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Morphological and Phenological Characterization of Some Potato Cultivars in Turkey[1]

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Abstract: Fifteen potato cultivars were morphologically and phenologically characterized under greenhouse conditions in 2019 and 2020. The highest percentage of emergence was 100% in L-Olympia and the lowest was 12.5% in Malice within the first 25 days after planting (DAP). The duration to complete 100% emergence was 7.33 days in Soleia as the shortest period, meanwhile, it was 15.67 days in Triomphe. The stems number ranged between 2.13 in both Passion & Aurea and 7.50 in L.Olympia. The highest plant was 14.71, 35.83 at 25, 35, respectively in L-Olympia and 80.33 cm in Blondine at 45 DAP. The lowest height was 3.21, 9.13 and 46.17 cm at 25, 35, and 45 DAP, respectively in Malice. Only nine cultivars were able to give inflorescences. The highest number of inflorescences was 5.00 in Toronto and the highest number of flowers per inflorescences was 15.00 in Aurea. The flowering duration ranged between 14.33 and 43.20 days in Blondine and Triomphe, respectively. Many correlation coefficient relationships were noted between traits, a significantly positive correlations coefficient between stems number and plant height, stems numbers and tubers number per plant, plant height and tubers number per plant. Meanwhile, significantly negative correlation coefficient was noted between number of stems per plant and average of tuber weight, duration of emergence and plant productivity. Overall results of this study suggest there is a big differences among potato genotypes led to farther morphological and phenological traits can be improved for having most suitable and adaptable potato cultivars in Turkey.

Keywords: potato cultivars, *Solanum tuberosum*, Morphology, Phenology, Flowering, Emergence, Turkey.

توصيف الصفات الشكلية والفينولوجية لبعض أصناف البطاطس في تركيا

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المستخلص: تم توصيف خمسة عشر صنفاً من البطاطس مورفولوجياً (شكلياً) وفينولوجياً ضمن ظروف البيت الزجاجي خلال عامي 2019 و2020. كانت أعلى نسبة انبات 100% لدى الصنف ليه أولومبيا وأقلها 12.5% لدى الصنف ماليكا خلال أول 25 يوماً بعد الزراعة. كانت المدة الزمنية اللازمة لاكتمال الانبثاق 7.33 يوماً في سوليا كأقصر فترة زمنية، فيما كانت 15.67 يوماً في الصنف تريومفي. تراوح عدد السيقان بين 2.13 ساق في كل من الصنفين أوريا وبيجين و(7.50 ساق) في الصنف ليه اولومبيا. كان أعلى طول للنبات 14.71 سم و35.83 سم عند عمر 25 و35 يوماً على التوالي في الصنف ليه أولومبيا و80.33 سم عند عمر 45 يوم لدى الصنف بلوديني. كان أدنى طول للنبات 3.21 سم،9.13 سم و46.17 سم عند عمر 25، 35 و45 يوماً على التوالي لدى الصنف ماليكا. تسعة أصناف فقط كانت قادرة على إعطاء نورات زهرية، إذ إن أعلى عدد للنورات كان (5.00) في الصنف تورينتو وأعلى عدد للأزهار في النورة الواحدة كان 15.00 لدى الصنف أوريا. تراوحت مدة الإزهار بين 14.33 يوماً و43.20 يوماً في الصنف بلونديني والصنف تريومفي على التوالي. ولوحظت العديد من علاقات معامل الارتباط بين الصفات، إذ وجد علاقة ارتباط موجبة معنوية بين عدد السيقان وارتفاع النبات، وعدد السيقان ومتوسط عدد الدرنات في النبات، ارتفاع النبات ومتوسط عدد الدرنات في النبات. وفي الوقت نفسه، لوحظت علاقة ارتباط سلبية معنوية بين عدد السوق ومتوسط وزن الدرنات، المدة الزمنية اللازمة لاكتمال الانبثاق وإنتاجية النبات. تشير النتائج الإجمالية لهذه الدراسة إلى أن هناك اختلافاً كبيراً بين الأنماط الجينية للبطاطس يمكن من خلاله تحسين الصفات المورفولوجية والفينولوجية للحصول على أصناف أكثر ملاءمة وقابلة للتكيف في تركيا.

الكلمات المفتاحية: أصناف البطاطس، *Solanum tuberosum*، موفولوجي، فينولوجي، إزهار، تركيا.

INTRODUCTION

Potato (Solanum tuberosum L.) is one of the most important vegetable crops in the world with an annual production of more than 365 million tons (FAO, 2018). It grows as a major crop in countries with very large populations in different climatological zones, including temperate regions, the sub-tropics, and tropics, under very different agroecological conditions (Haj Hamed, 2008; Spooner et al., 2005). There are many different cultivars of potato, each cultivar is preferably grown for different purposes of production like industry, cooking, etc. (Ozgonen and Erkilic, 2013).

Because of potato adaptability, yielding capacity, nutrition contribution, and as an important component of diversified cropping systems, has a long history of helping relieve food insecurities, and contributing to improve household incomes in times of crisis and today's population expansion (Campos and Ortiz, 2020).

