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The Effect of K-Humate on the Nitrate Content and Accumulation and Some Yield Components in Three Potato Cultivars

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Abstract: The nitrate accumulation is one of the problems in potato production that causes to decrease the production quality. The nitrate accumulation can have more reasons such as excess use of fertilizers. However, this research has studied to find the solution for this problem. This study evaluated some material effects such as the effect of K-Humate on nitrate accumulation. This experiment was performed according to the spilt plot and as base of the complete randomized design with three replications and two factors. Main factor included four levels of irrigation treatments; normal, normal with potassium humate, stress and stress with potassium humate. Sub factor included three potato cultivars; Ceaser, Satina and Agria. Variance analysis results showed significant differences in total yield, marketable yield and nitrate accumulation in tubers. Tuber the most yield was under normal with potassium humate in Ceaser and Satina cultivars and tuber the less yield was under stress condition in Agria cultivar. The nitrate accumulation decreased under stress with potassium humate condition.

Key words: K-humate, NO_3^-, nitrate content, potato

INTRODUCTION

Potato (*Solanum tuberosum* L.) planted and consumed in some countries more than other crops (Stephen, 1999). Among the most important crops in the world and Iran, potato has the fourth grade in annual production after the cereal species rice, wheat and barley (Fernie and Willmitzer, 2001). Iran is known as the worlds 12th potato producer and the third biggest producer in Asia, after China and India. A lot of available nitrogen is necessary for beginning the growth of potato. Nitrogen needs to take carbon. Sufficient nitrogen increases both plant growth power and leaf surface index, tuber size and causes crop to become tolerant against the leaf blot disease. Leaching of nitrogen decreases, tuber germination and steady leaf area improves by optimum using of nitrogen. Excess nitrogen at the last growth stage causes the development of stem and leaf, instead of tubers as a result of high amount of amino acids and amid, which have not been transformed to proteins. Excess nitrogen influences tuber yield and quality negatively. Nitrogen deficiency causes the photosynthesis decreasing, because the lower leaves of plant become yellow and fall on the earth (Hassanpanah *et al.*, 2009). Nitrogen fertilization increased plant N accumulation (Sharifi *et al.*, 2005).

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Where moisture and disease stress were limited and the growing season was short, differences in dry matter and N accumulation among the selected clonal did not translated into a significant effect on plant productivity (Sharifi *et al*., 2005).

Chemical composition affects the potato quality, through changes in its nutritional value. Potatoes contain both nutritional compounds and substances adversely affecting our health (toxic or causing disease). Nitrates are natural plant products. Their presence in plants related to the nitrogen transformations to amino acids and proteins. Nitrates concentration in potato tubers depends on the activity of the enzyme nitrate reductase (NRA), (Meltzer, 1987). It causes to promotion of the nitrate ions accumulation in the potato tuber over the period of its growth (Rogozinska *et al*., 2005).

Potato (*Solanum tuberosum*) is ranked among vegetables with low nitrate content. It can contribute to the nitrate daily intake in the diet, greatly, because of the large amounts consumed. This is the reason to increase the attention to potato nitrate content. Cultivar, maturity of the tubers and their size, type and amount of nitrogen fertiliser, weather, site and storage condition are the results of nitrates amount varing (Lerna, 2008). Numerous researchers say that nitrates concentration in the tubers is under mineral fertilisation with elements such as nitrogen and potassium (Miller, 1983). The effects of nitrates accumulation in plants is a complicated process and depends on some factors such as environmental conditions (soil, climate, tillage and irrigation) (Grassert *et al*., 1990). Increase in the permeability of plant membranes due to humate application resulted in improve growth of various groups of beneficial microorganisms, accelerate cell division, increased root growth and all plant organs for a number of horticultural crops (Zaghloul *et al*., 2009). Humates are widespread carbonic matters of plant and animal residues from biological and chemical decomposition. Potassium humate is an active natural substance. It extracts from plants and animals remains existed in the bottom of marshes. In this material component, there are N, P, K and microelements namely Mo, Cu, Zn, B, Co, Mg (Gadimov and Allahverdiev, 2007). The accumulation of chlorophyll, sugar and amino acids is result of the potassium humate. It modifies the nitrogen utilization efficiency, allows to reduce fertilizer rates, the plant ability to tolerant the heat, drought, cold, disease, insect and other types of environmental or cultural pressures stresses. It increases general plant productivity, in terms of yield, as well as plant stem strength. Potassium humate application in the field increased root system, tuber yield, tuber number per plant in potato (Hassanpanah *et al*., 2007). The objective of this research was to study the K-Humate effects on the nitrate content, it's accumulating and effects on yield component in three potato cultivars.

