenger showed the highest number of stems that was 4.66 and 4.51 respectively. The lowest value was that of Eden cultivar (2.44).

Production parameters

Number of stolons

Analysis of variance of number of stolons showed a significant effect of cultivar on this parameter (Table 4). Evora and Challenger had the most important number of stolons with respectively 9.88 and 9.29 cm. Spunta showed the lowest value with 88. Regarding changes in number of stolons per plant (Figure 7), it was noted that

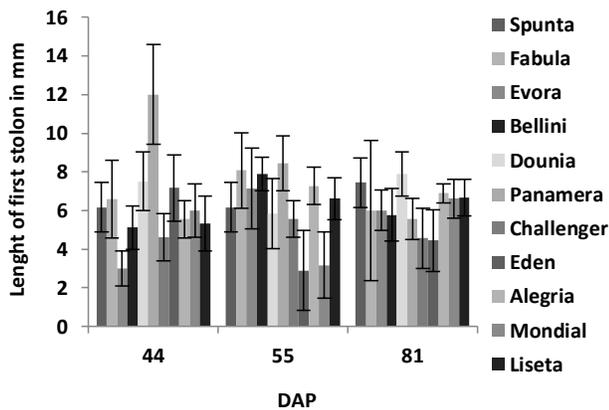


Figure 8. Evolution of length of first stolon per plant.

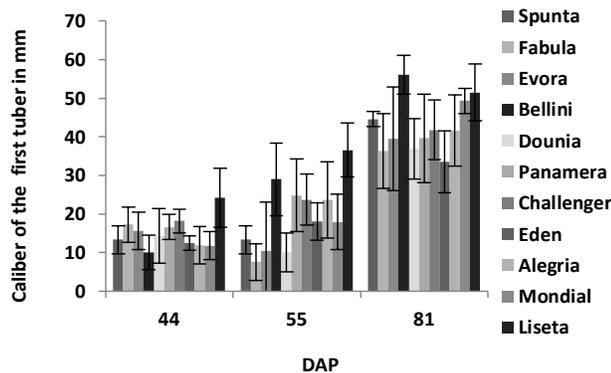


Figure 9. Evolution of caliber of first tuber per plant.

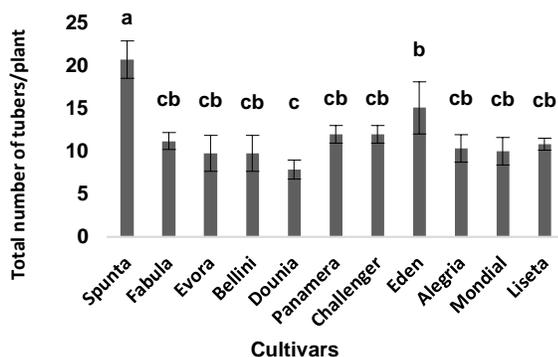


Figure 10. Total number of tubers per plant.

all cultivars had very high values in the beginning (44 DAP), during this time, the largest number of stolons was that of Bellini, while the lowest number of stolons was that of Spunta. A remarkable decrease in this parameter

was recorded after 55 and 81 DAP. Analysis of variance of interaction cultivar*date showed a very highly significant difference ($P \leq 0.01$).

Length of first stolon

Table 4 showed the highest length of first stolon that was produced by Panamera (8.66 cm). Evora showed the lowest value with 4.50 cm. The control was in the middle with 6.16 cm. There was a significant cultivar-by-date interaction for this trait. The change in the Length of first stolon was presented in Figure 8. After 44 DAP, the Panamera cultivar produced the highest Length of first stolon. After 55 DAP, cultivars Spunta, Fabula, Evora, Bellini, Challenger, and Alegria Liseta showed an increasing progression for this parameter. While Dounia, Panamera, Eden and Mondial showed a decrease for this character.

Median diameter of first stolon

For median diameter of first stolon (Table 4), Mondial and Panamera presented the most important values of this parameter (2.23 and 2.17 mm), respectively. Which are statistically significant ($P \leq 0.05$) compared to Spunta (1.22 mm).

Caliber of first tuber

Table 4 presented also Liseta has the largest value of caliber of first tuber (37.40 mm), for cons, the control presented the lowest measure (13.36 mm). There was a significant cultivar-by-date interaction ($P \leq 0.01$). Study of changes in caliber of first tuber (Figure 9) showed a significant increase in this parameter for all cultivars. Bellini, Spunta (control), Mondial and Liseta showed the highest measures for this parameter at 81 DAP.

Final number of tubers per plant

For the number of fruits per plant (Figure 10), analysis of variance make out a highly significant difference between cultivars ($P \leq 0.01$).