In Turkey, potato is widely produced in many areas, mainly in Niğde, Konya, Afyonkarahisar, İzmir and Kayseri. The total productivity of potato in 2019 was 4979824 Ton from the cultivated area around /135937 Ha. 83% of the produced potato are locally consumed, 5% is exported and 7% is used as potato seeds, while 5 % is considered as loss (TÜİK, 2019).

Crop emergence and canopy cover are important physiological traits for potato cultivar evaluation and nutrients management. They play important roles in variety screening, field management and yield prediction (Li et al., 2019). Potato emergence dynamics, including emergence rate and uniformity, play important roles in screening varieties (Spitters and Schapendonk, 1990), field management (Ciuberkis et al., 2007; Moran et al., 1997) and yield prediction (Ciuberkis et al., 2007). Consistent emergence is always desirable as it leads to more efficient crop management. Crop canopies

cover directly determines the amount of sunlight interception and hence affects photosynthetic efficiency. The measurement of emergence rate and uniformity is crucially important for field-scale phenotyping, especially in crop breeding and precision agronomy (Li et al., 2019).

Genetic factors affect plant height, number of stems, number of leaves, leaf weight and leaf surface area, leaf width, number of tubers, yield per plant, average weight, length and width, shape, skin color and specific gravity of tuber. Therefore, the varieties of potato differ among themselves in these characteristics (Tessema et al., 2020; Getie et al., 2018; Habtamu et al. 2016; Yıldırım and Ozturk, 2016; Zein et al., 2013).

The potato plant's flowers are formed in semi-inflorescences; each one contains between 1-30 flowers, and this number ranges in most flowering varieties between 7-15 flowers. This is mainly due to genetic factors (Acquaah, 2007).

The flowering and fruiting of potato related with many factors one of them is the genetic factors where the potato varieties differ among themselves to varying degrees in their ability to give flowers and form fruits. As well as the flowering potato varieties differ from each other in the time of their flowering, length of flowering period, size of flower and the color of their petals which is one of the ways to distinguish between them, as they range from white through blue to red and purple (Tessema et al., 2020; Mohamad Alyousef, 2013; Nizamuddin et al., 2007; Sleper and Poehlman, 2006; Acquaah, 2007; Gopal et al., 1994). flowering of potato cultivars ranges from abscission of floral buds after initiation to profuse flowering (Sadik, 1982). Also, Potato varieties differ in their light requirements for flowering, and the short duration of lighting during the flowering period leads to the dropping of the flowering buds (Almekinders and Struik, 1996).

The differences among potato varieties in many characteristics suggested the presence of sufficient genetic differences that might be related to the wide range of parental backgrounds used in the development of these varieties over years. As well as it could be concluded that varietal and environmental variations. In addition to that, considerable influence on tuber yield and the potato's attributes due to the interaction between both varietal and environmental variations. (Tessema et al., 2020).

Many researches on characterization potato cultivars had been done globally, but on the other hand, very few studies describing potato cultivars in Turkey. This study aims to characterize several potato cultivars in morphological and phenological characteristics under greenhouse conditions in Kahramanmaraş, Turkey region in order to start deep breeding process for improving both quantity and quality characteristics of potato cultivars to enhance local and regional food security as a main challenge for the time being.

MATERIAL AND METHODS

This study carried out under greenhouse conditions during 2019 and 2020 growing seasons in Kahramanmaras Sutcu Imam University in East Mediterranean of Turkey. The site is located at 37°35' N latitude, 36°48' E longitude and at an altitude of 545 meters above sea level (Uzun et al., 2018).

Fifteen potato cultivars released by different Turkish companies produced in 2018 and 2019 (Table 1.) were planted in Randomized Complete Block Design (RCBD); the cultivars were as unique factor within 2 blocks and 24 plants of each cultivar were used per block.

Table (1) Tested potato cultivars.

No.	Cultivar	Country of Origin
1	Passion	France
2	Alonso	Austria
3	Husar	Turkey
4	Malice	France
5	Diego	Turkey
6	Galata	Austria
7	Aurea	France
8	Toronto	Holland
9	Triomphe	France
10	Universa	France
11	Melody	Holland
12	L.Olympia	Holland
13	Christel	Germany
14	Soleia	France
15	Blondine	France

Newly produced medium size tubers (40-50 gr), well-sprouted (4-8 buds) as the best certified potato seeds (Jica, 2019) were sowed in plastic pots of 30 cm in diameter and 35 cm in height after filling them with a mixture of peatmoss and perlite in a ratio of 3: 1, respectively (Table 2), in the middle of the pot at a rate of 2 tubers per pot with 5 cm in depth (Mahmood et al., 2001). The pots were irrigated manually during the growth stage at a rate of 1-2 times per week according to age of the plant and the surrounding conditions. Approximately one liter per pot for the first month after planting then increased to two liters per pot for the last two months till harvesting.