MATERIALS AND METHODS

A factorial split plot on the base of randomized complete blocks design with two factors and three replications was conducted to study K-Humate effects on potato yield, growth, nitrate content and accumulation in three potato cultivars. Factor A included four irrigation conditions (Normal after seven days, Normal with Humate after seven days, Stress after ten days and Stress with Humate after ten days). In order to prepare the K-Humate solution, 250 mL of K-Humate was solved in 300 L of water for per hectare. Factor B included the three potato cultivars (Agria, Satina and Ceaser). This experiment was conducted in Ardebil, Iran, 2007-2008. The region climate was moderate and wet with 320-350 mm rainfall and the soil texture was Loamy clay (pH 7.7, EC 0.6 dS m^{-1}). Each plot included three furrows with 2.75 m length. The distance between replications and two plots was 3 m and 75 cm, respectively. The plants distance on the row was 25 cm. After harvesting, tubers were categorized in two groups (Less than 35 mm and more than 35 mm) according to their size and the nitrate content was measured by Solfosalsilic acid method (Hassanpanah *et al*., 2007). Analysis of complete variance was done and comparison of means was done according to LSD test by MSTATC software.

Tubers (0.4 g) were collected from all of potato cultivars and weighted and dried in oven at 50°C and 0.2 g active carbon and 40 mL sulphate alominum (0.025 M) was added on the powder of potato and samples were shaked for 30 min at 200 rpm. The reactions were terminated after adding 0.8 mL Solfosalsilic acid 0.05% and 16.7 mL NaOH (2N) to 1.5 mL supernatant and the color was developed, then the nitrite's concentrations in the samples were measured by spectrophotometer at 410 nm.

RESULTS AND DISCUSSION

The ANOVA Table showed that non-seed tuber number, non-seed tuber weight, marketable tuber weight, plant height, total yield, nitrate amount, marketable yield had significant differences in 1% probability level, while marketable tuber number had significant difference in 5% probability level in different irrigation treatments. There were significant differences in plant height; plant stem number, marketable yield and marketable tuber weight in 1% probability level and, in non-seed weight and total yield in 5% probability level in tested cultivars. The total yield was affected by interaction effects, in 1% of probability level, between irrigation and cultivar, in which, Satina in normal irrigation with Humate had the highest yield and Agria in stress condition had the lowest yield (Table 1).

According to the means comparison of irrigation treatments, plant height, was highest in stress with Humate treatment and was lowest in stress condition. The highest and lowest number and the weight of non-seed tubers were in normal irrigation and stress condition, respectively. Number and weight of marketable tubers and marketable yield were the highest in normal irrigation with Humate and were the lowest in stress condition. Marketable yield was significantly higher under stress with humate, than Stress condition in 0.05 probability level (Table 2).

Table 1: ANOVA for the effects of various irrigation treatments and cultivars on the traits of potato

		MS				
SOV	df	Non-seed tuber No.	Non-seed tuber weight (g)	Marketable tuber No.	Marketable tuber weight (g)	Marketable yield (t h^{-1})
Replication	2	0.070 ns	1044.414 ns	0.416 ns	3142.900 ns	1.019 ns
Irrigation	3	2.498*	23075.714*	6.282**	1202288.704*	424.165*
Treatment (A)						
E1	6	0.074	23075.71	0.878	5924.964	2.177
Cultivars (B)	6	0.006 ns	83393.301**	0.533 ns	59602.210*	21.230*
A×B	6	0.163 ns	4319.860 ns	0.442 ns	15823.879 ns	5.586 ns
E2	16	0.144	2581.053	0.435	10101.28	3.598
CV%		18.13	22.85	23.05	10.06	10.05

