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The Determination of Tuber Yield and Some Agronomic Characteristics of Potato Breeding Lines and Varieties Grown in Winter Season in Cukurova Region

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Abstract **–** This study was conducted at the Cukurova University research farm in winter season between January and June in Cukurova Region (Adana-Turkey) in 2018. The objective of this study was to determinate the tuber yield and some agronomic characteristics of potato breeding lines and varieties grown in winter season. The experimental design was a Randomized Complete Block Design with three replications. The twenty one potato breeding lines and varieties (table and processing types) such as Agata, Agria, Alegria, Austin 2T, Doruk, Hermes, Maraton, Kutup, L.Olimpia, Laura, Markies, Nahita, Sante, Soraya, Testa 3T, Macar-140211, Macar-140607, Macar-140717, MEÇ-140209, MEÇ-140717 and Zirve were used as a plant material in this research. Tuber yield and tuber number per hill, marketable tuber percentage, tuber yield per hectare and dry matter content were investigated in this research. The tuber yield of the breeding lines and varieties varied between 12840-37930 kg ha^{-1} per hectare. The dry matter content of the research materials varied between 13.75% and 22.67%.

Keywords **–** *Winter potato production, Potato varieties, Breeding lines, Tuber yield and Dry matter*

I. Introduction

The potato is a crop grown all parts of the world due to easily adapted to different climate conditions. In addition, it is one of the important crops to be obtained the highest yield per unit area. The world annual potato production is around 376.8 million tones and it is the fourth largest production after corn, rice and wheat in the world (Anonymous, 2017).

The potato tubers supply mainly carbohydrates, but are also relatively rich source of proteins. It also contains valuable minerals, such as iron and magnesium and vitamins. For this reason, potato tuber is known as an important food for human nutrition (Arioglu, 2014). Potato tubers consumed as ware potatoes are a common staple food in most of the world and it is also an important industrial crop, which is processed into frozen products (french fries), chips, mash, flour, alcohol, starch and its derivates (Caliskan et al., 2010).

There are 81 provinces in Turkey and most of them are grown potato. The annual potato production is 4.8 million ton in 2017 and it is the fourth largest production after wheat, sugar beet and barley in Turkey (Caliskan et al., 2010 and Anonymous, 2017). Potato having a history of nearly 167 years in Turkey has become one of the most important agricultural crops of the country and its production, industry, marketing and consumption have become a sector on its own. However, the current situation has still not reached its full potential (Caliskan et al., 2010).

The potato can be grown at different seasons such as early crop, main crop and late crop during the whole year in Turkey. Early crop was grown in winter and spring seasons, main crop was in summer season and late crop was in autumn season. Most of the potato varieties are grown in Turkey is originated from foreign countries and growing periods of these varieties ranges from 90 to140 days. The average tuber yield of these varieties ranges from 20 to 80 tons per hectare. Some varieties can be grown for fresh market and some others for processing (Arioglu and Caliskan, 1999).

The potato can be grown as an early crop during winter and spring seasons for the suitable climate in Mediterranean and Aegean regions. Early potato production in the Mediterranean region accounts for 15% of the country's total production. In winter growing season, planting was done in January and harvesting was in end of May (Arioglu, 1979; Arioglu et al., 2002 and Arioglu et al. 2016). Early and medium-early varieties are grown for fresh market (ware potatoes), medium-late and late varieties for processing.

It is difficult and expensive to storage of potato tuber keeping as high quality for a long time. For this reason, potato processing factories prefer the winter season's crop to reduce the production cost. Recently, potato was successfully grown for processing (high dry matter and low sugar content) by the harvesting delayed to June in winter crops (Arioglu et al., 2005 and Celik et al., 2006).

It is very important to get high tuber yield and tuber quality in potato farming. There are so many factors affect the tuber yield and quality in potato production. The first of these factors is variety selection. There are many researches were done to determine the suitable varieties can be grown in winter season for table and processing potatoes in Cukurova region by some researchers (Arioglu, 1986; Senol and

Arioglu, 1991; Arioglu et al., 2006; Arioglu et al., 2010; Arioglu et al., 2013 and Arioglu et al. 2016)

The aim of this study was to determine the new potato varieties and their quality characters can be grown in winter season in Cukurova region.

