Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 11(2): 1559-1567, 2021
Journal of the Institute of Science and Technology, 11(2): 1559-1567, 2021

ISSN: 2146-0574, eISSN: 2536-4618

Tarla Bitkileri / *Field Crops* **DOI: 10.21597/jist.840082**

Araştırma Makalesi / *Research Article*

Geliş tarihi / Received: 13-12-2020 **Kabul tarihi / Accepted: 31-01-2021**

Atıf İçin: Çöl Keskin N, Akınerdem F, 2021. Hümik Asit Uygulamalarının Patates (*Solanum tuberosum* L.) Bitkisinin Gelişimi ve Kalite Özellikleri Üzerine Etkileri. Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 11(2): 1559-1567.

To Cite: Çöl Keskin N, Akınerdem F, 2021. The Effect of Humic Acid Applications on Growth and Quality Properties of Potato (*Solanum tuberosum* L.). Journal of the Institute of Science and Technology, 11(2): 1559-1567.

The Effect of Humic Acid Applications on Growth and Quality Properties of Potato (*Solanum tuberosum* L.)

Nursel ÇÖL KESKİN[1*], Fikret AKINERDEM[1]

ABSTRACT: This study was carried out in Konya Soil, Water and Combating Desertification Research Station in 2015 in order to determine the effect of humic acid applications in different amounts on the development and quality properties of some potato varieties in Konya ecological conditions. Three different potato varieties (Agria, VR808, Brooke) and four different humic acid doses (0, 3, 6, 9 L da^{-1}) were used in this study, which was established in three replications according to "The Randomized Complete Block in a Split Plot Design". In the study, large, medium, small, discarded tuber yields per decare, protein content, specific gravity, chips yield, oil holding capacity of chips, dry matter content, starch content were investigated. It was determined that there was a significant increase in humic acid applications in large, medium, small and discarded tuber yields per decare. Oil holding capacity of chips was between 32.9 % and 46.2 %, starch content was between 11.7 % and 17.3 %, and the differences between humic acid applications were found to be statistically significant for these properties. In terms of chips yield and protein content, statistical significance was not determined among the applications. Considering all the properties examined, it was determined that increasing humic acid applications positively affected the yield of large, medium and small discarded tubers per decare and significant variations were obtained among some quality properties of the varieties.

Keywords: Humic acid, quality parameters, potato, variety

Hümik Asit Uygulamalarının Patates (*Solanum tuberosum* L.) Bitkisinin Gelişimi ve Kalite Özellikleri Üzerine Etkileri

ÖZET: Bu araştırma, Konya ekolojik koşullarında bazı patates çeşitlerinin farklı miktarlardaki hümik asit uygulamalarının bitkinin gelişimi ve kalite özellikleri üzerine etkisini belirlemek amacı ile 2015 yılında Konya Toprak, Su ve Çölleşme ile Mücadele Araştırma İstasyonu Müdürlüğü deneme tarlasında yürütülmüştür. "Tesadüf Blokları Bölünmüş Deneme Deseni"ne göre üç tekerrürlü olarak kurulan bu araştırmada, üç adet farklı patates çeşidi (Agria, VR808, Brooke) ve dört farklı hümik asit dozu (0, 3, 6, 9 L da^{-1}) kullanılmıştır. Araştırmada; dekara büyük, orta, küçük, ıskarta yumru verimleri, protein oranı, özgül ağırlık, cips verimi, cipsin yağ çekme oranı, kuru madde, nişasta oranı incelenmiştir. Dekara büyük, orta, küçük, ıskarta yumru verimlerinde artan hümik asit uygulamalarında önemli artışlar saptanmıştır. Yağ çekme oranı % 32.9-46.2, nişasta oranı % 11.7-17.3 arasında olup, hümik asit uygulamaları arasındaki farklılıklar istatistikî düzeyde önemli bulunmuştur. Cips verimi ve protein oranlarında ise uygulamalar arasında istatistikî düzeyde önem tespit edilmemiştir. İncelenen tüm parametreler göz önüne alındığında artan hümik asit uygulamalarının dekara büyük, orta, küçük ıskarta yumru verimlerini olumlu yönde etkilediği ve çeşitlerin bazı kalite özellikleri arasında da önemli varyasyonlar elde edildiği saptanmıştır.