Spunta and Edén showed the heighest number of fruits that was 22.7 and 15.11 respectively. The lowest number of tubers was that of Dounia (7.88).

Final yeild per plant

Measure of final yield per plant (Figure 11), showed Bellini produced the heighest yield per plant (0.96 kg), followed by Evora (0.95), which are statistically different

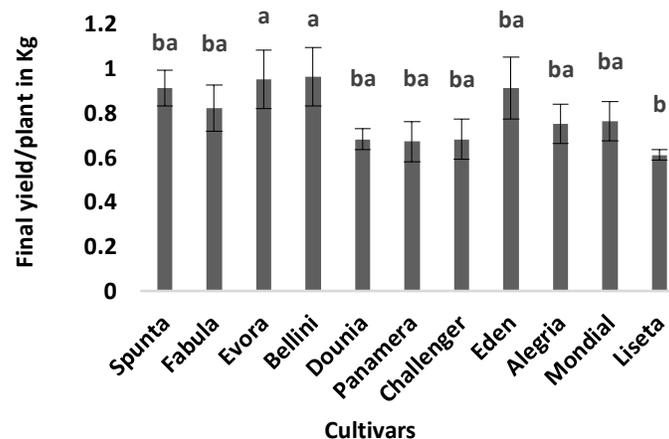


Figure 11. Final yield per plant.

Table 5. Correlations between various characters.

Parameter	Number of stems	Height of the plant	Total number of leaves	Number of mature leaves	Ground cover	Number of stolons	Lenght of first stolon	Median diameter of first stolon	Caliber of first tuber
Number of stems	1								
Plant height	0.086 ^{ns}	1							
Total number of leaves	0.333 ^{ns}	0.434 ^{ns}	1						
Number of mature leaves	0.288 ^{ns}	0.568*	0.804**	1					
Ground cover	-0.032 ^{ns}	0.555*	0.410 ^{ns}	0.442 ^{ns}	1				
Number of stolons	0.093 ^{ns}	-0.377 ^{ns}	-0.087 ^{ns}	-0.140 ^{ns}	-0.234 ^{ns}	1			
Lenght of first stolon	0.018 ^{ns}	0.041 ^{ns}	0.167 ^{ns}	0.095 ^{ns}	-0.023 ^{ns}	0.010 ^{ns}	1		
Median diameter of first stolon	-0.161 ^{ns}	0.149 ^{ns}	0.078 ^{ns}	0.067 ^{ns}	0.108 ^{ns}	0.080 ^{ns}	0.306 ^{ns}	1	
Caliber of first tuber	-0.013 ^{ns}	0.568*	0.186 ^{ns}	0.267 ^{ns}	0.296 ^{ns}	-0.394 ^{ns}	0.050 ^{ns}	0.180 ^{ns}	1

** P≤0.01 ; *P≤0.05 ; ns, non- significant.

compared to Liseta (0.61 kg).

Relationship between number of mature leaves, plant height, vegetation cover and caliber of first tuber

There was a positive correlation between plant height, number of mature leaves, vegetation cover and caliber of first tuber ($P \leq 0.05$) (Table 5). This correlation provided increasing of plant height, increased number of adult leaves, vegetation cover and caliber of first tuber.

Relationship between number of mature leaves and total number of leaves

Table 5 showed a strong positive correlation between

total number of leaves and number of mature leaves ($P \leq 0.01$). This result showed number of mature leaves was increased by increasing number of total leaves.

This study characterized differences in growth and yield between early, mid-early, mid-late and late potato cultivars. For all measured parameters, except, plant height and median diameter of first stolon, we observed significant differences between cultivars and significant cultivar-by-date interaction. This indicates cultivars behaved differently. Those different behaviours could be a result of combined factors including cultivar (genetics) and climatic conditions. In this context, Ghebreslassie et al. (2016), revealed environment had a significant effect on growth and performance of plants. This purpose is also in consistency with results found previously by Teshome et al. (2014) showed a number of differences in morphological traits among and within cultivars. Those

Table 6. Agro-Morphological characteristics of cultivars by the best performance.

Cultivars	Vegetation cover (%)	Average height of plants (cm)	Total number of leaves	Number of mature leaves	Number of main stems	Number of stolons	Length of t first stolon (cm)	Median diameter of first stolon (mm)	Caliber of first tuber (mm)	Total number of tubers per plant	Final yield per plant
Spunta (M-E)					***					***	
Fabula (M-L)											
Evora (M-L)						***					***
Bellini (M-L)											***
Dounia (M-L)	***										
Panamera (M-L)		***	***	***			***	***			
Challenger (M-L)					***						
Eden (M-L)											
Alegria (E)											
Mondial (L)	***							***			
Liseta (E)									***		

***Cultivar from homogeneous group a.

variations were probably due to genetic factors.