Table (2) The specifications of used mixture

Product Name	Klasmann TS 1	Perlite
Color	Black	White
Chemical characteristics	Nitrogen (mg N/l): 140 phosphor (mg P_2O_5/l): 160 potassium (mg K_2O/l): 180 Magnesium (mg Mg/l): 100 All necessary small elements EDTA iron chelates	SiO_2: % 71-75 Al_2O_3: % 12-16 Na_2O: % 2.9-4 K_2O: % 4-5 CaO: % 0.2-0.5 Fe_2O_3: % 0.5-1.45 MgO: % 0.03- 0.2
pH	6	6.5-7.5
Size	<5 mm	<2.5 mm
Origin	Klasmann company / Germany	İPNER company/Turkey
package	200 L	200 L

The morphological and phenological parameters were taken for the potato cultivars as follows:

1- The percentage of emergence at 25 and 30 Days after planting (DAP): It was calculated by following formula: Emergence % = $\frac{\text{Number of sprouted tubers}}{\text{Number of tubers sown}} \times 100$

2- The duration to complete emergence (Day): the period as a days between starting date of the emergence and complete 100% emergence.

3- Number of stems per plant (stem / plant).

4- The height of plant (cm) at 25, 35 and 45 DAP.

5- Number of flowers per inflorescences.

6- Number of inflorescences per plant.

7- The flowering duration: the period as days from appearance of the first flower until plants stop giving flowers (Day).

8- The color of flower.

As the methods described by Mohamad Alyousef (2013) and Zein *et al* (2013).

The data were subjected to analysis of variance using the General Analysis of Variance and Duncan's multiple range test at 0.05 level, as well as simple linear correlations between some parameters were computed by (GenStat 12th Edition) statistical analysis program.

RESULTS

1- The percentage of emergence

In the 2019 experiment, at 25 days after planting (DAP), the percentage of emergence ranged between 12.5% as minimum level of emergence in Malice and 100% in L-Olympia. Some cultivars showed high significant level of emergence; 97.92%, 95.83%, 95.83% and 89.58 in Universa, Cristal, Soleia, and Melody, respectively. Meanwhile, the others such as Galata, Alonso, Diego, and Aurea showed very low level of emergence; (33.33%, 43.75%, 50%, and 50%, respectively). The rest of cultivars showed good level in emergence ranged between 70.83% in Husar cultivar and 83.33% in both Passion and Toronto.

In the 2019 experiment, at 30 DAP, the percentage of emergence ranged between 70.83% as minimum level of emergence in Malice and 100% in L-Olympia, Toronto, Universa, Melody and Soleia. Some cultivars showed high significant level of emergence; 97.92%, 97.92%, 95.83%, 95.83%, 95.83%, 93.75%, 91.67% and 91.67% in Passion, Cristal, Alonso, Husar, Blondine, Triomphe, Diego and Galata, respectively.

The results in the 2020 experiment were close to the previous year with slight differences, where, at 25 (DAP), the percentage of emergence ranged between 6.25% as minimum level of emergence in both Malice & Alonso, and 83.33% in both L-Olympia and Universa. Some cultivars showed moderate significant level of emergence; 66.67% and 64.58% in Melody & Soleia, respectively. Meanwhile, the others such as Galata, Husar, Diego, and Aurea showed very low level of emergence; 8.33%, 10.42%, 14.58% and 25.00%, respectively.

In the 2020 experiment, at 30 (DAP), the percentage of emergence ranged between 62.5% as minimum level of emergence in both Aurea & Alonso, and 100% in both L-Olympia, Cristal and Soleia. Some cultivars showed high significant level of emergence; 97.92%, 95.83%, 91.67%, 89.58%, 89.58%, and 87.50% in Universa, Melody, Toronto Galata, Triomphe and Passion, respectively. Meanwhile, the others showed low level of emergence rate such as: 79.17% in Diego, and 83.33% in both Husar and Blondine, as shown in (Table 3).

2- The duration to complete emergence (Day):

In the experiment of 2019, the cultivars were different in duration to complete their emergence. The duration of emergence was 7.33 days in Soleia as the shortest period of completing emergence, meanwhile it was 15.67 days in Triomphe. The Soleia cultivar was significantly superior on Galata, Passion, Husar, Aurea, Diego, Blondine and Triomphe. On the other sides, there was not significantly differences between Soleia, L.Olympia, Toronto, Malice, Universa, Melody, Christel, and Alonso.

In the experiment of 2020, the emergence duration ranged between 5.33 days in Christel as the shortest period of completing emergence and 13.00 days in Triomphe. In addition to Aurea, which was 12.00 days, there was a long period to completing emergence in both Diego and Blondine cultivars which was 11.67 days. On other hand; Christal, Universa, L.Olympia and Soleia were significantly superiors on all remained cultivars (Table 3).

Table (3) The emergence percentage and the duration to complete emergence of potato tested cultivars in 2019-2020 experiments under the greenhouse conditions.

