

The Effect of Soil and Foliar Humic Acid Applications on Yield and Some Characteristics of Potato (*Solanum tuberosum* L.)*

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Abstract

Objective: This study was conducted to determine the effects of different doses soil and foliar humic acid applications, on yield and certain characteristics of potatoes.

Material and Method: The registered "Jelly" potato variety was used as the material in the study. Before planting, rows were created at 70 cm intervals using a fully automatic potato planting machine. Then, single tubers were planted on the ridges by hand, 30 cm apart. This study was carried out with 3 replications according to the factorial design in randomized blocks; humic acid was applied at the pre-planting from soil (0, 40, 80, 120 lt/ha) and at the pre-flowering from leaves (0 and 4000 ml/ha).

Results: As a result of the research, it was determined that plant height was 97.97-112.93 cm, tuber number per hill was 6.13-7.93 tuber/hill, tuber yield per hill was 510.58-693.41 g/hill, tuber yield was 33091.8 - 41274.8 kg/ha, marketable tuber yield was 26468.2-37525.7 kg/ha, dry matter ratio was 17.65-18.54% and starch ratio was 13.86-14.46%. In addition, it was determined that the combined application of humic acid from soil and leaves had a very significant effect on plant height and main stem number, that the application of humic acid only from soil had a significant effect on tuber yield per hill, total and marketable tuber yield and that its effects on other traits examined in the study were statistically insignificant.

Conclusion: The highest tuber yield (39149.3 kg/ha) and marketable tuber yield (34475.1 kg/ha) were achieved in potatoes when 120 kg/ha of humic acid was applied to the soil before planting. Based on these

results, it was concluded that humic acid application has a significant effect on potato yield, but that it would be beneficial to examine its effects in different locations and on varieties from different maturity groups before making recommendations for production.

Key words: Humic acid, potato, *Solanum tuberosum* L.

Topraktan ve Yapraktan Humik Asit Uygulamalarının Patates Bitkisinin (*Solanum tuberosum* L.) Verim ve Bazı Özelliklerine Etkisi Öz

Amaç: Bu çalışma; topraktan ve yapraktan farklı dozlarda humik asit uygulamalarının patatesin verim ve bazı özellikleri üzerine etkilerini belirlemek amacıyla yürütülmüştür.

Materyal ve Yöntem: Araştırmada materyal olarak tescilli Jelly patates çeşidi kullanılmıştır. Dikim işlemi sıra arası 70 cm olan ve içerisinde patates bulunmayan tam otomatik patates dikim makinesi ile sıralar oluşturulmuş ve sırtlar üzerine 30 cm aralıkla her bir ocağa tek yumru gelecek şekilde elle yapılmıştır. Tesadüf bloklarında faktöriyel deneme desenine göre 3 tekerrürlü olarak yürütülen bu araştırmada; humik asit uygulaması dikim öncesi topraktan (0, 40, 80, 120 lt/ha) ve çiçeklenme öncesi yapraktan (0 ve 4000 ml/ha) olmak üzere iki farklı dönemde yapılmıştır.

Araştırma Bulguları: Araştırma sonucunda bitki boyunun 97.97-112.93 cm, ana sap sayısının 6.03-8.03 adet/ocak, ocak başına yumru sayısının 6.13-7.93 adet/ocak, ocak başına yumru veriminin 510.58-693.41 g/ocak, yumru veriminin 33091.8 - 41274.8

kg/ha, pazarlanabilir yumru veriminin 26468.2-37525.7 kg/ha, kuru madde oranının %17.65-18.54 ve nişasta oranının da %13.86-14.46 arasında değişim gösterdiği belirlenmiştir. Bu çalışmada humik asidin topraktan ve yapraktan birlikte uygulamasının bitki boyu ve ana sap sayısı üzerine çok önemli, topraktan humik asit uygulamasının ocak başına yumru verimi, dekara yumru verimi ve pazarlanabilir yumru verimi üzerine önemli etkiye bulunduğu, diğer özellikler üzerine olan etkilerinin ise istatistiksel olarak önemsiz olduğu belirlenmiştir.

Sonuç: Araştırma sonucunda; patatete birim alandan en yüksek yumru verimi (39149.3 kg/ha) ve pazarlanabilir yumru verimi (34475.1 kg/ha) 120 kg/ha dozunda topraktan humik asit uygulamasından elde edilmiştir. Elde edilen bu sonuçlara göre; humik asit uygulamasının patatete verim üzerinde önemli bir etkisinin olduğu, ancak üretimde tavsiye edilemek için farklı lokasyonlarda ve değişik olum grubuna ait çeşitler bazında da incelenmesinin faydalı olabileceği sonucuna varılmıştır.