Anahtar Kelimeler: Hümik asit, kalite parametreleri, patates, çeşit

[1] Nursel ÇÖL KESKİN (**Orcid ID:** 0000-0002-0089-8442), Fikret AKINERDEM (**Orcid ID:** 0000-0003-3336-6992), Selcuk University, Department of Field Crops, Faculty of Agriculture, Konya, Turkey

***Sorumlu Yazar/Corresponding Author:** Nursel ÇÖL KESKİN, e-mail: nurselcol@selcuk.edu.tr

This article was produced from a part of Nursel ÇÖL KESKİN's Master Thesis.

INTRODUCTION

The origin of the potato is known as the highlands of the Andes in South America. It was brought to our country from the Caucasian and Russia and its cultivation started (Gecit et al., 2009). In 2018, 368 million tons of potatoes were produced on 17.5 million hectares of land in the world (Anonymous, 2020a). In our country, in 2019, the potato planting area was recorded as 140 thousand hectares, and the production was close to 5 million tons. In Konya, which is one of the important producer centers in the potato sector of our country, 600 thousand tons of potatoes were produced in 14.3 hectares of planting area in 2019 (Anonymous, 2020b). In addition to being rich in carbohydrates, proteins, vitamins and minerals, its tubers are also used in many industries (chips, mash, frozen products (French fries), flour, alcohol, starch etc.) (Caliskan et al., 2010; Anonymous, 2020c). Improving the soil structure with cultural processes and fertilization practices increases the yield and yield factors for crop production. Due to the damage of intensive chemical fertilization to the environment and living creatures, the tendency towards organic fertilization has increased gradually in recent years. It has been reported in many studies that organic fertilization studies as an alternative to chemical fertilization positively increase the yield and quality of potato plants (Asmaa and Hafez, 2010; Seyedbagheri, 2010; Sanli et al., 2013).

One of the solutions to the organic matter problem in modern agriculture is the direct application of humic acid to the soil or plant. Humic acid and its derivatives are used to increase soil fertility and to grow healthy plants (Akinci, 2011; Celik et al., 2015). Humic acids, on the other hand, can be found in sources such as leonardite, peat, animal manure, and turbines (Akinci, 2011). Humic acids are defined as heterogeneous sources with a high molecular weight and are resistant to deterioration, varying in color from black to yellow, while remaining in the soil for a long time and slowly decomposing become useful to the soil and plant. This usefulness can be listed as providing the aeration of the soil, increasing the Cation Exchange Capacity (CEC), increasing the soil fertility, making the mineral nutrient contents suitable for intake of the plants, protecting the water-soluble inorganic fertilizers and supplying the plant as much as it needs. In addition, chemical fertilizers have positive effects on plants and soil such as minimizing the damage to the soil and plant, increasing the resistance of plants to stress conditions, diseases and pests (Akinci, 2011; Celik et al., 2015). Effects of humic substances on plant growth; it may vary depending on its source, concentration and molecular weight (Nardi et al., 2002). At the same time, humic substances encourage the growth of beneficial microorganisms in the soil thanks to natural carbon (30-36 %) in their bodies, and some types of fungi that are formed as a result of the biological activities of microorganisms in the soil give the plant resistance by producing natural antibiotics (Ozkan, 2007). In potato cultivation, humic acid increases the water conservation of the root area where it is applied, increases the resistance of the plant and provides resistance against diseases (Mosa, 2012).

In potato cultivation, it is important to reduce the excessive and unconscious chemical fertilization and to include humic acid and its derivatives in the production more consciously. Therefore, in the study, it was aimed to determine the effect of different amounts of humic acid applications on plant growth and quality properties in some potato varieties produced widely in Konya region.

MATERIALS AND METHODS

The climatic values of the means of the year (2015) and long years in which the study was carried out in Konya province were shown in Table 1. According to the 35-year observations made in Konya, the mean temperature was 21.2 ^{o}C, the total precipitation was 101.7 mm, the mean temperature for the year the study was conducted (2015) was 21.8 ^{o}C, and the total precipitation was 127.1 mm. Accordingly, it was seen that the mean temperature during the study period was higher (Table 1). The soil of the land where the research was established is loamy in texture, organic matter 1.09 %, inorganic nitrogen 0.04 %, favorable P_2O_5 3 Kg da^{-1}, suitable K_2O 53.95 Kg da^{-1} and pH 7.78.

