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Original article

Evaluation of the Yield and Quality Properties of Some Potato Varieties and Candidate Genotypes in Yenisehir-Bursa Ecological Conditions

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Abstract

The experiment was implemented to evaluate the yield and quality properties of potato varieties and candidate genotypes were examined in 2019 growing seansons under Yenisehir- Bursa conditions. The experimental design was a "Randomized Complete Block Design" with three replications. Eight potato candidate genotypes ("EA10", "GAF4", "MK-2", "AH-11", AFK-3", "AA12", "HA5", "LOH3Y") which were developed by Associate Proffessor Rahim Ada and four potato varieties (Marabel, Florice, Melody, Lady Olympia) were used as plant material in this experiment. The plant height (cm), number of stem per plant, number of tuber per plant, total tuber yield (t ha-1), dry matter content (%), yield of chips (%), yield of french-fries (%) were examined. According to results of this experiment, significant differences were found in all properties among the potato varieties and candidate genotypes statistically. The plant height changed between 48.3-107.3 cm, number of stem per plant was 4.6-10.0, number of tuber per hill was 4.3-16.6, total tuber yield per hectare was 8.9-52.1 t. In addition, dry matter content changed between 16.7- 25.0 %, yield of chips was 36.1-60.3 %, yield of french-fries was 55.0-70.8 %. The highest total tuber yield was obtained from Florice variety (52.1 t ha-1) and "GAF4" potato candidate genotype (49.6 t ha-1) and the lowest total tuber yield was obtained from "AFK-3" potato candidate genotype (8.9 t ha-1, respectively). The experiment results indicated that "GAF4" potato candidate genotype was found promising.

Keywords: Potato breeding, adaptation, yield, quality.

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is the fifth most produced plant in the world after, sugar cane, wheat, rice and corn. As of 2018, the potato planting area in the world was 17.5 million ha and the production was 368 million tons (Anonymous, 2020a). Our country has a geography suitable for the cultivation of potatoes in terms of climate and soil characteristics. It can be grown in 75 of our 81 provinces and can be obtained in almost every period of the year (Caliskan et al., 2010). Potato planting area in our country was realized as 35.4 t ha^{-1} with a production of approximately 5 million tons in 2019 on an area of 140 thousand ha (Anonymous, 2020b). Tuber species of the potato plant remained closed in the American continent and only the cultivated forms were found in South America. Afterwards, it was recorded that these cultural forms were cultivated in the Ant Mountains, Peru and Chile (Incekara, 1973). It is highly probable that it came to our country from Russia and the Caucasus to the Eastern Black Sea plateaus (Ilisulu, 1986). Cultured potato varieties are divided into two subspecies as "Tuberosum" and "Andigena". Today, cultivated potatoes are included in the tuberosum subtype (Er et al., 1987). There are about 2000 species in this genus.

There are over 150 species of tubers. These include polyploid series from diploid (2x) to hexaploid (6x) (75% is diploid) (Sleper and Poehlman, 2006). Potatoes consist mainly of the carbohydrate group and contain a relatively large amount of protein compared to the grain groups. Approximately in one medium potato tuber (173 g); total carbohydrate is 36.6 g (12%), protein is around 4.3 g (9%). It also contains vitamins C, B1, B3, B6, K, folate, pantothenic acid (Anonymous, 2020c). In this sense, potatoes are used both in human nutrition at the table and in animal feeding with scrapped tubers and dried trunks. In addition, it is widely used in large industrial branches (frozen products (French fries), chips, mash, flour, alcohol, starch etc.) (Caliskan et al., 2010).

Although our country has a suitable geography and climate for cultivation, it is a significant loss that we do not have local varieties used in commercial production and one of the most important problems of the potato sector in our country is the lack of adequate organization. This brings with it significant price fluctuations. The firms in Turkey, did not give weight to domestic breeding, which they import a certain level (Basic 1 and Basic-2) are marketed seed potatoes certified in one or two generations duplicate positions. With the "Seed Import Implementation Circular" numbered 2011/1 published in 2011, the unregistered direct transfer of imported seeds to the farmer was stopped, and it was obligatory to receive certification by taking all of them into the seed production system (Caliskan et al., 2011; Caliskan, 2018). Potato is a plant that shows high genotype x environment interaction although it has a wide range (Yılmaz and Tugay, 1999). In this sense, it is essential to give more weight to potato breeding programs and to identify ecologically adaptable variety/variety candidates/hopeful clones. First of all, variety development studies gain meaning with the healthy seed system (Gunel et al., 2010). Our domestic varieties should be shaped with a breeding program that is resistant to yield,

