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Effect of Different Doses of Nitrogen and Potassium Fertilization on Yield and Nutrient Uptake in Grafted Watermelon Growing in Çukurova Region Conditions

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Abstract
Turkey ranks second in watermelon (*Citrullus lunatus* L.) cultivation in the World and Adana takes the first place in the country. Although watermelon is one of the most common crop grown in the Çukurova region, studies on optimal nitrogen (N) and potassium (K) doses in watermelon fertilization are very limited.

This research was conducted to determine the optimum doses of N and K fertilization in grafted watermelon (Karain) at open field farmer conditions. For this aim, increasing doses of N (0, 6, 12, 18, 24 kg da^{-1}) and K (0, 6, 12, 18, 24 kg da^{-1}) were applied to soil. Main stem length (cm), main stem diameter (mm), number of nodes on main stem, total branch number, fruit yield (g $bitki^{-1}$), fruit weight (g), fruit length (cm), fruit diameter (cm), fruit rind thickness (mm) and total soluble solids (%) were measured. The N% and K% concentration in shoot, fruit flesh and fruit rind were also determined.

According to the results it was determined that the effect of N and K applications on the observed parameters were changed depending on the application doses. The effect of different N application doses were significant in all measured plant and fruit parameters except rind thickness. However, different doses of K applications were statistically insignificant in terms of main stem diameter, fruit yield, fruit weight, fruit length and fruit diameter.

Different doses of N application did not change the concentration of K in shoot, fruit rind and fruit flesh. However the increasing doses of N application increased the N concentration in both fruit rind and fruit flesh. Application of K only affected K concentration in fruit rind while the N concentration in fruit rind and fruit flesh found to be statistically different.

Keywords: Watermelon, Nitrogen, Potassium, Fertilization

INTRODUCTION

Water melon is a member of Cucurbitaceae family and one of the most important vegetable species in international trade. Watermelon cultivation is carried out in a very wide area in the world and in Turkey. Turkey ranks second (3.9 million tons) in watermelon (*Citrullus lanatus* L.) production after China (73 million tons) in the world. Watermelon is widely produced in open field and under low tunnels according to the ecological conditions of the region in Turkey. Significant part of the protected watermelon production has been performed in the Çukurova Region [1,2]. In this production, Adana province ranks first with a rate of 20% [3]. Increase in yield and quality can be achieved by conscious and balanced fertilization. The chemical fertilizers commonly used for the nutrient requirements of plants are N, phosphorus (P) and K. It is expected to gain greater increases in productivity with more consciously use of the fertilizers which are one of the production inputs. Nitrogen and K have a special importance in terms of quality as well as yield [4]. Even though watermelon is the most common vegetable in the Çukurova region, studies on N and K doses in watermelon cultivation in Çukurova conditions are very limited. Within this information, it has been recognized that optimized nutrition and fertilization program is needed for watermelon which is widely produced in the region [5,6].

There are a number of physiological parameters which are closely associated with osmotic stress and affected by the mineral nutritional status of plants. In particular, plant N, magnesium (Mg) and K concentrations affect parameters such as photosynthesis, stomatal conductance, photo assimilate transport from source to sink organs, formation and detoxification of reactive oxygen species and leaf morphology [7,8,9,10,11].

Plants have developed a wide range of adaptive/ resistance mechanisms to maintain productivity and ensure survival under a variety of environmental stress conditions. Increasing evidence suggests that mineral-nutrient status of plants plays a critical role in increasing plant resistance to environmental stress factors [12]. Of the mineral nutrients, K plays a particular role in contributing to the survival of crop plants under environmental stress conditions. Potassium is essential for many physiological processes, such as photosynthesis, translocation of photosynthates into sink organs, maintenance of turgor, activation of enzymes, and reducing excess uptake of ions such as sodium (Na) and iron (Fe) in saline and flooded soils [12,13]. The roles of K in minimizing adverse effects of environmental stress conditions on crop production, with particular emphasis on abiotic stress factors. Nitrogen and K are the nutrients required in largest amounts by an almond crop. Nitrogen deficiency reduces photosynthesis and plant growth and in severe N deficiency fruit drop may occur and nut quality is affected by reducing protein content. Nitrogen fertilization in excess of tree demand is poorly utilized by the plant and may be lost to leaching or result in excessive vegetative growth and will increase susceptibility to diseases such as almond hull rot [14]. Over-fertilization with N fertilizers is a leading cause of contamination of ground water with nitrate and the deterioration of drinking water quality [15].

This study was conducted to determine the optimum doses of N and K fertilization in grafted watermelon at open field conditions, to increase the yield quality and the nutrient uptake of the watermelon.