Anahtar kelimeler: Humik asit, patates, *Solanum tuberosum* L.

Introduction

Potatoes, with their high nutrient content and high dry matter production per unit area, can play a leading role in alleviating the ever-increasing food shortage. Humans must obtain their daily energy needs to sustain life. This energy is provided by the carbohydrates, protein and fat in the foods they consume. Furthermore, a balanced diet requires vitamins and minerals in addition to energy. Considered from this perspective, the potato is a source of energy, protein, and minerals. While the chemical composition of potatoes varies depending on the variety, they contain an average of 10-24% starch and 1-2% protein. Furthermore, they contain significant amounts of vitamin C, B vitamins, and minerals such as P, K, Mg and Cl making them a crucial nutritional resource. Potatoes are a popular choice for a variety of dishes, and all kinds of products, from salads to fried foods. Potatoes can be processed industrially to produce high-value-added products (starch, sago, dextrin, glue, etc.). Furthermore, tubers not used in cooking or industry, or the residues of tubers, can be used as animal feed (Er and Uranbey, 1998; Dede, 2004; Kara, 2011; Fernie and Willmitzer, 2001; Tunçtürk, 2006). In addition to human and animal nutrition, starch and starch products obtained from potatoes are also used in the textile, paper, and pharmaceutical industries (Arslan, 2002). Potatoes, a

hoe crop, play an important role in crop rotation and are a significant source of income for farmers because they provide economic returns thanks to their high yield (Arioğlu et al., 2006).

According to 2023 data, potatoes are among the top produced agricultural products worldwide, with approximately 16.7 million ha planted and 383 million tons produced. In the same year, 5.7 million tons of potatoes were produced in Turkey on 150.927 ha, with a yield of 37.7 tons/ha (Anonymous, 2025).

Increasing yield in agricultural production is of great importance to meet the ever-increasing global food demand. Chemical fertilization is the primary source of increasing yield in plant production. As is well known, the low organic matter content of Türkiye's soils necessitates the use of fertilizers, particularly nitrogenous fertilizers. However, the increasing use of chemical fertilizers is deteriorating soil structure and creating problems such as soil and water pollution. Therefore, the trend toward organic fertilizers has been increasing in recent years (Özkan, 2007; Kacar and Katkat, 2018).

Organic fertilizers consist of animal or plant matter. In this context, barnyard manure, compost, green manures, and leonardite and the humic and fulvic acid derived from them can be utilized (Kacar and Katkat, 2018).

Humic acids accelerate plant growth and development by positively influencing plant roots. This positive effect occurs by stimulating H-ATPase enzyme activity in plant root cells, thereby promoting water and nutrient uptake. Furthermore, humic substances increase beneficial microorganisms in the soil, and finally, photosynthesis increases (Çöl and Akinerdem, 2017).

The amount of fertilizer used in the production of high-yielding plants such as potatoes is always higher than other crops. It indicates that the negative effects of excessive fertilizer use may be even greater in potato production areas. Therefore, research aimed at increasing yields through the use of organic fertilizers or materials, such as humic acid, which can be beneficial for both plant and soil health in potato production, is of great agricultural importance. This study was conducted to determine the effects of soil and foliar application of different doses of humic acid on potato yield and some yield components.

Materials and Methods

This research was carried out in Yukarı Kirazdere (900 m a.s.l.) Kabadüz district, Ordu-Türkiye located

at the east of the Melet River in 2018. In the experimental year, total precipitation, average temperature, and average relative humidity during the growing season (May-October) were 572.5 mm, 14.7 °C, and 82.8%, respectively; while the long-term average was 513.4 mm, 14.0 °C, and 78.6%, respectively (Anonymous, 2019).

Soil samples taken from a depth of 0-30 cm from the experimental area were analyzed in the laboratory of the Soil Science and Plant Nutrition Department of Faculty of Agriculture, Ordu University. According to the analysis results, the experimental area soil has a sandy-loam structure, acidic (pH=4.39), contains high organic matter and nitrogen, and is insufficient in phosphorus and potassium.

The tubers of potato cv. Jelly were used as the material in the study. This variety is of mid-to-late maturity, high-yielding, high-quality, suitable for both cooking and industrial use, and resistant to viral and fungal diseases.