quality and storage according to consumer and producer demands. Our country, on the other hand, is dependent on foreign countries in terms of potato varieties, and the imported tubers dominate the market, making it compulsory to develop our local varieties and transfer them to the consumer/farmer/producer. The basis of classical potato breeding is that suitable clones or varieties are crossed with each other, the desired genes are combined and these genes appear in their progeny. When developing a good potato variety, many characters need to be combined. Parental choice and the combination of different characters is important. Although a desired selection study is carried out, the possibility of combining all the desired features is very low. The most widely used classical breeding methods are known as introduction, selection, mutation and hybridization (Harris, 2012).

The aim of this experiment was to evaluate the yield and quality characteristics of some potato varieties and candidate genotypes in Bursa-Yenisehir ecological conditions and to determine the prominent candidate genotypes in terms of these characteristics.

MATERIALS and METHODS

Experimental location, design and treatments/varieties

The field experiment was carried out at the farmer's field under Bursa-Yenişehir conditions in 2019 growing seasons. Eight potato candidate genotypes (EA10, GAF4, MK-2, AH-11, AFK-3, LOH3Y, HA5, AA12) which were developed by Associate Professor Rahim Ada and four varieties of potatoes (Marabel, Lady Olympia, Melody, Florice) were investigated for their yield and quality properties by using Randomized Complete Block Design with three replications. Some tuber characteristics of potato varieties and candidate genotypes used in this experiment were shown in Table 1.

Table 1. Some tuber characteristics of potato varieties and candidate genotypes used as research material

Genotypes	Using target	Skin color	Flesh color	Genotypes	Maturity
EA10	ME	W	SO	Y	PY
GAF4	ML	W	SO	Y	DY
MK-2	ME	W	O	Y	DY
AH-11	ME	W	O	Y	PY
AFK-3	ME	W	O	Y	PY
LOH3Y	ME	FF	O	Y	PY
HA5	ME	W	O	Y	PY
AA12	ME	FF	O	Y	PY
Marabel	ME	W	O	Y	Y
Lady Olympia	ME	FF	O	Y	PY
Melody	ML	W	O	Y	Y
Florice	VE	W	LO	Y	PY

Anonymous (2020e,f,g,h). **Maturity:** Very early (VE), Medium-early (ME), Medium-late (ML), Late (L); **Using target:** Ware potato (W), French Fry (FF); Chips (C); **Tuber shape:** Oval (O), Short-oval (SO), Long-oval (LO); **Flesh color:** Yellow (Y), Dark-yellow (DY), Pale-yellow (PY); **Skin color:** Yellow (Y), Light-yellow (LY), Red (R).

Experimental methodology

The planting of seed tubers was done by hand on 5th of March in 2019 with 70 cm between row distance and 30 cm in-row distance. The plot size was set as 6.2 m^2. Before planting, 700 kg ha^{-1} compose fertilizer containing 15% N, 15% P and 15% K were applied to the furrows by hand and afterwards seed tubers were placed in the furrows according to the given row spaces (Arioglu et al. 2018). The others standard cultural practices were applied at proper time intervals during the growing period. The tubers were harvested on 7th of July in 2019.

Statistical analysis

The data were statistically analyzed by using JMP Version 7, SAS Institute Inc. Cary, NC programs with Randomized Complete Block design. The Least Significant Differences (LSD) test was used to compare the genotypes at 0.01 level by using MSTAT-C (1991).

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Data collection

The plants in each plot were harvested by hand. The plant height (cm), number of stems per plant, number of tuber per hill, total tuber yield per hectare (t ha^{-1}), dry matter content (%), yield of chips (%), yield of french-fries (%) were determined following the harvest (Arioglu et al. 2016; Ozyildirim, 2014; Kacar, 1972; Senol, 1973; Ross and Porter, 1976).

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RESULTS and DISCUSSION

Weather data of the experimental area

The weather data of the experimental area in 2019 with growing season for the potato with the long-term climatic data were depicted in Table 2. Data showed that the average temperature was 7.3 ^oC,

11.4 ºC, 18.1 ºC, 22.5 ºC, 22.4 ºC; whereas, the total amount of rainfall was 17.4 mm, 34.2 mm, 37.9 mm, 0 mm, 69.9 mm during the month of March, April, May, June, July, 2019 respectively (Table 2).