Table 1. Climate data for the years in which the research was conducted*

Months	Mean Temperature (ºC)		Total Precipitation (mm)		Mean Relative Humidity (%)	
	1980-2014	2015	1980-2014	2015	1980-2014	2015
May	16.0	17.4	42.5	18.2	51.9	48.1
June	20.5	19.3	41.8	40.7	47.2	55.8
July	25.4	24.4	6.2	10.4	36.4	37.1
August	24.4	25.1	3.0	37.8	33.8	42.1
September	19.5	22.9	8.2	20.0	36.3	39.7
Mean	21.2	21.8	20.3	25.4	34.3	44.6
Total	127.0	130.6	101.7	127.1	205.6	222.8

*It was taken from the Meteorology Journal of the Prime Ministry State Meteorology Affairs General Directorate (1980-2014 = long years mean)

This study, which was carried out in Konya ecological conditions in May-September 2015, was established in three replications according to "The Randomized Complete Block in a Split Plot Design". In the study, three different potato varieties (Agria, VR-808, Brooke) which was from Milva Seed Agriculture Animal Husbandry Transport Food Industry Trade Corporation and Toprak Agriculture Industry Trade Corporation and four different amounts of humic acid application as "Control (D_0), 3 L da^{-1}, (D_1), 6 L da^{-1} (D_2), 9 L da^{-1} (D_3)" were used. Each sub-parcel of the experiment consists of four rows and each row consists of 15 hills, each harvesting plot was established with a size of 1.4 m x 4.5 m = 6.3 m^2. In the trial area, 0.7 m between the parcels was left, and the blocks were arranged as 1.9 m. Tuber seeds kept under appropriate conditions were planted manually in 70x30 cm hills on May 15, 2015, after tuber seeds spraying with Imidacloprid active ingredient. Four humic acid applications (D_0, D_1, D_2, D_3) were randomly distributed to the parcels and 2 L da^{-1} of water was added to all doses and sprayed on the relevant plots before planting. With planting, compound (NPK) fertilizer (15-15-15) in the form of 6 Kg da^{-1} nitrogen, 6 Kg da^{-1} phosphorus, 6 Kg da^{-1} potassium was calculated and given to each parcel. As top fertilizer, 3 Kg da^{-1} N was treated in the form of urea with the growth process. Base and top fertilizers were applied as sprinkling and mixed into the soil. The irrigation was carried out by sprinkling and manual hoeing was made against weeds, and disinfestation implementation was made two times with the chemical agent in which effective substance was Azinphos-methly (25 %) for dealing with The Colorado Potato Beetle (*Leptinotarsa decemlineata*). The harvest was done by hand on 20 September 2015 by considering harvesting plots.

The tubers obtained from the harvest plots were classified separately and placed in sacks, then passed through 5.0, 3.5 and 2.8 cm sieves and divided into 4 classes according to their diameter (Ozyildirim, 2014). Dry matter content according to Kacar (1972), protein content according to Kjeldhal method (Kadaster, 1960; Augustin, 1975), specific gravity according to air-water weighing method (Incekara, 1973), starch content according to "Ewers Method" (Anonymous, 1974), chips yield according to the method specified by Senol (1973), oil holding capacity of chips using Soxhlet method (Senol, 1973; Dogan and Basoglu, 1985) were determined.

The data obtained from the study were subjected to variance analysis according to "The Randomized Complete Block in a Split Plot Design"using the "MSTAT-C" statistical program and the differences between the means were determined according to the LSD test.

RESULTS AND DISCUSSION

Considering the large tuber yield values in the study; Brooke (3149.2 Kg da^{-1}) was in the first group (a), followed by Agria (2623.8 Kg da^{-1}) and VR808 (2616.3 Kg da^{-1}) (b) in the second group. In mean humic acid, large tuber yield increased at all doses compared to D_0. The values obtained from D_2 and D_3 were in the same group (a). In terms of variety x humic acid interaction; Agria and D_0 group (1964.2 Kg da^{-1}) got the lowest value, while Brooke and D_2 group (3366.2 Kg da^{-1}) got the highest value.

For medium tuber yield; among the varieties, Agria (1228.9 Kg da^{-1}) (a), VR808 (936.5 Kg da$^{-1)}$ (b), Brooke (745.6 Kg da^{-1}) (c) took place in different groups. Among the mean humic acid; In D_1 (1229.3 Kg da^{-1}) (a) it was found to be the most, and the lowest in D_3 (838.5 Kg da^{-1}) (c). In terms of variety x humic acid interaction, medium tuber yield showed different responses depending on the humic acid applications and varieties. While D_0 and Brooke (550.4 Kg da^{-1}) was the lowest, Agria and D_1 (1474.7 Kg da^{-1}) was found to be the highest.