No.	Cultivar Name	% emergence at 25 DAP		% emergence at 30 DAP		Duration of emergence Day	
		2019	2020	2019	2020	2019	2020
1	Passion	83.33 ^{abcd}	41.67 ^{de}	97.92 ^{a}	87.50 ^{abc}	11.67 ^{cde}	9.33 ^{c}
2	Alonso	43.75 ^{e}	6.25 ^{g}	95.83 ^{ab}	62.50 ^{e}	10.67 ^{abcde}	10.00 ^{c}
3	Husar	70.83 ^{cd}	10.42 ^{g}	95.83 ^{ab}	83.33 ^{bc}	12.00 ^{de}	9.00 ^{bc}
4	Malice	12.50 ^{f}	6.25 ^{g}	70.83 ^{c}	66.67 ^{de}	9.33 ^{abcd}	9.67 ^{c}
5	Diego	50.00 ^{e}	14.58 ^{g}	91.67 ^{ab}	79.17 ^{cd}	13.00 ^{ef}	11.67 ^{d}
6	Galata	33.33 ^{e}	8.33 ^{g}	91.67 ^{ab}	89.58 ^{abc}	11.33 ^{bcde}	9.00 ^{bc}
7	Aurea	50.00 ^{e}	25.00 ^{f}	87.50 ^{b}	62.5 ^{e}	12.67 ^{def}	12.00 ^{d}
8	Toronto	83.33 ^{abcd}	35.42 ^{e}	100 ^{a}	91.67 ^{abc}	8.33 ^{abc}	7.67 ^{b}
9	Triomphe	77.08 ^{bcd}	47.92 ^{cd}	93.75 ^{ab}	89.58 ^{abc}	15.67 ^{f}	13.00 ^{d}
10	Universa	97.92 ^{a}	83.33 ^{a}	100 ^{a}	97.92 ^{a}	9.33 ^{abcd}	5.67 ^{a}
11	Melody	89.58 ^{abc}	66.67 ^{b}	100 ^{a}	95.83 ^{ab}	10.00 ^{abcde}	8.33 ^{bc}
12	L.Olympia	100.00 ^{a}	83.33 ^{a}	100 ^{a}	100 ^{a}	8.00 ^{ab}	5.67 ^{a}
13	Christel	95.83 ^{ab}	54.17 ^{c}	97.92 ^{a}	100 ^{a}	10.00 ^{abcde}	5.33 ^{a}
14	Soleia	95.83 ^{ab}	64.58 ^{b}	100 ^{a}	100 ^{a}	7.33 ^{a}	6.00 ^{a}
15	Blondine	68.75 ^{d}	43.75 ^{de}	95.83 ^{ab}	83.33 ^{bc}	13.00 ^{ef}	11.67 ^{d}
L.S.D 0.05		17.07	9.56	8.13	12.61	2.98	1.51

Values followed by the same letter(s) in each column are not significantly different at P= 0.05 according to Duncan's multiple range tests.

DAP: Day after planting.

3- The number of stems per plant:

In the 2019 experiment, the number of stems ranged between 2.13 in Aurea and 7.38 in L.Olympia which significantly outnumbered on all the other cultivars. Both Melody and Christal gave a significantly high level which was 5.25 stems per plant. Meanwhile Universa, Soleia, Blondine, Triomphe, Diego and Toronto gave 3.88, 3.75, 3.63, 3.38, and 3.25, respectively as moderate significantly level. The rest cultivars Alonso, Husar, Galata, Passion, and Malice showed significantly very low number of stems; 2.50, 2.38, 2.38, 2.25, 2.25 and 2.13, respectively.

The results were very close in 2020 experiment, the number of stems ranged between 2.13 in both Passion & Aurea and 7.50 in L.Olympia which was significantly outnumbered on all the other cultivars. Melody and Christal gave 5.63 & 5.38 stems per plant, respectively as a high level. Meanwhile Soleia, Universa, Blondine, Triomphe, Toronto and Diego gave 4.13, 3.88, 3.50, 3.25, 3.00 and 3.00, respectively as a moderate level. The rest ones: Galata, Alonso, Husar, Malice, Passion, and Aurea showed significantly low number of stems; 2.50, 2.38, 2.25, 2.25, 2.13 and 2.13, respectively (Table 4).

4- The height of plant:

In the 2019 experiment, at 25 days after planting (DAP), the height of plant ranged between 3.21 cm as minimum level in Malice and 14.71 cm as a maximum in L-Olympia. Some cultivars showed high significant level; 13.21, 11.42, 11.38, 10.46, 10.25 and 9.58 cm in Universa, Soleia, Triomphe, Melody, Cristal, and Blondine, respectively. Meanwhile, the others such as, Aurea, Husar, Passion, Toronto, and Alonso showed moderate level of height; 7.04, 6.92, 6.83, 6.50, and 5.88 cm, respectively. The rest cultivars Diego & Galata showed low level in height of plant 5.50 & 4.21, respectively. At 35 (DAP), the height of plant ranged between 9.13cm as minimum level in Malice and 35.83 cm as a maximum level in L-Olympia. Some cultivars showed high significant level of plant height; 33.33, 28.08 cm in Cristal and Universa, respectively. Meanwhile, the others such as, Triomphe, Blondine, Melody, Soleia and Husar showed a good level of plant height; 25.21, 25.00, 24.17, 24.08 and 21.67. the rest cultivars: Alonso, Toronto, Diego, Aurea, Passion, and Galata showed low level in plant height; 17.92, 16.96, 15.88, 15.54, 14.46, and 13.96, respectively. At 45 (DAP), the height of plant ranged between 46.17cm as minimum level in Malice and 80.33 as a maximum in Blondine. Some cultivars showed high significant level of plant height; 71.17, 70.46, and 69.67 cm in Triomphe, Soleia and Husar, respectively. Meanwhile, Diego showed a low level of plant height; 46.96. the rest cultivars showed a moderate level in the plant height ranged between 53.17 and 62.5 in Galata and Toronto, respectively.