II. Materials and Method

Describe in detail the materials and methods used when conducting the study. The citations you make from different sources must be given and referenced in references.

This study was conducted at the Cukurova University research farm in winter season between beginning of January and May in Cukurova region (Adana-Turkey, 36°59' N, 35°18' E; 23 m elevation) in 2018. The objective of this study was to determinate the tuber yield and some agronomic and quality characteristics of potato breeding lines and varieties grown in winter season. The experimental design was a Randomized Complete Block Design with three replications. The 21 potato varieties such as Agata, Agria, Alegria, Austin, Doruk, Hermes, Maraton, Kutup, Lady Olimpia, Laura, Macar-1402.11, Macar-1406.07, Macar-1409.09, Markies, MEC-1402.09, MEC-1407.17, Nahita, Sante, Soraya, Tessa and Zirve were used as a plant material in this research. Some tuber characteristics of potato breeding lines and varieties used in this study were shown in Table 1.

Table 1. Some tuber characteristics of potato genotypes (breeding lines and varieties) used as research material

Genotypes	Maturity	Using target	Tuber shape	Skin color	Flesh color
Agata	VE	W	SO	Y	DY
Agria	ML	W, FF	LO	LY	DY
Alegria	ME	W, FF	O	Y	Y
Austin	ME	C	O	Y	Y
Doruk	ML	C	O	Y	Y
Hermes	ME	C	O	LY	PY
Maraton	ME	W	O	LY	PY
Kutup	ME	FF	O	Y	PY
L.Olympia	ME	FF	LO	LY	YY
Laura	ME	W	O	R	Y
Macar-1402.11	L	W, FF	LO	Y	PY
Macar-1406.07	ME	W, FF	LO	Y	PY
Macar-1409.09	ML	W, FF	LO	Y	Y
Markies	ML	C, FF	O	LY	PY
MEC-1402.09	ME	W, FF	O	Y	Y
MEC-1407.17	ME	W, FF	O	Y	Y
Nahita	ME	W	O	Y	PY
Sante	ME	W	SO	LY	PY
Soraya	VE	W	LO	LY	PY
Tessa	ME	W, FF	O	Y	Y
Zirve	ME	W	O	Y	Y

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).

The texture of the soil was clay loam. The soil tests in both years indicated a pH of 7.5 with high concentrations of K_2O and low concentrations of P_2O_5. In addition, the organic matter and nitrogen content of the soil were very low. The lime content was 21.5 % in the upper layers with increased levels in lower layers.

In the Adana province (Mediterranean Region) of Turkey, winters are mild and rainy, whereas summers are dry and warm, which is a typical of a Mediterranean climate. The average monthly air temperature during the research period (January-May) was 10.5 °C to 24.4°C in 2018. The total rainfall was 493.7 mm during the growing periods in 2018. The average relative humidity was ranged from 64.0% to 69.7% in 201. The differences between the years and long term for the climatic data were not significant (Table 2).

Table 2. The average monthly temperature, precipitation and relative humidity during the 2018 and long term (1950-2015) growing seasons in Adana, Turkey (Anonymous, 2018).

Months	Avg. Temp. (°C)		Precipitation (mm)		Relative Humidity (%)	
	2018	Long term	2018	Long term	2018	Long term
January	10.5	9.6	324.3	109.8	76.2	69.7
February	13.5	10.5	64.8	84.8	71.3	64.0
March	16.8	13.5	40.1	67.8	71.6	66.3
April	20.1	17.5	35.0	54.7	61.2	67.3
May	24.4	21.7	29.5	47.6	62.8	66.9

The field was cultivated deeply by the moldboard following the harvest of the previous crop in the fall, and then the soil was prepared by using diskharrow. The planting of seed tubers was done by hand on 25th of December in 2017, with 70 cm between row distance and 30 cm in-row distance. The plot size was set as 14 m^2 (2.8 m x 5.0 m). Before planting, 700 $kgha^{-1}$ 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. During the growing period, Ridomil was applied two times to prevent Late blight (*Phytophtora infestans*) and overhead sprinkler irrigation was applied two times. 400 $kgha^{-1}$ Urea (46%N) fertilizer was applied after emergence (1/2 at the tuber formation and 1/2 at the 20 days after first application). The others standard cultural practices were applied at proper time intervals during the growing period.