Table 2. Mean values of the properties examined in the study and formed groups-1

Humic Acid Applications	Large Tuber Yield (Kg da^{-1})				Medium Tuber Yield (Kg da^{-1})			
	Varieties							
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
D_0	2182.9^{gh}	2950.3^{de}	<u>1964.2^{h}</u>	**2365.8c**	1014.1^{c}	<u>550.4^{e}</u>	1320.9^{ab}	**961.8b**
D_1	2501.6^{ef}	3135.8^{ab}	2312.3^{fg}	**2649.9b**	1151.1^{bc}	1062.2^{c}	<u>1474.7^{a}</u>	**1229.3a**
D_2	2837.9^{cd}	<u>3366.2^{a}</u>	3080.9^{b}	**3095.0a**	783.2^{d}	670.0^{de}	1102.0^{c}	**851.7bc**
D_3	2942.9^{bc}	3144.3^{ab}	3137.7^{ab}	**3075.0a**	797.6^{d}	700.0^{de}	1018.1^{c}	**838.5c**
Mean	**2616.3b**	**3149.2a**	**2623.8b**	**2796.4**	**936.5b**	**745.6c**	**1228.9a**	**970.3**
LSD_V:96.62; LSD_{HA}: 134.9; LSD_{VXHA}: 233.6					LSD_V: 134.9; LSD_{HA}: 111.4; LSD_{VXHA}: 192.9			
	Small Tuber Yield (Kg da^{-1})				Discarded Tuber Yield (Kg da^{-1})			
D_0	85.1^{d}	83.2^{d}	<u>235.6^{a}</u>	**134.6b**	31.3^{def}	13.0^{gh}	45.9^{cd}	**30.0c**
D_1	148.5^{bc}	134.3^{c}	188.7^{b}	**157.2a**	42.0^{cde}	48.5^{c}	52.6^{bc}	**47.7b**
D_2	88.8^{d}	68.0^{d}	185.5^{b}	**114.1b**	69.3^{ab}	19.3^{fgh}	<u>85.6^{a}</u>	**58.0a**
D_3	74.9^{d}	<u>60.8^{d}</u>	127.9^{c}	**87.9c**	<u>6.5^{h}</u>	28.4^{efg}	58.9^{bc}	**31.3c**
Mean	**99.3b**	**86.6b**	**184.4a**	**123.4**	**37.3b**	**27.3b**	**60.7a**	**41.8**
LSD_V:28.99; LSD_{HA}: 22.24; LSD_{VXHA}: 38.53					LSD_V:10.58; LSD_{HA}:9.771; LSD_{VXHA}:16.92			

* : $p \leq 0.05$, ** : $p \leq 0.01$ (V_1:VR808, V_2: Brooke, V_3: Agria) (V: Variety, HA: Humic acid)

Looking at the small tuber yield; among the varieties, small tuber yield was the highest in the Agria (184.4 Kg da^{-1}) (a), followed by VR808 (99.3 Kg da^{-1}), Brooke (86.6 Kg da^{-1}) (b) in the same group. According to the mean humic acid, D_1 was found to be the most (157.2 Kg da^{-1}) (a) and this was followed by D_0 (134.6 Kg da^{-1}), D_2 (114.1 Kg da^{-1}) (b) in the same group and the lowest yield (c) (87.9 Kg da^{-1}) was obtained. While the highest yield was obtained with the combination of Agria and D_0 (235.6 Kg da^{-1}) in the variety x humic acid interaction, the Brooke and D_3 (60.8 Kg da^{-1}) were in the same group (d) with different combinations with the lowest yield.

When looking at the discarded tuber yield; in the mean of the varieties, Agria (60.7 Kg da^{-1}) was the highest (a), VR808 (37.3 Kg da^{-1}) followed by Brooke (27.3 Kg da^{-1}) and they were in the same group (b). According to the mean of humic acid, D_2 (58.0 Kg da^{-1}) (a) was found the most, followed by D_1 (47.7 Kg da^{-1}) (b). In D_0 and D_3 (30.0 Kg da^{-1} and 31.3 Kg da^{-1}) the lowest yields were obtained and they were included in the same group (c). In terms of variety x humic acid interaction, the highest efficiency was obtained from Agria and D_2 (85.6 Kg da^{-1}), while yield of VR808 and D_3 (6.5 Kg da^{-1}) combination the lowest (Table 2).