In 2020 experiment, at 25 (DAP) the height of plant ranged between 1.54 cm as minimum level in Malice and 6.88 cm as a maximum in L-Olympia which significant outnumbered all studied cultivars. Some cultivars showed moderate level of height ranged between 4.42 cm in Blondine and 6.21 cm in Universa. Meanwhile, the others showed low level of plant height; 3.13, 3.08, 3.00, 2.83, 2.54, 2.38 and 1.71cm in Aurea, Husar, Passion, Toronto, Alonso, Diego, and Galata, respectively.

At 35 (DAP), the height of plant ranged between 8.29 cm as minimum level in Malice and 27.71 cm as a maximum level in L-Olympia. Some cultivars showed high significant level of plant height; 26.67 and 26.08 cm in Cristal and Universa, respectively. Meanwhile, the others such as, Triomphe, Blondine, Melody, Soleia and Husar showed a good level of height; 22.92, 22.33, 22.17, 22.08 and 19.67 cm, respectively. the rest cultivars Alonso, Toronto, Diego, Aurea, Passion, and Galata showed low level in plant height 15.92, 14.96, 13.87, 13.54, 12.46, and 11.96 cm, respectively.

At 45 (DAP), the height of plant ranged between 44.50 cm as minimum level in Malice and 78.25 cm as a maximum level in Blondine. Some cultivars showed high significant level of plant height; 70.67, 68.50, and 67.83 cm in Triomphe, Soleia and Husar, respectively. some cultivars showed a moderate level in the height ranged between 50.67 and 61.00 in Galata and Toronto, respectively. Meanwhile, Diego showed a low level of plant height which was 46.96 cm (Table 4).

Table (4) The stems number and plant height of potato tested cultivars in 2019-2020 experiments under the greenhouse conditions.

No.	Cultivar Name	No of stems per plant		plant height at 25 DAP (cm)		Plant height at 35 DAP (cm)		Plant height at 45 DAP (cm)	
		2019	2020	2019	2020	2019	2020	2019	2020
1	Passion	2.25 ^{e}	2.13 ^{h}	6.83 ^{ef}	3.00 ^{ef}	14.46 ^{de}	12.46 ^{ef}	59.88 ^{cd}	58.58 ^{cd}
2	Alonso	2.50 ^{de}	2.38 ^{gh}	5.88 ^{ef}	2.54 ^{ef}	17.92 ^{d}	15.92 ^{d}	60.33 ^{cd}	58.25 ^{cd}
3	Husar	2.38 ^{e}	2.25 ^{gh}	6.92 ^{e}	3.08 ^{e}	21.67 ^{c}	19.67 ^{c}	69.67 ^{b}	67.83 ^{b}
4	Malice	2.25 ^{e}	2.25 ^{gh}	3.21 ^{g}	1.54 ^{g}	9.13 ^{f}	8.29 ^{g}	46.17 ^{f}	44.5 ^{f}
5	Diego	3.25 ^{cde}	3.00 ^{efg}	5.50 ^{f}	2.38 ^{f}	15.88 ^{de}	13.87 ^{def}	46.96 ^{f}	45.25 ^{f}
6	Galata	2.38 ^{de}	2.50 ^{fgh}	4.21 ^{g}	1.71 ^{g}	13.96 ^{e}	11.96 ^{f}	53.17 ^{e}	50.67 ^{e}
7	Aurea	2.13 ^{e}	2.13 ^{h}	7.04 ^{e}	3.16 ^{e}	15.54 ^{de}	13.54 ^{def}	53.62 ^{e}	51.25 ^{e}
8	Toronto	3.13 ^{cde}	3.00 ^{efg}	6.50 ^{ef}	2.84 ^{ef}	16.96 ^{de}	14.96 ^{de}	62.50 ^{c}	61.00 ^{c}
9	Triomphe	3.38 ^{cde}	3.25 ^{def}	11.38 ^{c}	5.33 ^{c}	25.21 ^{bc}	22.92 ^{b}	71.17 ^{b}	70.67 ^{b}
10	Universa	3.88 ^{c}	3.88 ^{cd}	13.21 ^{b}	6.21 ^{b}	28.08 ^{b}	26.08 ^{a}	53.29 ^{e}	51.83 ^{e}
11	Melody	5.25 ^{b}	5.38 ^{b}	10.46 ^{cd}	4.83 ^{cd}	24.17 ^{c}	22.17 ^{bc}	58.83 ^{d}	56.42 ^{cd}
12	L.Olympia	7.38 ^{a}	7.50 ^{a}	14.71 ^{a}	6.88 ^{a}	35.83 ^{a}	27.71 ^{a}	55.75 ^{e}	54.00 ^{de}
13	Christel	5.25 ^{b}	5.63 ^{b}	10.25 ^{cd}	4.75 ^{cd}	33.33 ^{a}	26.67 ^{a}	59.79 ^{cd}	57.33 ^{cd}
14	Soleia	3.75 ^{c}	4.13 ^{c}	11.48 ^{c}	5.29 ^{c}	24.08 ^{c}	22.08 ^{bc}	70.46 ^{b}	68.50 ^{b}
15	Blondine	3.63 ^{cd}	3.50 ^{cde}	9.58 ^{d}	4.48 ^{d}	25.00 ^{bc}	22.33 ^{bc}	80.33 ^{a}	78.25 ^{a}
L.S.D 0.05		1.106	0.359	1.231	0.621	3.182	2.634	2.936	4.134

Values followed by the same letter(s) in each column are not significantly different at P= 0.05 according to Duncan's multiple range tests.