The tubers were harvested in the second week of May. The plants in each plot were harvested by hand. The number of tubers and tuber yield per hill, total tuber yield per hectare, marketable tuber yield percentage and dry matter content were determined following the harvest (Arioglu et al. 2016). The dry matter content was determined by "Potato Hydrometer".

The data were statistically analyzed by using MSTAT-C package program with Randomized Complete Block design. The Least Significant Differences (LSD) test was used to compare the genotypes at 0.05 level.

III. Results

Tuber Number (no $hill^{-1}$)

It can be seen from Table 3, the tuber number per hill varied between 4.77 and 11.43 no $hill^{-1}$. The differences between the genotypes (breeding lines and varieties) were

statistically significant. The highest number of tuber per hill was obtained from Maraton (11.43 no hill^{-1}), Soraya (11.10 no hill^{-1}) and Laura (10.13 no hill^{-1}) varieties and the lowest from Hermes (4.77 no. hill^{-1}) and Nahita (4.90 no. hill^{-1}) varieties. The average number of tuber per hill was 7.74 no hill^{-1}.

Tuber Yield (g hill^{-1})

There was a statistically significant difference in tuber yield per plant between the potato genotypes. The tuber yield per hill varied between 322.7-998.1 g hill^{-1}. The highest tuber yield per hill was obtained from Macar 1409.09 (998.1 g hill^{-1}) breeding line and the lowest from Hermes (322.7 g hill^{-1}) variety. The average tuber yield of genotypes was found 668.0 g hill^{-1} (Table 3).

Total Tuber Yield (kg ha^{-1})

The differences between the genotypes were statistically significant for the total tuber yield. The total tuber yield values varied between 12.840-37.930 kgha^{-1}. The highest total tuber yield was obtained from Macar-1409.09 (37.930 kgha^{-1}) breeding line and Agata (35.210 kgha^{-1}) variety and the lowest from Hermes (12.840 kgha^{-1}) and Nahita (15.180 kgha^{-1}) varieties (Table 3). The genetic background of the potato genotypes is different. Also, the potato genotypes has different growing period. For these reasons, the difference between the genotypes for the tuber yield was found different (Arioglu, 1986; Senol and Arioglu, 1991; Arioglu et al., 2006; Arioglu et al., 2010 and Arioglu et al., 2013).

Table 3. The tuber number and tuber yield per hill, total tuber yield per hectare, values for potato genotypes grown in winter season in 2018

Genotypes	Tuber number (no hill^{-1})	Tuber yield (g hill^{-1})	Total tuber yield (kg ha^{-1})
Agata	8,97 bcd	901,8 ab	35210 ab
Agria	5,13 ı	577,1 gh	23050 ghı
Alegria	8,37 cde	638,4 fgh	22860 ghı
Austin	9,17 bc	792,0 bcd	29420 cde
Doruk	8,57 cde	675,4 efg	25080 fgh
Hermes	4,77 ı	322,7 k	12840 k
Maraton	11,43 a	860,2 bc	31950 bcd
Kutup	5,73 hı	536,5 hı	19930 ıj
L.Olympia	5,83 hı	572,6 gh	22890 ghı
Laura	10,13 ab	777,3 cde	28870 c-f
Macar-1402.11	9,00 bcd	569,8 gh	21160 hı
Macar-1406.07	6,70 fgh	441,9 ıj	16790 jk
Macar-1409.09	7,77 def	998,1 a	37930 a
Markies	7,30 efg	754,0 cde	28050 def
MEC-1402.09	9,33 bc	695,2 def	26750 efg
MEC-1407.17	7,33 efg	446,9 ıj	15740 k
Nahita	4,90 ı	408,8 jk	15180 k
Sante	6,00 ghı	702,7 def	25720 efg
Soraya	11,10 a	864,7 bc	32540 bc
Tessa	6,57 fgh	709,2 def	26200 efg
Zirve	8,50 cde	783,7 cde	32010 bcd
Average	**7,74**	**668,0**	**25247,0**
LSD(%5)	**1,35**	**12,31**	**4030,40**

Marketable Tuber Yield Percentage (%)

It can be seen from Table 4, the marketable tuber yield percentage ranged from 63.8% to 92.7%. The highest percentage value was found in Markies (92.7%) variety and the lowest in Macar-1406.07 (63.8%) breeding line. The marketable tuber yield percentage is an important factor for the marketing in potato farming. For this reason, this percentage value has to high.