Table 2. Weather data of the experimental areas (Yenisehir-Bursa)

The long-term*	**March**	**April**	**May**	**June**	**July**
Max. T. (ºC)	24.4	28.6	32.0	35.6	37.5
Min. T. (ºC)	- 5.5	- 2.0	3.1	8.4	10.7
Avg. T. (ºC)	8.3	12.1	16.9	20.9	23.7
T. Rain. (mm)	58.7	42.6	68.0	53.1	11.8
Humd. (%)	74.9	72.1	73.8	70.3	64.4
2019	**March**	**April**	**May**	**June**	**July**
Max. T. (ºC)	24.0	29.4	36.9	33.2	35.5
Min. T. (ºC)	- 5.0	-3.1	4.3	10.3	9.8
Avg. T. (ºC)	7.3	11.4	18.1	22.5	22.4
T. Rain. (mm)	17.4	34.2	37.9	--	69.9
Humd. (%)	73.9	74.4	72.7	73.1	69.9

Anonymous,2020d. General Directorate of Meteorology-Ankara.* 2010-2018

Plant height (cm)

The data regarding plant height (cm) were shown in Table 3 and Table 4. The variance analysis of plant height in potato varieties and candidate genotypes showed that the means of all candidate genotypes and varieties were statistically highly significant ($p<0.01$) (Table 3). The data presented in Table 4 explains that the mean value was (86.0 cm) for plant height. The maximum plant height (107.3 cm) was taken by AFK-3 followed by AA12, EA10 and GAF4 by taking the measures as 104.0 cm, 102.0 cm and 101.0 cm respectively. It was at par with the check Marabel, Florice and Lady Olimpia having 78.6 cm, 81.3 cm and 84.6 cm as the minimum plant height, respectively. The plant type is significantly related to the number of main stems, leaf length and width, plant height, leaf index and width and leaf number. Different applications (plant growth regulators, different fertilizer applications etc.), varieties, ecological factors and different planting densities and methods applied in many studies can be directly associated with the differences in plant height. In studies on the subject; the findings were similar as the results of Arslan and Kevseroglu (1991) (31.0-76.0 cm); Karadogan and Günel (1992) (21.6-46.7 cm); Caliskan and Caliskan (2010) (43.1-68.9 cm); Sanli and Karadogan (2012) (49.0-78.8 cm).

Number of stems per plant

The data regarding the number of stems per plant was shown in Table 3 and Table 4. The variance analysis of number of stems per plant in potato varieties and candidate genotypes showed that all candidate genotypes and varieties were statistically highly significant ($p<0.01$) regarding the number of stems per plant (Table 3). The data presented in Table 4 explains that the mean value was (7.3

number/plant) for number of stems. Maximum number of stems (10.0 number/plant) was taken by AFK-3 followed by Melody, Florice and Lady Olympia which took 9.7 number/plant, 9.0 number/plant and 7.6 number/plant, respectively. The minimum number of stems (4.6 number/plant) were taken as MK-2 followed by AA12 and GAF4 having 5.3 number/plant, 6.3 number/plant, respectively. The number of main stalks was formed as a result of the growth of the eyes on the seed tuber in the potato, and the number of the main stem, the genetic structure, the large size of the seed tubers, and the duration of dormancy, therefore, the physiological age significantly affects (Karadogan et al., 1996; Caliskan, 1997). The findings of Sanlı and Karadogan (2012) (3.9-4.1 pieces/plant; Caliskan and Caliskan (2010) (1.6-3.3 pieces/plant); Caliskan (2001) (2.4-4.0 pieces/plant) Ogurlu (2019) (6.0-8.0 pieces/plant) and the findings of our study were compatible with each other and closer to the upper limit. The number of tubers changed according to per month, tuber size, genetic structure of varieties, environmental factors and cultural practices (Caliskan, 2001).

Number of tuber per hill

The data regarding number of tuber per hill of studied candidate genotypes and varieties of potatoes was presented in Table 3 and Table 4. The variance analysis of number of tuber per hill in potatoes varieties and candidate genotypes showed that the means of all candidate genotypes and varieties were statistically highly significant ($p<0.01$) (Table 3). The data presented in Table 4 explains that the mean value was (10.9) for number of tuber per hill. It was at par with the check GAF4 and Melody as the highest number of tuber per hill having 16.6 and 16.3, respectively. The lowest number of tuber per hill (4.3) was recorded in the varieties and candidate genotypes named AFK-3. Caliskan's (2001) (4.2-6.8 number/hill); (Arıoglu et al., 2018) (4.8-11.4 number / hill) findings were compatible with each other and the findings of our study were closer to the upper limit.