The differences between potato varieties, applied humic acid applications and variety x humic acid interaction in terms of chips yield and protein content were not found statistically significant.

The differences between variety, humic acid, variety x humic acid interaction in terms of oil holding capacity of chips were statistically significant at 1 % level. Among the varieties, Agria (42.1 %) (a), Brooke (40.0 %) (b) and VR808 (39.9 %) (c) were ranked in different groups. According to the mean humic acid applications; while the oil holding capacity of chips was determined the most in the D_0 (42.3 %) (a), it was followed by D_2 (41.5 %) (b), D_3 (40.1 %) (c), D_1 (38.7 %) (d), respectively. Variety x humic acid interactions, the highest value was obtained in VR808 and D_0 (46.2 %), while the lowest value was obtained from VR808 and D_1 (32.9 %) (k).

Table 3. Mean values of the properties examined in the research and the groups formed-2

Humic Acid Applications	Dry Matter Content (%)				Specific Gravity (g/cm^3)			
	Varieties							
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
D_0	22.9^{a}	21.3^{ab}	16.7^{c}	**20.3**	1.090	1.100	1.083	**1.091**
D_1	21.2^{ab}	21.8^{ab}	19.5^{b}	**20.8**	1.090	1.090	1.070	**1.083**
D_2	21.7^{ab}	22.2^{a}	15.2^{c}	**19.7**	1.093	1.090	1.070	**1.084**
D_3	21.4^{ab}	22.3^{a}	16.6^{c}	**20.1**	1.090	1.100	1.077	**1.089**
Mean	**21.8a**	**21.9a**	**17.0b**	**20.2**	**1.091a**	**1.095a**	**1.075b**	**1.087**
LSD_V:4.107; LSD_{VXHA}: 2.311					LSD_V: 0.1281			
	Starch Content (%)				Protein Content (%)			
D_0	15.3^{d}	17.1^{ab}	14.4^{e}	**15.6a**	11.8	12.8	12.4	**12.3**
D_1	15.4^{d}	17.0^{ab}	12.1^{g}	**14.8b**	11.9	10.5	13.8	**12.1**
D_2	16.5^{bc}	15.7^{cd}	11.7^{g}	**14.6b**	11.3	12.1	12.1	**11.9**
D_3	16.2^{c}	17.3^{a}	13.2^{f}	**15.6a**	11.2	11.7	10.9	**11.3**
Mean	**15.8b**	**16.8a**	**12.8c**	**15.2**	**11.5**	**11.8**	**12.3**	**11.9**
LSD_V: 0.9266; LSD_{HA}: 0.4312; LSD_{VXHA}: 0.7469								
	Chips Yield (%)				Oil Holding Capacity of Chips (%)			
D_0	51.6	53.6	35.2	**46.8**	46.2^{a}	41.0^{d}	39.7^{g}	**42.3a**
D_1	50.5	46.3	43.0	**46.6**	32.9^{k}	38.9^{j}	44.5^{c}	**38.7d**
D_2	49.8	50.5	41.9	**47.4**	39.4^{h}	39.9^{f}	45.3^{b}	**41.5b**
D_3	50.0	50.8	39.2	**46.7**	41.0^{d}	40.1^{e}	$39.1^{ı}$	**40.1c**
Mean	**50.5**	**50.3**	**39.8**	**46.9**	**39.9c**	**40.0b**	**42.1a**	**40.7**
					LSD_V:0.05944; LSD_{HA}:0.06068; LSD_{VXHA}:0.1051			

* : $p \leq 0.05$, ** : $p \leq 0.01$ (Ç$_1$:VR808, Ç$_2$: Brooke, Ç$_3$: Agria) (V: Variety, HA: Humic acid)

The difference between the variety and variety x humic acid interaction in terms of dry matter content was found statistically significant at the level of 5 %. Brooke and VR808 were in the same group (a) (21.9 % and 21.8 %, respectively) and Agria (b) in the second group (17.0 %) in terms of dry matter content among the variety means. Looking at the interactions of variety x humic acid, Brooke and VR808 varieties were found in (a) and (ab) group in all humic acid applications, while the lowest dry matter content was obtained from Agria variety and D_0, D_2, D_3 humic acid applications (16.7 %, 16.6 %, 15.2 %).