SOV	df	Total yield (t h^{-1})	Nitrate amount (ppm)	Plant stem No.	Plant height (cm)
Replication	2	0.745 ns	743.071 ns	2.892 ns	94.901 ns
Irrigation	3	432.929*	2194.010*	5.410 ns	223.528*
Treatment (A)					
E1	6	0.944	312.281	1.818	18.783
Cultivars (B)	6	16.163**	1205.024 ns	15.836*	512.089*
A×B	6	7.322*	1253.113 ns	1.318 ns	79.887 ns
E2	16	3.288	1106.204	0.725	110.038
CV%		8.58	13.56	21.34	20.47

*,**Significant at 5% and 1% level of probability, respectively; ns: non-significant

Table 2: Mean of measured traits for different irrigation treatments

Irrigation treatments	Non-seed tuber No.	Non-seed tuber weight (g)	Marketable tuber No.	Marketable tuber weight (g)	Marketable yield (t h^{-1})	Nitrate amount (ppm)	Plant height (cm)
Normal	2.578a	289.0a	3.149ab	1184.6b	22.35b	250.2ab	53.53ab
Normal with humate	2.267ab	230.8b	3.744a	1419.5a	26.78a	244.8ab	52.62ab
Stress	1.344c	171.4c	1.753c	643.0d	12.18d	261.6a	43.90b
Stress with humate	2.178b	198.0bc	2.800b	748.5c	14.19c	224.3b	54.90a

Mean with the same letter (s) in each column does not have significant difference at the 5% level of probability according to value of LSD

Table 3: Mean of measured traits for potato cultivars

Cultivars	Non-seed tuber weight (g)	Marketable tube weight (g)	Marketable yield (t h^{-1})	Plantstem No.	Plant height (cm)
Agria	134.0c	917.9b	17.35b	2.667b	57.44a
Satina	233.3b	1032.2a	19.50a	4.583a	51.85ab
Cesear	299.6a	1046.6a	19.78a	4.722a	44.42b

Mean with the same letters in each column does not have significant difference at the 5% level of probability according to value of LSD

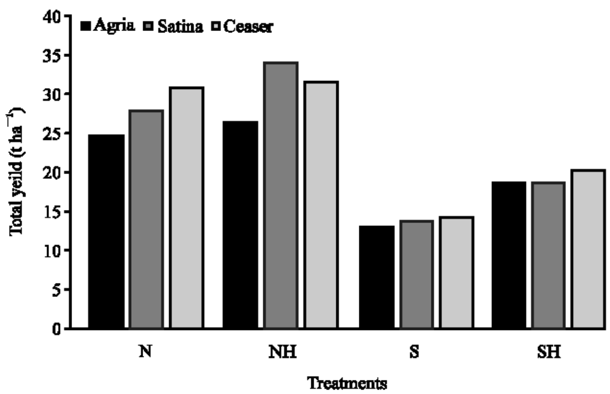

Fig. 1: The interaction effects of irrigation and cultivar on total yield

Plant stem number, plant height, the weight of non-seed and marketable tubers and marketable yield in Satina and Ceasar Cultivars was higher than Agria (Table 3).

The total yield was affected by interaction effects between irrigation and cultivar, in which, Satina in normal irrigation with Humate had the highest yield and Agria in stress condition had the lowest yield (Fig. 1).

According to the table of correlations between the measured traits, plant stem number had significant and positive correlation with the weight of non-seed tubers and with the total yield. Marketable tuber weight had significant and positive correlation with non-seed tuber numbers and marketable tuber numbers. Marketable yield also had significant and positive correlation with non-seed tuber numbers, the number and the weight of the marketable tubers. Total yield showed significant positive correlation with the number and weight of non-seed tubers, the number and weight of marketable tubers and the marketable yield (Table 4).

The amount of nitrate accumulation was highest in normal irrigation and was lowest in stress with Humate (Table 2). The amount of nitrate accumulation was not significantly different in tested cultivars (Table 3). Significant correlation was not found between nitrate accumulation and other traits (Table 4).