Dry Matter Content (%)

The differences between the genotypes were statistically significant for the dry matter content. The dry matter content varied between 15.10-22.67%. The highest dry matter content was found in Doruk potato variety. The dry matter content was higher in processing type potato genotypes. The dry matter content was found lower than 16% in Nahita (15.10%) and Soraya (15.60%) varieties. These varieties use only as ware potato. These results are in agreement with the findings of Arioglu et al. (2005), Arioglu et al. (2006), Celik et al. (2006), Arioglu et al. (2013) and Arioglu et al. (2016).

Table 4. The marketable tuber yield percentage and dry matter content values for potato genotypes grown in winter season in 2018

Genotypes	Marketable tuber yield (%)	Dry matter content (%)
Agata	84,1 a-e	16,00 jk
Agria	85,6 a-d	18,12 fgh
Alegria	79,6 cde	19,72 cd
Austin	83,5 a-e	20,18 bc
Doruk	82,7 a-e	22,67 a
Hermes	61,6 h	18,63 d-g
Maraton	76,1 c-f	16,93 ıj
Kutup	82,5 a-e	20,94 b
L.Olympia	86,8 abc	18,15fghl
Laura	67,3 fgh	17,10 hıj
Macar-1402.11	73,9 efg	18,42 efg
Macar-1406.07	63,8 gh	19,56 cde
Macar-1409.09	91,0 ab	19,71 cd
Markies	92,7 a	19,62 cd
MEC-1402.09	77,7 c-f	20,13 bc
MEC-1407.17	75,6 def	19,69 cd
Nahita	81,2 b-e	15,10 k
Sante	83,2 a-e	17,55 ghı
Soraya	75,1 def	15,60 k
Tessa	84,1 a-e	19,23 c-f
Zirve	85,1 a-d	17,17 hıj
Average	**79,7**	**18,4**
LSD(%5)	**10,80**	**1,19**

IV. CONCLUSION

The potato can be grown as an early crop during winter and spring seasons for the suitable climate in Mediterranean and Aegean regions in Turkey. In this region, the farmers usually grow to potato for the fresh market. Recently, potato was successfully grown for processing (high dry matter and low sugar content) by the harvesting delayed in winter crops. It is difficult and expensive to storage of potato tuber keeping as high quality for a long time. For this reason, potato processing factories prefer the winter season's crop to reduce the production cost. So, winter potato production is very important for potato processing factories.

It is very important to get high tuber yield and tuber quality in potato farming. There are so many factors affect the tuber yield and quality in potato production. The first of these factors is variety selection. In this study 21 different potato genotypes (breeding lines and varieties) used as a research material. All of the genotypes can be grown as a winter crop in Mediterranean region.

The tuber yield of the genotypes ranged from 12.840 kgha^{-1} to 37.930 kgha^{-1}. Agata, Maraton, Macar-1409.09, Soraya and Zirve genotypes were the highest tuber yield (Table 3). In this research, 21 different potato genotypes were tested and 13 of them use for ware, eight of them for ware and french fries, nine of them use only french fries and four of them use for chips (Table 1).

REFERENCES

[1] Anonymous, 2016. Faostat-Agriculture. http://faostat.org

[2] Anonyomus, 2017. The Turkish Statistical Institute. http://www.tuik.gov.tr

[3] Anonymous, 2018. The Meteorological Data for Adana.TheTurkish State Meteorological Service Adana Regional Directorship, 2018 and long term.