Differences between varieties in terms of specific gravity were found statistically significant at 1 % level. According to the variety means, VR808 and Brooke (1.091 and 1.095 g/cm^3) were in the same group (a), followed by Agria (1.075 g/cm^3) (b). The reactions of the varieties to all applications were different, when evaluated numerically, the highest value was determined from Brooke and D_0-D_3 combination (1.100 g/cm^3), and the lowest value was determined from Agria and D_1-D_2 combinations (1.070 g/cm^3).

In terms of starch content, the differences between variety, humic acid, variety x humic acid interactions were found statistically significant at 1 % level. Among the mean varieties, Brooke (16.8 %) (a), VR808 (15.8 %) (b) and Agria (12.8 %) (c) were in different groups. In humic acid means, starch content were the highest in D_3 and D_0 (15.6 %) (a), followed by D_1 (14.8 %) and D_2 (14.6 %) (b), which are in the same group, respectively. In the variety x humic acid interactions, the responses of the varieties were different in terms of starch content. A significant increase was obtained from the combination of VR808 and D_2 compared to D_0 and D_1. While the Brooke had high starch content in all doses except from D_2, the lowest starch content was recorded in Agria and D_2 and D_1 (11.7 % and 12.1 %). The highest starch content was obtained from the Brooke and D_3 combination (17.3 %) (Table 3).

Table 4. The mean square values of all traits examined in potato varieties grown at different humic acid doses

Source of variation	Df	Large Tuber Yield (Kg da^{-1})	Medium Tuber Yield (Kg da^{-1})	Small Tuber Yield (Kg da^{-1})	Discarded Tuber Yield (Kg da^{-1})	Dry Matter Content (%)
Blocks	2	9847.245	13549.656	300.105	52.437	5.315
Varieties (A)	2	1120060.379**	711283.924**	33930.559**	3543.752**	93.128*
Error $_1$	4	2642.178	5153.175	237.851	31.672	13.128
Humic Acid Doses (B)	3	1121018.493**	295849.812**	7841.548**	1644.589**	1.910
(A x B) İnt.	6	163895.711**	37305.981**	2304.480**	1006.582**	5.095*
Error $_2$	18	9383.159	6739.519	268.713	51.854	1.815
Source of variation	**Df**	**Specific Gravity (g/cm^3)**	**Starch Content (%)**	**Protein Content (%)**	**Chips Yield (%)**	**Oil Holding Capacity of Chips (%)**
Blocks	2	0.000	0.381	2.111	59.864	0.005
Varieties (A)	2	0.001**	50.548**	4.148	447.890	19.590**
Error $_1$	4	0.000	0.243	1.769	89.998	0.001
Humic Acid Doses (B)	3	0.000	2.190**	1.769	1.059	22.159**
(A x B) İnt.	6	0.000	2.373**	2.788	31.976	50.651**
Error $_2$	18	0.000	0.101	2.793	23.192	0.002

Df: degrees of freedom; * $P<0.05$; ** $P<0.01$

CONCLUSION

Suh et al. (2014), in their studies on the development and quality of fulvic and humic acids, reported that the effect of humic and fulvic acid applications on tuber sizes was irregular and that there was a slight increase in yield in some applications, but this was not statistically significant. Sanli et al. (2013) found that the marketable tuber yield increased compared to the control, and the highest marketable tuber yield was obtained from 400 and 600 Kg ha^{-1} leonardite applications according to the two-year results. In these studies, our study was in agreement with the findings that there is a general increase in large, medium, small, discarded tuber yields per decare, but this increase does not show a regular distribution. At the same time, the different ratios of medium-sized tubers in the varieties taken to the study were due to the different responses of the varieties to environmental and ecological conditions, as well as the different total growth duration of the varieties. It has also been reported by (Selim et al., 2009; Asmaa and Hafez, 2010).

Chips yield depends on tuber specific gravity and dry matter content. The chemical composition of potato tubers also varies according to the variety, growth period, ecological conditions and cultivation techniques (Senol, 1973; Karadogan and Gunel, 1992; Polat et al., 2008). In this study, although the varieties showed deviations, the chips productivity of the variety with high specific gravity was also high. A high value was obtained from the chips yield of the VR808, which was a high specific gravity. This situation also explained the different reactions of each variety to humic acid as a result of our study. At the same time, the chips yield of the varieties with low dry matter ratio were low, the water loss during frying in the varieties with high dry matter content caused the chips yield to be high (Sanli et al., 2013). The findings of the researchers in this direction are in agreement with our results.