Field trials examining humic acid applications from foliar and soil at different doses were conducted using a randomized block factorial design with three replications. Row spacing was 70 cm and within-row spacing was 30 cm (Kara, 2011; Er and Uranbey, 2009) and each plot was planted in four rows 5 m long. Before planting, rows were created using a fully automatic potato planting machine (free of potatoes). The rows were then manually planted on the ridges, placing a single tuber per hill. The tubers, placed 30 cm apart on the ridges, were pressed down manually and planted to a depth of 8-10 cm.

At the planting, phosphorus and potassium fertilizers were applied at 100 kg/ha. Also, the humic acid doses (0, 40, 80, 120 lt/ha) to from the soil were applied homogeneously across the planting rows in each plot at planting. Foliar application of humic acid was carried out at 4000 ml/ha at the pre-flowering stage on July 26, 2018, using a backpack sprayer, with each plot protected.

Harvest was completed on September 13, 2018, and plant height (cm), number of tuber per hill, average tuber weight (g), tuber yield (kg/ha), marketable tuber yield (kg/ha), dry matter ratio (%) and starch ratio (%) were determined.

The data obtained from the study were subjected to analysis of variance using the SAS-JMP-5.01 software package, according to the randomized block design in factorial arrangements. And then the LSD multiple comparison test was used to group.

Results and Discussion

Plant Height

In the study, the interaction effect of soil and foliar humic acid application in terms of plant height was found to be statistically significant ($p < 0.01$) (Table 1). When humic acid applied at different doses from soil and foliar, the average plant heights varied between 97.97 and 112.93 cm, with the lowest plant height obtained from the control dose, while the highest plant height was obtained from 120 kg/ha from soil + 4000 ml/ha humic acid from foliar.

In some similar studies, Laz (2011) reported that the application of humic acid and soil conditioners to soil and plants positively affected soil structure and plant height. Lulakis and Petsas (1995) noticed that humic acid applications positively affected the stem development of Sultana seedless grapes. Killı (2004) notified that potassium humate application increased the cotton seedlings' height. Elkatmış (2013) reported that humic acid and phosphorus fertilisers had a significant effect on the height of chickpea plants. The increase in plant height when humic acid is applied both from leaves and soil is parallel to the findings of other researchers. Çöl and Akınerdem (2017) determined that plant height in potatoes varied between 36.3 and 60.4 cm when different humic acid doses were applied to some potato varieties.

Considering this research, it can be said that the average plant height determined in the research is higher. It is thought that this difference may be due to the diversity of varieties and ecological conditions.

Number of Tuber Per Hill

The effect of humic acid applications on number of tuber per hill was found to be statistically insignificant. In this study, the average number of tuber per hill varied between 6.13 and 7.93. As with plant height, the fewest tubers were obtained from the control plot, while the number of tubers tended to increase with increasing humic acid doses. Çöl and Akınerdem (2017) found that the effect of humic acid on the number of tubers per hill in potato varied among varieties and generally found that increasing the dose also increased the number of tubers. According to the average values, the highest number of tubers was obtained from a dose of 90 L/ha, with 8.4 tubers. The similarity of the results obtained in this study with the findings of these researchers and the positive effect of humic acid indicates that both studies support each other.

Average Tuber Weight

In this study, the average tuber weight determined as a result of different doses of humic acid applied to soil and foliar was 84.16 g, and the differences in treatments and doses were found to be statistically

insignificant. The lowest average tuber weight (79.68 g) was obtained from 4000 ppm humic acid applied to foliar alone, while the highest (97.10 g) was obtained when 120 kg/ha of humic acid applied from soil and 4000 ml/ha humic acid applied from foliar.

Table 1. Some plant and tuber properties of potato obtained from different doses of humic acid application to soil and foliar.