This agro-Morphological characteristic study notify growth and production performances of plants are strongly affected by the cultivar (table 6).

It was reported that tuberization process depend on characteristics of mother tubers planted which include number of sprouts and caliber of mother tubers. Plants from larger seed potato tubers exhibited greater physiological growth and yield in comparasion with smaller seed tubers (Masarirambi et al., 2012), same study showed seed tubers size had an effect in leaf area, leaf number, number of potato tubers and stem number. Seed tubers used in this test are characterized by high variability. We found a significant difference between cultivars regarding caliber of mother tubers, weight of mother tubers, weight of mother tubers without sprouts, weight of sprouts, number of sprouts and length of sprouts. Furthermore, average leaf area was found to have variation for all cultivars. These results are in agreement with those communicated by Khan et al. (2012). The eleven potato cultivars studied were characterized by high variability in vegetation cover. A significant interaction date-cultivar is also showed for this parameter, cultivars behaved differently from one to other, this difference is probably due to their earliness character. Plant height analysis in current experiment revealed also a high level of variation for all studied cultivars. These results are similar to those reported by Khan et al. (2012), a significant interaction cultivar-by-date was also showed for this parameter. However, variation of total number of leaves was observed for all cultivars. Panamera produced maximum number of leaves. High variability has been achieved for number of

leaves per plant by Masarirambi et al. (2012) and Khan et al. (2012). Significant differences of cultivars was showed for adult leaves. Cultivars had evolved differently between decreasing and increasing from first to last date of measure. Gandin (2010) proved in first days after planting, hydrolysis can power reserve carbohydrate expansion of leaf apparatus and underground unit. In our study we found a significant effect of cultivar on number of stems. These results are in comparasion with those reported earlier by Khaliq (2002) and Masarirambi et al. (2012). Number of stolons per plant revealed a considerable amount of variation among eleven cultivars. Mean values ranged from 9.88 to 6.88, indicating a high level of variation for this trait. Analysis of variance of interaction cultivar * date showed a significant difference at 1% level. Lenght of first stolon revealed a considerable amount of variation among all cultivars. A significant interaction date-by-cultivar was showed for this character. A high level of variation was observed for median diameter of first stolon, Panamera and Mondial presented the most important values (2.23 and 2.17 cm) respectively. High variation has also been acheived for caliber of first tuber among all cultivars. A significant interaction date-cultivar was also observed for this trait. Bielek (1974) showed that performance of potato crop is depending on a large number of factors including, disease, nutrition, leaf area, environment, mother tubers and genetics. There was a positive correlation between plant height, number of mature leaves, vegetation cover and caliber of first tuber ($P \leq 0.05$). A strong positive correlation between total number of leaves and number of mature leaves ($P \leq 0.01$). Relationship between number of stems and number of stolons (Cother and

Cullis, 1983), and number of stolons and tubers (Wurr, 1977; Haverkort et al., 1990) has rarely been reported. Number of fruit per plant revealed a considerable amount of variation among all cultivars. Mean values ranged from 22.77 to 7.88 tubers per plant, indicating a high level of variation for this trait. These findings are in keeping with those of Rashidi (2009) showed that number of tubers per plant is 3 to 10 tubers and it has a high correlation with number of produced stem. Average yield per plant was found to have variation for all cultivars. Rezaii et al. (1996) presented that determining tuber weight is influenced by two major factors such as tuber size and number of produced tubers per unit.

Conclusion

Results showed analysis of quantitative and qualitative parameters of seed tuber concerning caliber of mother tubers, weight of mother tubers, weight of mother tubers without sprouts, weight of sprouts, number of sprouts and mean length of sprouts showed a difference between cultivars. Results showed also analysis of vegetative growth parameters regarding leaf area, vegetation cover, height of plants, number of leaves per plant, number of true leaves per plant and number of stems per plant indicate a significant difference between cultivars. Analysis of production parameters showed number of stolon, length of first stolon, median diameter of first stolon, caliber of first stolon, final number of tubers per plant and final yield per plant was statistically different from one cultivar to another. There is an interaction date-by-cultivar for major measured parameters except number of stem and median diameter of first stolon. Cultivars behaved differently during their development cycle. There is also a positive correlation between total number of leaves and number of mature leaves ($P \leq 0.01$), And a positive correlation between plant height, number of mature leaves, vegetation cover and caliber of first tuber ($P \leq 0.05$).

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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