DAP: Day after planting.

cm: centimeter

5- Flowering

Only nine cultivars; Passion, Alonso, Diego, Galata, Aurea, Toronto, Triomphe, Soleia and Blondine out of total studied cultivars were able to give inflorescences as flowered cultivars. Meanwhile only eight; Alonso, Diego, Galata, Aurea, Toronto, Soleia and Blondine out of those nine cultivars gave flowers during both 2019 and 2020 experiments.

In the experiment of 2019, the number of inflorescences per plant ranged from 2.00 in Passion, Alonso & Triomphe as a minimum significant number of inflorescences per plant and 5.00 as a maximum significant number of inflorescences per plant in Toronto. Meanwhile Galata, Aurea, Blondine, Diego and Soleia showed a high significant number of inflorescences per plant; 3.50, 3.40, 3.20, 2.50 and 2.40 inflorescences, respectively. The number of flowers per inflorescence ranged from abscission of floral buds after initiation in Triomphe cultivar to 15.00 flowers per inflorescence in Aurea cultivar which significantly outnumbered on all flowered cultivars. Toronto, Galata, Blondine and Alonso showed a high significantly number of flowers per inflorescence; 13.25, 11.00, 10.15, and 10.00 flowers, respectively. Meanwhile the rest cultivars showed low significant number of flowers per inflorescence. The flowering duration (the period as days from appearance of the first flower until plants stop giving flowers) ranged between 14.70 days as a minimum significantly duration in Triomphe cultivar and 43.20, 43.00 and 41.75 days as a maximum significantly duration in Blondine, Galata and Diego, respectively. Both Alonso and Toronto showed significantly moderate duration; 39.90 and 38.80 days, respectively. The rest cultivars showed significant low flowering duration.

The results of 2020 experiment were very close to those in 2019. The number of inflorescences per plant ranged from 1.83 in Triomphe as a minimum number of inflorescences per plant and 4.50 inflorescences as a maximum significant number inflorescence per plant in Toronto. Meanwhile Aurea, Galata, Blondine, and Diego showed a high significant number of inflorescences per plant; 3.50, 3.33, 3.17, and 2.33 inflorescences, respectively. The rest cultivars showed low significant number of inflorescences per plant. The number of flowers per inflorescence ranged from abscission of floral buds after initiation in Triomphe cultivar to 13.00 flowers per inflorescence in both Toronto & Aurea cultivars which significantly outnumbered on all flowered cultivars. Galata, Blondine and Alonso showed a high significantly number of flowers per inflorescence; 10.83, 10.50, and 10.00 flowers, respectively. Meanwhile the rest cultivars showed low significant number of flowers per inflorescence. The flowering duration ranged between 14.33 days as a minimum significantly duration in Triomphe cultivar and 41.00, 40.83 and 39.67 days as a maximum significantly duration in Galata, Blondine, and Diego, respectively. Both Aurea and Alonso showed significantly moderate duration; 37.67 and 36.83 days, respectively. The rest cultivars showed significant low flowering duration. The flowers' color in all flowered cultivars was white except Diego gave pink flowers (Table 5).

Table (5) The flowering characterization of potato tested cultivars in 2019-2020 experiments under the greenhouse conditions.

No.	Cultivar Name	No of Inflorescences per plant		No of flowers per inflorescence		Duration of flowering Day		flowers' color
		2019	2020	2019	2020	2019	2020	-
1	Passion	2.00 ^{c}	2.17 ^{d}	8.40 ^{ef}	9.17 ^{cd}	18.60 ^{f}	17.67 ^{f}	white