The fact that chips absorb less oil is important in terms of both health and cost (Ozyildirim, 2014). There is a negative correlation between dry matter content and oil holding capacity of chips (Abong et al., 2009). This situation also explained that the chips in our study differed between applications in terms of the oil holding capacity of chips. The oil holding capacity of chips of varieties varied irregularly in terms of different humic acid applications.

The most important issue in potato cultivation is tuber quality, which is particularly related to dry matter content and protein content. At the same time, environmental factors, growing different varieties in the same environment, planting time, control program, ripening conditions before harvest, applied fertilizer dosage, form and application method, storage period and method directly affect the main factors forming the tuber and food value (Karadogan and Oral , 1995; Senol, 1973). This situation also explained the different reactions of each variety to humic acid as a result of our research.

It was reported by Karadogan and Gunel (1992) and Karadogan (1994) that there was a negative correlation between tuber dry matter ratio and specific gravity and protein ratio. Sanli et al. (2013), in their study with leonardite, concluded that the specific gravity did not make a significant difference in statistical terms, which was in parallel with this study.

Suh et al. (2014) found that the rate of humic and fulvic acid increased in the starch content compared to the control group and that the difference between starch contents in all applications was not statistically significant. In this study, our study was in agreement with the findings. The differences that tubers show in terms of protein content are due to the genetic structure of the varieties (Kara and Kara, 2016). In potato varieties, protein content are thought to be due to their genetic structure and the decrease in some applications is due to dry matter content. Because protein is a component of tuber dry matter content and the increase in the amount of dry matter content increases the protein value proportionally. At the same time, the protein content of the varieties with high tuber specific gravity are low (Karadogan and Gunel, 1992; Karadogan, 1994). This situation also explained the different responses of each variety to humic acid as a result of our study.

According to the results of the study, it can be concluded that increasing humic acid applications positively affect all large, medium, small, discarded tuber yield and some quality components, while determining the differences between varieties in terms of properties examined. Different results were obtained from humic acid applications, and significant increases were achieved in humic acid applications, which increased the yield of large, medium, small and discarded tubers. Considering the yields of large and medium tubers considered as marketable tuber yield per decare, Brooke variety (in large tuber yield with 3149.2 Kg da^{-1}) and Agria variety (medium tuber yield with 1228.9 Kg da^{-1}) can be recommended under Konya conditions. As for the humic acid dosage, although the reactions of the varieties to the applications of different amounts of humic acid are irregular, it was seen that the highest yield was obtained in the large tuber yield of the Brooke variety (3366.2 Kg da^{-1}) in the application of 6

L humic acid application per decare. Although certain results were obtained in this one-year study, more research and especially multi-year studies were needed for clearer and more reliable results.

ACKNOWLEDGEMENTS

The thesis study was supported by OYP allowances numbered as 2015 - OYP - 080; and also, we would like to thank the authorities and our coordinator who provided us this opportunity.

Conflict of Interest

The article authors declare that there is no conflict of interest between them.

Author's Contiıbutions

The authors declare that they have contributed equally to the article.

REFERENCES

Abong GO, Okoth MW, Karuri EG, Kabira JN, Mathooko FM, 2009. Influence of potato cultivar and stage of maturity on oil content of French fries (chips) made from eight Kenyan potato cultivars. African Journal of Food, Agriculture, Nutrition and Development, 9(8).

Augustin J, 1975. Variations in the nutritional composition of fresh potatoes, Journal of Food Science, 40 (6): 1295-1299. https://doi.org/10.1111/j.1365-2621.1975.tb01076.x

Akinci Ş, 2011. Humic acids, plant growth and nutrient uptake, Marmara University Journal of Science, 23 (1): 46-56.

Anonymous, 1974. Analitical Methods for Potato Research. No:A-6, The Inst. Res. On Storage and Process. Agrich Pred.

Anonymous, 2020a, FAOSTAT. http://www.fao.org/faostat/en/#data/QC Accessed: 01.08.2020.

Anonymous, 2020b, TÜİK. http://www.tuik.gov.tr/Start.do Accessed: 01.08.2020.

Anonymous, 2020c, Self Nutrition Data. http://www.nutritiondata.com/facts/vegetables-and-vegetableproducts/2770/ Accessed: 05.08.2020.