Dry matter (%)

The differences between the varieties and candidate genotypes were statistically significant ($p<0.01$) for the dry matter content (%) (Table 5). The dry matter content was varied between 16.7-25.0 %. The highest dry matter content was found in LOH3Y potato candidate genotype (25.0 %) followed by HA5, AH-11 and Lady Olympia which took 23.4 %, 22.0 % and 21.4 %, respectively. The lowest dry matter content was found by Melody (17.4 %) and Florice (16.7 %) varieties as f group (Table 6). Dry matter, which is one of the most important quality components, is an important and positive relationship with starch, the largest component, and is also associated with tuber yield (Yildirim et al., 1997). Oranic acids, lipids, phenolic thresholds are composed of minerals and non-starch polysaccharides (Kita, 2002). The variations in dry matter content and specific gravity among cultivars are closely related to the directing of more dry matter to tubers, directly related to the transport efficiency of assimilation products to tubers (Tekalign and Hammes, 2005). Dry matter content; depends on the potato variety, the cultural practices applied during plant development, the root health of the plant, the

water content during tuber development, and the composition of the tuber (Pringle et al., 2009). The findings of Sanli and Karadogan (2012) (17.2-20.8%); Caliskan and Caliskan (2010) (20.0-23.9%); Ogurlu (2019) (17.6-18.5%) were similar to those related to the dry matter rate in our experiment.

Total tuber yield (t ha^{-1})

There was a statistically significant difference ($p<0.01$) in total tuber yield (t ha^{-1}) between the potato varieties and candidate genotypes (Table 5). Total tuber yield per hectare varied between 8.9-52.1 t. The highest tuber yield per hectare was obtained from Florice and GAF4 as the same group (g) (52.1 and 49.6 t ha^{-1}, respectively) and the lowest from AFK-3 (f) (8.9 t ha^{-1}). The average total tuber yield of varieties and candidate genotypes was found 32.2 t ha^{-1}(Table 6). It was determined that the varieties included in the experiment differed significantly in terms of total tuber yield. Tuber onset, photosynthesis speed, efficiency of assimilate splitting into tubers (volume ratio) and maturity period may have been effective in this change. There is a strong and positive relationship between tuber yield and leaf web photosynthesis (Tekalign and Hammes, 2005). Also, tuber yield, which is the most important feature in potato breeding; plant vitality, plant height, number of tubers, leaf width, average tuber weight positively affected the process (Luthra, 2001). Similarly, many researchers have reported that tuber numbers and hence tuber yields change depending on the genetic characteristics of the variety (Caliskan, 2001; Karadogan et al., 1997; Sanli and Karadogan, 2012). The findings of Caliskan and Caliskan (2010) (20.7-43.8 t ha-1); Arıgolu et al. (2018) (12.8-37.9 t ha^{-1}) and the total tuber yield findings in our research are in harmony.

Yield of chips (%)

The differences between the varieties and candidate genotypes were statistically significant ($p<0.01$) for the yield of chips (Table 5). The yield of chips values varied between 36.1 %-60.3 % . The highest yield of chips were obtained from Marabel and Florice as the same group (a) (60.3 % and 59.1 %, respectively) while the lowest yield of chips from Melody (36.1 %) (Table 6). High dry matter content is preferred for the production of the desired chips texture. It is the low dry matter content that causes low chips yield and dough texture due to excessive oil absorption during and after frying. The organic acid content of the tuber (such as malic, tartaric and fumaric) plays an important role in the quality of chips (Wibowo et al., 2014). Dry matter ratio of potatoes for chips production (20-25 %), of which more than 15% should contain starch (Polish Norm PN-A-74780) (Kita, 2002). The findings of our study on chips yield were consistent with Tarakci's (2014) (control values: 30.5-33.7 %) findings and closer to the lower limit.

Yield of french-fries (%)

The differences between the varieties and candidate genotypes were statistically significant ($p<0.01$) for yield of french-fries (Table 5). The yield of french-fries values varied between 55.0%-

70.8%. The highest yield of french-fries was obtained from LOH3Y (70.8 %) while the lowest yield of french-fries from Melody and AFK-3 as the same group (d) (55.3 % and 55.0 %) (Table 6). Required criteria for French fries; oval tubers longer than 85 mm are requested (Sing et al., 2003). Regarding the French fries yield; it can be said that although the findings of Karadoğan (1994) (27.6-48.2 %) and Sanli and Karadogan (2012) (27.1-32.0 %) were lower than our research findings, the results differ according to the variety, type of oil, holding time, frying time.