Soil App. (kg HA/ha)	Foliar App. (ppm HA)	Plant height (cm)	Number of tuber per hill	Average tuber weight (g)	Tuber yield (kg/ha)	Marketable tuber yield (kg/ha)	Dry matter ratio (%)	Starch ratio (%)	
0	0	97.97 g	6.13	84.98	30535.7	27790.6	17.83	13.96	
	4000	103.97 f	6.45	79.68	30391.8	26468.2	18.48	14.32	
Means Soil Application		100.97	6.29	82.33	30463.7 C	27129.4 C	18.16	14.15	
40	0	106.50 e	7.00	83.34	34662.6	29540.6	17.67	13.87	
	4000	106.90 de	6.90	78.21	31771.8	27986.1	17.76	13.92	
Means Soil Application		106.70	6.95	80.77	33217.2 BC	28763.3 BC	17.72	13.90	
80	0	107.17 d	7.03	85.50	35357.1	31743.0	17.65	13.86	
	4000	110.87 b	7.93	81.96	38679.5	34364.0	18.25	14.20	
Means Soil Application		109.02	7.48	83.73	37018.3 AB	33053.5 AB	17.95	14.03	
120	0	109.60 c	7.68	82.44	37023.8	31424.6	18.73	14.46	
	4000	112.93 a	7.15	97.10	41274.8	37525.7	18.55	14.36	
Means Soil Application		111.27	7.41	89.77	39149.3 A	34475.1 A	18.64	14.41	
Means		0	105.31	6.96	84.07	34394.8	30124.7	17.97	14.04
Foliar Application		4000	108.67	7.10	84.24	35529.5	31586.0	18.26	14.21
Means			106.99	7.03	84.16	34962.2	30855.4	18.12	14.13
Significance level		LSD (0.01):	LSD _{SAxFA} (0.01):		LSD _{SA} (0.01):	LSD _{SA} (0.01):			
		0.523			3849.2	4325.6			

SA: Soil application; FA: Foliar application

Tuber Yield

As seen in Table 1, the effect of different soil humic acid doses applied from soil on the tuber yield was found to be statistically significant ($p < 0.01$), and the tuber yield increased as the dose increased. Indeed, in the study, maximum tuber yield (39.149,3 kg/ha) was obtained from the highest dose of 120 kg/ha of humic acid. Humic acid may have increased tuber yield both by the nutrients it contains and by increasing the usefulness of nutritional elements in the soil. Avaid (1990) reported that humic acid has an effect on the chemical, biological, and physical properties of soil and that humic substances positively affect soil productivity. Similar to our results, Çöl and Akmerdem (2017) reported that humic acid significantly increased tuber yield of potato.

Marketable Tuber Yield

In terms of marketable tuber yield, the differences between soil-applied humic acid doses were found to be statistically very significant, while the differences between foliar-applied humic acid doses were found to be insignificant. Marketable tuber yield, increased

with increasing humic acid dose. While minimum marketable tuber yield obtained from control (27.129,4 kg/ha), it was maximum at 120 kg/ha (34.475,1 kg/ha). It was determined that this increase in marketable tuber yield was similarly parallel to tuber yield (Table 1).

Dry Matter Ratio

In this study, humic acid did not affect the dry matter content of potato tubers. The dry matter content of tuber ranged from 17.65% to 18.73% (Table 1). It is similar to Tunçtürk (2006) report which dry matter content in different potato cultivars varied between 22.9% and 17.9%. As is known, there is an inverse relationship between yield and dry matter content. As the humic acid increased the tuber yield, the starch content probably decreased.

Starch Ratio

As seen Table 1, the starch ratio of tubers varied between 13.86% and 14.46%, and the differences between treatments were found to be statistically insignificant. Yalçın and Tunçtürk (2014) determined that the starch ratio of tuber was 15.86%. The starch

ratio defined in the study was lower than Yalçın and Tunçtürk (2014) findings. As is known, there is an inverse relationship between yield and starch content. As the humic acid increased the tuber yield, the starch content probably decreased.

Conclusions

This study was conducted to determine the effects of different humic acid doses applied from soil and foliar on the tuber yield and some plant properties. The study revealed that the highest plant height obtained from soil application of 120 kg/ha + foliar humic acid application at 4000 ml/ha. The highest tuber yield (39.149,3 kg/ha) and marketable tuber yield (34.475,1 kg/ha) were obtained from soil application of humic acid at 120 kg/ha. Furthermore, the effect of humic acid on tuber number per hill, average tuber weight, dry matter content, and starch content was found to be statistically insignificant. Based on these results, it can be concluded that humic acid application has a significant effect on potato yield. However, considering that the research results are for a single year, the highest yield was obtained from the highest applied dose, and the uncertainty of the effect of a higher dose, and that a single variety was used as material in the research, it was concluded that it would be useful to examine similar studies in different locations and on the basis of varieties belonging to different maturity groups in order to be able to recommend them for production.

Çıkar çatışması

Yazarlar arasında herhangi bir çıkar çatışması yoktur.

Yazarların katkı beyanı

ÖD: Çalışmanın planlanması, kurulması, yürütülmesi, laboratuvar analizlerinin planlanması, verilerin değerlendirilmesi ve makale yazımı aşamalarında katkıda bulunmuştur. EO: laboratuvar analizlerinin planlanması, verilerin değerlendirilmesi, yüksek lisans tezinin yazılması ve makaleye dönüştürme aşamalarına katkıda bulunmuştur.

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