MATERIAL and METHOD

Experiment was carried out according to the split plot design with 4 replications under the farmer conditions in Ceyhan, which is a widely watermelon growing area in the Çukurova region. The plants were transplanted in open field as 1.8 m between rows and 1 m within rows at 31 March 2017. Experiment grafted watermelon variety Karain was used as plant material. 5 plants were used in each replication. Depending on the results of soil analysis 10 kg phosphorus (P_2O_5) per da were applied as basal fertilization before planting (Table 1). Increasing doses of N (0, 6, 12, 18 and 24 kg da^{-1} ($(NH_4)_2SO_4$) and K (0, 6, 12, 18 and 24 kg da^{-1}(K_2SO_4) were applied as different combinations at three different times before planting time, during flowering period and shortly after the first fruit setting. Ammonium sulphate as a N source and potassium sulphate as a K source were used.

After 45 days of transplanting, some plant growth characteristics such as; main stem length (cm), main stem diameter (mm), branch number and number of nodes on main stem were measured and counted by means of meter and compass under field conditions. The harvesting was carried out on 22 June 2017. The total yield was calculated as fruit weight per plant (g $plant^{-1}$) 3 fruits from each replication were brought to the laboratory for the following analysis in the fruit samples; fruit weight (g), fruit length (cm), fruit diameter (cm), fruit rind thickness (mm), TSS content (%) analysis were determined. Analyzes of macro nutrient concentrations, including N and K (%) in shoot, fruit flesh and fruit rind were performed. Nitrogen concentration was determined by Kjeldahl (%) method, K concentration was determined by dry ashing (%) method [5] (Table 1).

Table 1. Some important physical and chemical properties of the soil in which the trial was conducted.

Characteristics			
Texture Type	Clay (C)		
pH	7.63	±	0.01
EC (mmhos cm^{-1})	0.53	±	0.01
$CaCO_3$ (%)	26.23	±	0.20
OM (%)	1.64	±	0.10
NO_3^- (mg kg^{-1})	8.60	±	1.41
NH_4^+ (mg kg^{-1})	5.00	±	1.20
P (mg kg^{-1})	4.92	±	0.28
K (mg kg^{-1})	127.00	±	4.70
Cu (mg kg^{-1})	1.66	±	0.03
Zn (mg kg^{-1})	0.86	±	0.03
Mn (mg kg^{-1})	10.38	±	0.26
Fe (mg kg^{-1})	9.38	±	0.07

All experiments were set up in a randomized complete block design with four replications. All data were statistically analyzed using analysis of variance (ANOVA) with JMP Statistical Software. The means differences were compared with the Least Significant Differences (LSD) test at 5% probability level.

RESULT and DISCUSSION

It was determined that the effect of various doses of N and K treatments on the investigated parameters was changed depending on the treatment doses. Effects of N, K and their interaction on investigated parameters are given in Tables.

Main stem length (cm), main stem diameter (mm), branch number and number of nodes on main stem were measured and the results are given in Table 2.

The K dose x N dose interaction effect was not significant on stem length and diameter, branch number and number of nodes. The effect of different N application doses were significant in measured plant characters except number of nodes, however different doses of K applications were statistically insignificant in terms of main stem diameter. The highest main stem length (291 cm) was obtained from 24 kg N $ha^{-1}$and 6 kg K ha^{-1} treatment, whereas the lowest (211 cm) was in control (Table 2). Main stem diameter, branch number and number of nodes were determined between 12.2-16.7 mm, 3.33-6.50 and 20.8-26.3 respectively. Main stem length and stem diameter increased with increasing N dose.

Yield, weight, length, diameter and rind thickness of fruit were ranged from 5201-8700 g $plant^{-1}$ 4232-6971 g, 214-265 cm, 187-225 cm, 9.6-13.1 mm, respectively. The K dose x N dose interaction was insignificant on the fruit yield, fruit weight, fruit diameter and fruit length. The effect of different N application doses was significant in all measured fruit parameters except rind thickness. However, different doses of K applications were statistically insignificant in terms of fruit yield, fruit weight, fruit length and fruit diameter (Table 3). Muhammad et al. [16] reported that K applications had no significant effect on yield. Also, leaf K above 1% did not increase yield and there was no consistent effect of K supply and K source on yield parameters. On the contrary, Yağmur et al. [6] determined positive effect of K on fruit weight. Fruit yield was found to be increased in all N doses compared to the control, but these increases were statistically significant only at N24. Increased N application increased fruit weight. These increases were statistically significant at N12, N18, N24 doses compared to control (N0). Similar results were also found by Colla et al. [17] and Demirbas [18]. Furthermore, Colla et al. [17] reported that N-use efficiency, N-uptake efficiency, and N-utilization efficiency were significantly affected by N fertilization and grafting combinations. TSS content was ranged from 9.22-11.87%. Wehner [19] reported that TSS content in watermelon should be at least 10% for an ideal taste.