[4] Arioglu, H.H., 1979. Çukurova Bölgesinde Turfanda Patates Yetiştirebilme Olanakları. Türkiye I.Patates Kongresi Tebliğleri, Ankara, s. 69-79

[5] Arioglu, H.H., 1986. Çukurova Turfanda Patates Yetiştiriciliğinde Farklı Kökenli Patates Çeşitlerinin Verim ve Tarımsal Özelliklerinin Belirlenmesi Üzerinde Bir Araştırma. Doğa Bilim Dergisi, Tarım Ormancılık Dergisi, Cilt 10(2):141-148

[6] Arioglu, H.H., Caliskan, M.E., 1999. Akdeniz Sahil Bölgesinde Turfanda Patates Yetiştirilebilme Olanakları Üzerinde Araştırmalar. II.Ulusal Patates Kongresi, Bildiriler Kitabı. s. 220-226, Erzurum

[7] Arioglu, H.H., Incikli, H., Zaimoglu, B., Gulluoglu, L., 2002. Çukurova Bölgesinde Turfanda Patates Yetiştiriciliği Üzerinde Araştırmalar. III.Ulusal Patates Kongresi, Bildiriler Kitabı s.117-123, İzmir

[8] Arioglu, H.H., Caliskan, M.E., Curuk, U., Zaimoglu, B., Celik, H., Gulluoglu, L., 2005. The Effect of Harvest Date on Tuber Yield and Quality Characteristics of Some Processing Potato Cultivars Under the Mediterranean Conditions. Turkish Journal of Field Crops 10(2):49-56

[9] Arioglu, H.H., Curuk, U., Zaimoglu, F.B., Kurt, C., 2006. Çukurova Koşullarında Kışlık Dönemde Yetiştirilen Bazı Yemeklik ve Sanayi Tipi Patates Çeşitlerinin Verim Potansiyellerinin Belirlenmesi. IV.Ulusal Patates Kongresi, Bildiriler Kitabı, s. 91-97, Niğde

[10] Arioglu, H., Kurt, C., Gulluoglu, L., Zaimoglu, L., Onaran, H., 2010. The Determination of Yield Performance of Some Potato Varieties in Mediterranean Climate Conditions. International Symposium on Agronomy and Physiology of Potato. Proceedings of Symposium, p.302-306, Nevşehir-Turkey

[11] Arioglu, H., Kurt, C., Onat, B., Bakal, H., Onaran, H., Gulluoglu, L., 2013. Kışlık Turfanda Patates Üretiminde Bazı Yemeklik ve Sanayi Tipi Patates Çeşitlerinin Verim Potansiyellerinin ve Önemli Tarımsal Özelliklerinin Belirlenmesi. Türkiye 10.Tarla Bitkileri Kongresi Bildiri Kitapçığı, Cilt II. s.415-419, Konya

[12] Arioglu, H. 2014. Nişasta ve Şeker Bitkileri. Ders Kitabı. Genel Yayın No:188, Ders Kitapları Yayın No:A-57. Adana, 234 s

[13] Arıoğlu H.H., Güllüoğlu L., Bakal H., Çalışkan M.E. 2016. The Determination of Tuber Yield and Some Agronomic and Quality Characteristics of Potato Varieties Grown in Winter Season in Mediterranean Region. International Potato Meeting. Programme and Abstracts, p. 22, Riga, Letonya

[14] Caliskan, M.E., Onaran, H., Arioglu, H., 2010. Overview of the Turkish Potato Sector: Challenges, Achievements and Expectations. Potato Research 53:255-266

[15] Celik, H., Fenercioglu, H., Arioglu, H., 2006. Çukurova Bölgesinde Denemeye Alınan Bazı Patates Çeşitlerinin Cips Üretimine Uygunluğu. IV.Ulusal Patates Kongresi Bildiriler Kitabı, s. 178-193

[16] Kumar, D., Ezekiel, R., Singh, B., Ahmed, I., 2005. Conversion Table for Specific Gravity, Dry Matter and Starch Content From Under Water Weight of Potatoes Grown in North-India Plains. Potato J. 32(1-2):79-84

[17] Senol, S., Arioglu, H.H., 1991. Farklı Kökenli Patates Çeşitlerinin Çukurova Bölgesinde Turfanda Olarak Yetiştirilebilme Olanakları Üzerinde Bir Araştırma. Ç.Ü.Ziraat Fak. Dergisi. 6 (2):97-110