Table 4: Correlation between attributes for potato cultivars

Correlation coefficient	Non-seed tuber No.	Non-seed tuber weight (g)	Marketable tuber No.	Marketable tuber weight (g)	Marketable yield (g)	Total yield (g)	Nitrate amount (ppm)	Plant stem No.	Plant height (cm)
Non-seed tuber No.	1	0.2157	0.4086	0.5322 *	0.55321*	0.5193*	0.0857	0.056	-0.1947
Non-seed tuber weight		1	0.2695	0.3935	0.393	0.5934**	-0.1597	0.4931*	-0.292
Marketable tuber No.			1	0.5175 *	0.5176*	0.5214*	0.2049	0.2702	-0.2244
Marketable tuber weight				1	1.0**	0.9735**	0.1329	0.4216	0.0392
Marketable yield					1	0.9733**	0.1323	0.4215	0.0368
Total yield						1	0.0783	0.4908*	-0.04
Nitrate amount							1	-0.3549	0.1781
Plant stem No.								1	-0.2363
Plant height									1

*,**Significant at 5 and 1% level of probability, respectively

Accumulation of nitrates in plants is a complicated process depending on many factors and not all plant species show the same ability (Cieślik, 1995). The nitrate content is affected by planting date, soil and climatic conditions, physiological maturity of the tubers (influenced by the quality of seed potatoes) (Sylvester-Bradley and Chambers, 1992) (Chambers and Richardson, 1993) and (Johnsonp *et al.*, 1996) as well as the physiological age of the tubers. However, Padmos (1986) stated that physiological age of the tubers does not modify the nitrate content especially when the rate of mineral nitrogen fertilizer has been adjusted to nutritional needs of the soil. Therefore, reductive nitrogen is necessary for increasing assimilation of nitrogen by plants and thus also for their growth. The research on nitrate concentration in tubers of the same varieties grown under similar soil and climatic conditions with the same tillage, but at different locations proved that local conditions are a very crucial factor. Grassert *et al.* (1990) from their long-term studies observed that potato varieties cultivated in the same climatic region, but at different sites, showed a range of nitrate accumulation in tubers. Comparison of irrigation regimes showed that spraying potassium humate under normal and stress condition decreased the tuber yield and yield components. Spraying by potassium humate under water deficiency condition increased tuber yield about 0.93 and 9.63 t ha^{-1} under normal and stress condition, respectively (Hassanpanah, 2009).

According to Miller (1983) potato is a plant accumulating nitrates in the tubers at medium range (300-500 mg kg^{-1} f.w.). Rogozinska *et al.* (2005) reported that their experiment results indicated, the extended storage of potato tubers decreased nitrate concentrations. The changes found were small, just a couple of percent, but they were statistically significant. Similar results were reported by Miller (1983) and Cieślik (1995).

An increase of nitrate concentration in plant material will always occur after the use of higher rates of nitrogen, as confirmed in our study. In the investigations where fully matured tubers were harvested, early soil application of mineral nitrogen took place before planting. A progressive increase in the yield was found with nitrogen rates higher than 80 kg ha^{-1} and the content of nitrates increased by about 20 mg kg^{-1} f.w.

Many researchers, including Meltzer (1987) and Lejay *et al.* (1997) considered the activity of nitrate reductase (NRA), as one of the factors favouring accumulation of NO_3^-. According to Meltzer (1987) at the end of the vegetative period the activity of NRA declines and differs for varieties and was not correlated with their productivity. Potato tubers in this study were analyzed only immediately after harvest, but a higher activity of NRA over the vegetative period has an impact on the final nitrate level.

The research on nitrate concentration in tubers of the same varieties grown under similar soil and climatic conditions with the same tillage, but at different locations proved that local conditions are a very crucial factor (Rogozinska *et al.*, 2005).

CONCLUSION

Potassium humate showed to be able to reduce the effects of water stress and increase potato yield. In this study, the nitrate accumulation decreased under stress with potassium humate condition, so as a result, potassium humate application could reduce nitrate accumulation in potato farming regions suffering from water deficiency. This study was a part of a research project which was conducted in three different regions of Ardebil for two years and the results of this study is comparable with other studies of the project.

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