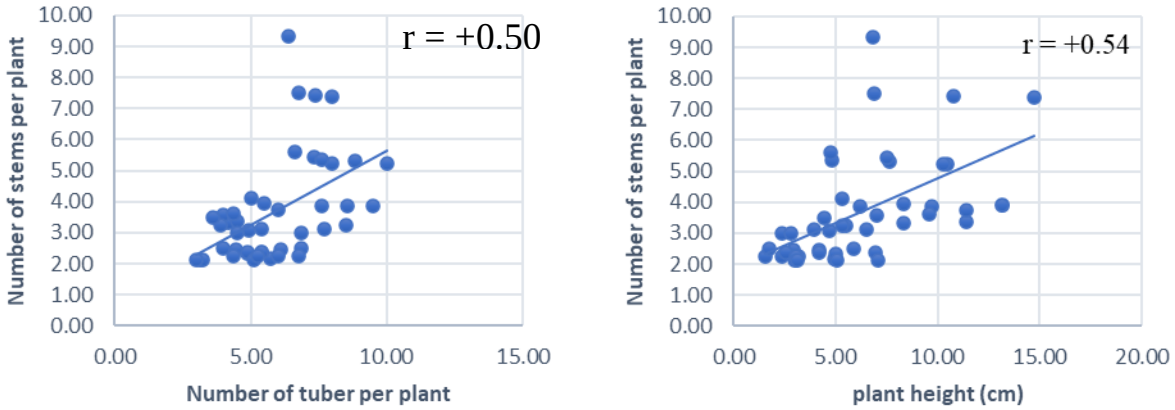
No.	Cultivar Name	No of Inflorescences per plant		No of flowers per inflorescence		Duration of flowering Day		flowers' color
		2019	2020	2019	2020	2019	2020	-
2	Alonso	2.00 ^{c}	2.17 ^{d}	10.00 ^{cd}	10.00 ^{bc}	38.80 ^{c}	36.83 ^{c}	white
5	Diego	2.50 ^{bc}	2.33 ^{cd}	9.00 ^{de}	9.67 ^{bcd}	41.75 ^{ab}	39.67 ^{ab}	pink
6	Galata	3.50 ^{b}	3.33 ^{b}	11.00 ^{c}	10.83 ^{b}	43.00 ^{a}	41.00 ^{a}	white
7	Aurea	3.40 ^{bc}	3.50 ^{b}	15.00 ^{a}	13.00 ^{a}	39.90 ^{bc}	37.67 ^{bc}	white
8	Toronto	5.00 ^{a}	4.50 ^{a}	13.25 ^{b}	13.00 ^{a}	34.30 ^{d}	33.00 ^{d}	white
9	Triomphe	2.00 ^{c}	1.83 ^{d}	0.00 ^{g}	0.00 ^{e}	14.70 ^{g}	14.33 ^{g}	white
14	Soleia	2.40 ^{bc}	2.17 ^{d}	7.60 ^{f}	8.33 ^{d}	23.90 ^{e}	22.83 ^{e}	white
15	Blondine	3.20 ^{bc}	3.17 ^{bc}	10.15 ^{cd}	10.50 ^{bc}	43.20 ^{a}	40.83 ^{a}	white
L.S.D 0.05		1.271	0.847	1.237	1.477	2.351	2.036	-

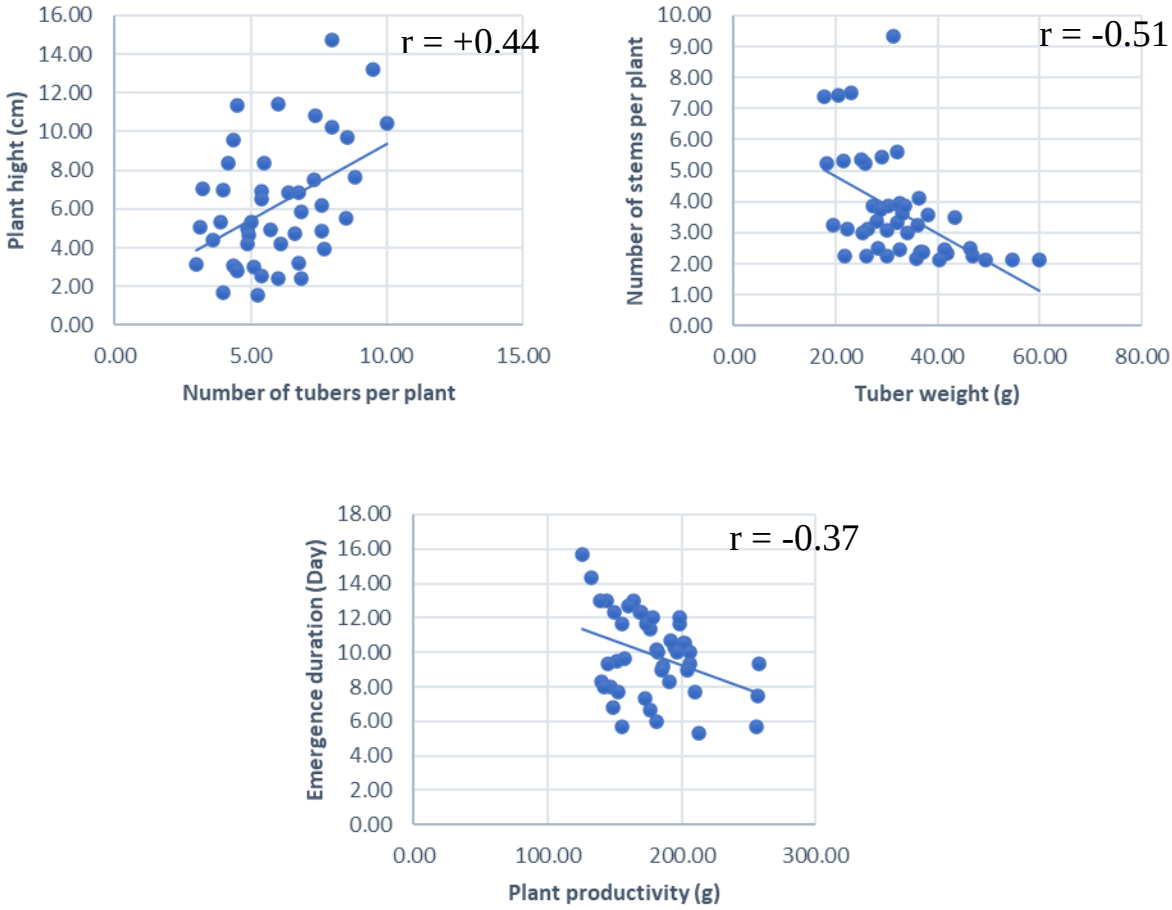
Values followed by the same letter(s) in each column are not significantly different at P= 0.05 according to Duncan's multiple range tests.