Table 3. Variance analysis of characteristics examined in potatoes varieties and candidate genotypes-1

Sources of Variation	**D.F.**	**Plant height (cm)**	**Number of stems (number/plant)**	**Number of tubers (number/hill)**
		Mean square	**Mean square**	**Mean square**
Total	35	-	-	-
Replication	2	6.778	2.77778	4.77778
Genotypes	11	997.92927**	7.72474**	39.86869**
Error	22	43.960	0.80808	1.0808
$LSD_{Genotypes\ (0.01)}$		15.26	2.069	2.393

**= Significant at p< 0.01

Table 4. Average values and LSD groups for the characteristics examined in the study-1

Genotypes	**Plant height**	**Number of stems**	**Number of tubers**
Marabel	78.6 d	7.0 cde	11.0 bc
Florice	81.3 d	9.0 abc	9.7 cd
Melody	88.0 cd	9.7 ab	16.3 a
Lady Olympia	84.6 d	7.6 cd	6.6 ef
EA10	102.0 abc	7.7 bcd	8.3 de
GAF4	101.0 abc	6.3 def	16.6 a
MK-2	48.3 e	4.6 f	9.0 cd
AH-11	56.6 e	7.3 cde	11.0 bc
AFK-3	107.3 a	10.0 a	4.3 f
AA12	104.0 ab	5.3 ef	12.7 b
HA5	91.0 bcd	6.7 de	12.6 b
LOH3Y	89.6 bcd	7.0 cde	13.0 b
Mean	86.0	7.3	10.9

Table 5. Variance analysis of characteristics examined in potatoes varieties and candidate genotypes-2

Sources of Variation	D.F.	Dry matter (%)	Total tuber yield (t ha^{-1})	Yield od chips (%)	Yield of french-fries (%)
		Mean square	Mean square	Mean square	Mean square
Total	35	-	-	-	-
Replication	2	0.52	18609	43.1786	14.62528
Genotypes	11	17.923333**	5417721.91**	189.11838**	61.63747**
Error	22	1.3261	16492	25.321	8.9086
LSD $_{\text{Genotypes (0.01)}}$		2.650	295.6	11.58	6.869

**= Significant at p< 0.01

Table 6. Average values and LSD groups for the characteristics examined in the study-2

Genotypes	Dry matter (%)	Total tuber yield (t ha^{-1})	Yield od chips (%)	Yield of french-fries (%)
Marabel	19.1 def	44.3 b	60.3 a	56.6 bcd
Florice	16.7 f	52.1 a	59.1 a	62.8 bc
Melody	17.4 f	32.4 d	36.1 e	55.3 d
Lady Olympia	21.4 bcd	28.5 e	40.1 cde	57.2 bcd
EA10	20.2 cde	18.9 f	50.2 abc	56.8 bcd
GAF4	18.6 ef	49.6 a	37.5 de	58.0 bcd
MK-2	19.3 def	19.9 f	48.8 abcd	63.4 b
AH-11	22.0 bc	32.8 cd	54.8 ab	57.8 bcd
AFK-3	19.3 def	8.9 g	44.8 bcde	55.0 d
AA12	18.7 ef	35.4 c	52.7 ab	56.5 cd
HA5	23.4 ab	21.0 f	49.3 abc	59.6 bcd
LOH3Y	25.0 a	43.1 b	53.3 ab	70.8 a
Mean	20.1	32.2	48.9	59.1

Conclusion

According to the results of the experiment, the ecological conditions of Yenisehir-Bursa of the varieties and variety candidates taken into the trial showed significant differences in terms of all examined parameters during the 2019 growing season. Since it is a one-year study, it is important to carry out the trial for two years and in different locations in order to make the results more understandable. The highest tuber yield per hectare was obtained from Florice and GAF4 as the same group (a) (52.1 and 49.6 t ha-1, respectively) and the lowest from AFK-3 (f) (8.9 t ha^{-1}). High yield was the most important criterion in the production of potatoes, and quality criteria such as tuber shape, tuber quality and cooking and frying efficiency are also important. In this experiment, it was concluded that the variety candidates GAF4 can be used in production in Yenisehir-Bursa conditions in terms of yield and quality.

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