Table 2. The effect of various doses of N (0, 6, 12, 18 and 24 kg da^{-1}) and K (0, 6, 12, 18 and 24 kg da^{-1}) and K treatments on the main stem length, main stem diameter, branch number and number of nodes.

Main stem length (cm)

K Doses	N0	N6	N12	N18	N24	Mean
K0	211	213	246	240	272	236b
K6	236	256	265	258	291	261a
K12	233	240	270	259	246	250ab
K18	219	268	249	236	244	243b
K24	224	219	245	231	248	233b
Mean	225c	239bc	255ab	245ab	260a	

K_{dose} : P<0.01, N_{dose} : P<0.001,

K_{dose} x N_{dose} : NS

Main stem diameter (mm)

K Doses	N0	N6	N12	N18	N24	Mean
K0	12.2	13.3	13.4	14.3	16.3	13.9
K6	16.0	14.2	14.5	14.3	15.2	14.8
K12	13.9	12.5	13.7	14.9	15.3	14.1
K18	13.8	13.6	14.5	14.2	16.0	14.4
K24	13.5	15.9	14.2	16.7	15.5	15.1
Mean	13.9b	13.9b	14.1b	14.9ab	15.7a	

K_{dose} : NS, N_{dose} : P<0.05,

K_{dose} x N_{dose} : NS

Branch number

K Doses	N0	N6	N12	N18	N24	Mean
K0	4.00	5.00	5.00	4.33	4.00	4.47c
K6	4.00	5.00	3.33	5.33	5.00	4.53c
K12	5.00	5.50	6.50	5.50	5.25	5.55a
K18	5.00	4.75	3.75	5.00	5.33	4.77bc
K24	4.25	5.67	5.33	5.33	5.33	5.18ab
Mean	4.45b	5.18a	4.78ab	5.10ab	4.98ab	

K_{dose} : P<0.05, N_{dose} : P<0.05,

K_{dose} x N_{dose} : NS

Number of nodes

K Doses	N0	N6	N12	N18	N24	Mean
K0	23.1	20.9	23.5	24.3	24.5	23.3ab
K6	22.8	23.7	23.4	22.1	25.1	23.4ab
K12	22.5	24.5	26.3	24.0	24.1	24.3a
K18	22.8	24.2	23.2	23.7	23.3	23.4ab
K24	22.0	20.8	24.1	22.5	23.3	22.5b
Mean	22.6	22.8	24.1	23.3	24.1	

K_{dose} : P<0.01, N_{dose} : NS,

K_{dose} x N_{dose} : NS

Table 3. The effect of various doses of N (0, 6, 12, 18 and 24 kg da^{-1}) and K (0, 6, 12, 18 and 24 kg da^{-1}) and K treatments on the fruit parameters.

Fruit yield (g plant $^{-1}$)

K Doses	N0	N6	N12	N18	N24	Mean
K0	5423	6168	6596	6038	6583	6162
K6	7070	6764	6654	5690	8700	6976
K12	5201	6323	6209	7048	7428	6442
K18	6498	7135	6491	7035	7008	6833
K24	6243	5883	8175	6347	7167	6763
Mean	6087b	6455b	6825ab	6432b	7377a	

K_{dose} : NS, N_{dose} : P<0.05,

$K_{dose} \times N_{dose}$: NS

Fruit diameter (cm)

K Doses	N0	N6	N12	N18	N24	Mean
K0	200	208	213	208	214	209
K6	211	220	207	216	217	214
K12	207	191	210	209	225	208
K18	187	216	225	215	214	211
K24	203	217	224	209	214	214
Mean	202b	210ab	216a	211ab	217a	

K_{dose} :NS, N_{dose} : P<0.05,

$K_{dose} \times N_{dose}$: NS

Fruit weight (g)

K Doses	N0	N6	N12	N18	N24	Mean
K0	5046	5061	6408	5864	5794	5634
K6	5002	6002	5087	6097	6971	5832
K12	5409	4512	5017	5387	6187	5302
K18	4232	6087	6828	6173	5862	5836
K24	5318	6196	6708	5759	5530	5902
Mean	5001b	5572ab	6010a	5856a	6069a	

K_{dose} :NS, N_{dose} : P<0.05,

$K_{dose} \times N_{dose}$: NS

Fruit rind thickness (mm)