DAP: Day after planting.

6- Correlation Coefficient Relationships

Many correlation coefficient relationships between traits were observed among tested cultivars as an average of result value in 2019 and 2020 experiments as follows; significantly positive correlation coefficient was noted between stems numbers and tubers number per plant (r = + 0.50), number of stems per plant and plant height at 25 DAP (r = + 0.54), plant height and number of tubers per plant (r =+ 0.44). Meanwhile significantly negative correlation coefficient was noted between number of stems per plant and average of tuber weight (r =- 0.51), duration of emergence and plant productivity (r =- 0.37) (Figure 1).





Figure(1) Correlation coefficient relationships between some traits of potato tested cultivars in 2019-2020 experiments under greenhouse conditions.

DISCUSSION

1- The percentage of emergence:

The cultivars showed varies levels of their emergence in the experiment of 2019. L-Olympia reached 100% of emergence within 25 DAP. Meanwhile four cultivars reached very good percentage of emergence (90% and more). The rest cultivars divided in two groups: very low (less than 50%) and moderate percentage of emergence (between 50% and 83.33%). After 30 DAP most cultivars reached more than 90% percentage of emergence. Only Malice cultivar reached 70.83% percentage of emergence. In the experiment of 2020, the results were similar with slight differences. At 25 DAP; the emergence percentage of all cultivars was low comparing with the experiment of 2019. But it was quite similar at 30 DAP.

Consistent emergence is always desirable as it leads to more efficient crop management. The measurement of emergence rate and uniformity is crucially important for field-scale phenotyping, especially in crop breeding and precision agronomy (Li et al., 2019). Our results are in line with the

findings of Bugarcic et al (1997) and Abbasi et al (2004) who reported diverse germination among various varieties of potatoes, and with Fantaw et al (2019) who mentioned that the year had little effect on most traits except for days to emergence and added that only days to emergence were affected by the variety by year interaction.

2- The duration to complete emergence (Day):

Numbers of days to emergence is important for potato producers because they enable growers to forecast and develop a suitable production scheme and marketing plan (Khalafalla, 2001).

Our results indicate that the duration to complete emergence was different among tested cultivars in both 2019 and 2020 experiments. This result was confirmed by Fantaw et al (2019) and Bradshaw, (2007) who highlighted that these differences may be due to genetic factors.

3- The number of stems per plant:

The noted differences in stem number among tested cultivars might be due to genetic differences, which in turn influence the number of sprouts or eyes on the tubers. This result was matched with Tessema et al (2020), Getie et al (2018), Berhanu and Tewodros (2016), Habtamu et al (2016), Yıldırım and Ozturk (2016), Zein et al (2013) and Morena et al (1994) who found similar results and reported that genetic factors effect on number of stems. Allen (1978) reported that the variation in stems number in a tuber to several factors: variety, storage condition of tuber, size of tuber, inherent variations in the number of buds per tubers or number of viable sprouts at planting, sprout damage at the time of planting, physiological age of the seed tuber and growth conditions.

4- The height of plant:

The significant differences between cultivars in plant height were due to genetic variations probably. Our results are in accordance with Eaton et al (2017) who reported difference in plant height of different potatoes genotypes and might be due to plant genetic makeup. Similar results were also reported by Luthra et al (2005) and Schittenhelm et al (2006). It is presumed that the differences in plant height among various genotypes might be due to combined effects of plant genetics. It is also confirmed by many researchers; where, Tessema et al (2020), Eaton et al (2017), Berhanu and Tewodros (2016), Girma and Niguisse (2015) and Elfinesh (2008) reported that plant height varied with potato varietal differences. This suggestion is also consistent with that of Manrique-Carpintero et al (2018) who reported that plant height is a quantitative trait controlled by many genes.

5- Flowering

The cultivars showed different ability for flowering. Some of them were flowering cultivars meanwhile the others were not flowering cultivars under the experimental conditions (greenhouse

conditions). The flowering cultivars varied in numbers of inflorescences per plant, flowers per inflorescences, and flowering duration. Our results are demonstrating the findings of Tessema et al (2020), Mohamad Alyousef (2013), Acquaah (2007), Nizamuddin et al (2007), Sleper and Poehlman (2006), Almekinders and Struik (1996), Gopal et al (1994), and Sadik (1982) as they mentioned that the flowering of potato correlated with genetic factors. As well as the flowering potato varieties differ from each other in the time of flowering, flowering period, and the color of their petals. Flowering of potato cultivars ranges from abscission of floral buds after initiation to profuse flowering. Also, Potato varieties differ in their light requirements for flowering, and the short duration of lighting during the flowering period leads to the dropping of the flowering buds. Some other researchers highlighted that the variations of days required in attaining 50% flowering among varieties which could attributed to genetic differences, and governed by many environmental factors, mainly temperature and light (Vreugdenhil, 2007; Getie et al., 2018).

CONCLUSIONS

The study indicates that there are important significant differences and many important correlation coefficient relationships among studied traits of tested potato cultivars which can be improved for having most suitable and adaptable potato cultivars. These results reflect urgent need for starting the breeding process to improve those properties to obtain the most suitable and adaptable potato varieties in Turkey.

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