Asmaa RM, Hafez MM, 2010. Increasing productivity of potato plants (*Solanum tubersoum* L.) by using potassium fertilizer and humic acid application. Int. J. Acad. Res. 2:83-88.

Caliskan ME, Onaran H, , Arioglu H, 2010. Overview of the Turkish potato sector: challenges, achievements and expectations. Potato Research, 53(4): 255-266. doi: 10.1007/s11540-010-9170-1.

Celik M, Yildirim M, Yildirim Z, 2015. Potato proteins, Ömer Halisdemir University Journal of Engineering Faculty, 4 (2): 68-77.

Dogan A, Basoglu F, 1985. Cooking vegetable oil chemistry and technology application guide, Ankara University Agricultural Faculty Course Publications, 951.

Gecit H, Ciftci C, Emeklier Y, İkincikarakaya S, Adak M, Kolsarici Ö, Ekiz H, Altinok S, Sancak C, , Sevimay C, 2009. Field Crops, Ankara University Agricultural Faculty Course Publications (1569).

Incekara F, 1973. Industrial Crops and Breeding. Starch Sugar Plants and Breeding. Ege University Agricultural Faculty Course Publications, (101).

Kacar B, 1972. Chemical analysis of plants and soil. II. Plant analysis. Ankara University Agricultural Faculty Course Publications, 453: 50-72.

Kadaster I, 1960. Agricultural Chemistry Application, Forage Crops -I. Ankara University Agricultural Faculty Course Publications, 113.

Kara K, Kara T, 2016. Quality Characteristics of Some Registered Potato Varieties in Erzurum Ecological Conditions, Journal of the Faculty of Agriculture, 47 (2):85-88.

Karadogan T, Gunel E, 1992. An Experiment on The Yield And Adaptation Some Potatoes under Ecological Condition in Erzurum, Journal of the Faculty of Agriculture, 23: 1-15.

Karadogan T, 1994. A Study on Chips and French-Fried Quality Of Potato Cultivars, Journal of the Faculty of Agriculture, 25 (1): 30-38.

Karadogan T, Oral E, 1995. Effect of Nitrogen Source and Application Times on Quality of Potatoes, Journal of the Faculty of Agriculture, 26 (1).

Mosa AA, 2012. Effect of the application of humic substances on yield, quality, and nutrient content of potato tubers in Egypt. In Sustainable Potato Production: Global Case Studies (pp. 471-492). Springer, Dordrecht.

Nardi S, Pizzeghello D, Muscolo A, , Vianello A, 2002. Physiological effects of humic substances on higher plants, Soil Biology and Biochemistry, 34 (11): 1527-1536.

Ozkan S, 2007. Production of humic acid and fertilizer from Turkish lignites, Ankara University Graduate School of Natural and Applied Sciences, Master Thesis (Printed).

Ozyildirim N, 2014. Effects of nitrogen fertilizer forms on yiled and yiled components of potato (*Solanum tuberosum* L.) genotypes of different maturity group, Ankara University Graduate School of Natural and Applied Sciences, Master Thesis (Printed).

Polat T, Ozturk,E, Kavurmaci Z, , Kara K, 2008. Determination of Some Quality Properties of Potato Cultivars under Erzurum Ecological Conditions, Alinteri Journal of Agriculture Science, 15 (2): 33-39.

Selim EM, El-Neklawy AS, El-Ashry SM, 2009. Beneficial effects of humic substances ferrtigation on soil fertility to potato grown on sandy soil. Aust. J. Basic Appl. Sci. 3:4351-4358.

Seyedbagheri MM, 2010. Influence of humic products on soil health and potato production, Potato research, 53 (4): 341-349.

Smith O, 1968. Potatoes: production, storing, processing, Potatoes: production, storing, processing.

Suh, H. Y, Yoo KS , Suh SG, 2014. Tuber growth and quality of potato (*Solanum tuberosum* L.) as affected by foliar or soil application of fulvic and humic acids, Horticulture, Environment, and Biotechnology, 55 (3): 183-189.

Sanli A, Karadogan T, Tonguc M, 2013. Effects of leonardite applications on yield and some quality parameters of potatoes (*Solanum tuberosum* L.). Turkish Journal of Field Crops, 18(1): 20-26.

Senol S, 1973. Effect of temperature, duration, tuber specific gravity and variety feature on sugar, dry matter and chips quality in potato storage, Atatürk University Agricultural Faculty Course Publications,159.