K Doses	N0	N6	N12	N18	N24	Mean
K0	12.4	11.5	13.1	10.5	11.1	11.7
K6	11.4	10.9	10.4	11.3	11.6	11.1
K12	11.6	10.7	11.8	11.3	12.8	11.6
K18	9.6	11.3	11.3	11.4	10.8	10.9
K24	12.1	12.4	12.8	11.6	10.3	11.8
Mean	11.4	11.3	11.9	11.2	11.3	

K_{dose} : NS, N_{dose} : NS,

$K_{dose} \times N_{dose}$: P<0.05, $LSD_{(0.05)}$: 1.77

Fruit length (cm)

K Doses	N0	N6	N12	N18	N24	Mean
K0	235	257	265	249	246	250
K6	246	259	241	252	245	249
K12	237	216	246	241	253	239
K18	214	249	264	248	257	246
K24	239	253	263	249	250	251
Mean	234b	247ab	256a	248ab	250ab	

K_{dose} : NS, N_{dose} : NS,

$K_{dose} \times N_{dose}$: NS

TSS content (%)

K Doses	N0	N6	N12	N18	N24	Mean
K0	9.58	9.22	9.60	9.48	10.63	9.70b
K6	9.27	11.04	10.53	9.48	10.27	10.12a
K12	9.46	9.48	9.58	9.88	9.44	9.57b
K18	10.05	9.81	11.76	9.72	10.74	10.41a
K24	9.91	9.67	10.37	10.85	11.87	10.53a
Mean	9.65b	9.84b	10.37a	9.88b	10.59a	

K_{dose} : P<0.001, N_{dose} :P<0.001,

$K_{dose} \times N_{dose}$: P<0.001, $LSD_{(0.05)}$: 0.927

While the effect of K application on the N concentration of fruit flesh and fruit rind of the plant was statistically significant, no significant effect was determined on the shoot. The concentrations of N in the shoot, fruit flesh and fruit rind were determined to increase in parallel with the increase of the N doses applied. These increases were determined to be statistically significant at N12, N18, N24 doses in fruit flesh and at N18, N24 doses in shoot and fruit rind (Table 4). Colla et al. [17] reported that total leaf area, SPAD index, and shoot N uptake increased in response to an increase of N concentration in the nutrient solution.

While the effect of K applications on K concentration of the shoot and fruit flesh was not observed, statistically significant differences has been determined only in fruit rind. Any effect of the N dose on K concentration could not been determined.

According to the results it was determined that the effect of N and K applications on the observed parameters was changed depending on the application doses. The effects of different N application doses were significant in all measured plant and fruit parameters except rind thickness. However, different doses of K applications were statistically insignificant in terms of main stem diameter, fruit yield, fruit weight, fruit length and fruit diameter. Different doses of N application did not change the concentration of K in shoot, fruit rind and fruit flesh. However, the increasing doses of N application increased the N concentration in both fruit rind and fruit flesh. Application of K only affected K concentration in fruit rind while the N concentration in fruit rind and fruit flesh was found to be statistically different.

Table 4. The effect of various doses of N (0, 6, 12, 18 and 24 kg da^{-1}) and K (0, 6, 12, 18 and 24 kg da^{-1}) and K treatments on the nitrogen and potassium concentration in shoot, fruit flesh and rind.

		Shoot K% concentration						**Shoot N% concentration**					
		N Doses						N Doses					
		N0	N6	N12	N18	N24	Mean	N0	N6	N12	N18	N24	Mean
K Doses	K0	2.6	2.7	3.1	2.9	3.1	2.9	2.63	2.92	3.00	3.18	4.21	3.19
	K6	2.5	2.7	2.9	3.6	3.2	3.0	2.99	2.57	2.62	3.55	3.38	3.02
	K12	2.9	3.4	2.8	2.6	2.5	2.9	2.84	3.45	3.02	3.07	2.64	3.00
	K18	3.4	2.9	2.2	3.4	3.7	3.1	3.32	2.79	2.73	3.00	3.29	3.03
	K24	3.6	3.0	2.5	2.7	3.3	3.0	3.42	2.83	3.46	2.93	2.74	3.08
	Mean	3.0	3.0	2.7	3.1	3.2		3.04ab	2.91b	2.97b	3.15a	3.25a	
	K_{dose}: NS, N_{dose}: NS,							K_{dose}: NS, N_{dose}: P<0.05,					
	K_{dose} x N_{dose} :P<0.01, $LSD_{(0.05)}$: 0.8							K_{dose} x N_{dose}: P<0.01, $LSD_{(0.05)}$: 0.55					

		Fruit flesh K% concentration						**Fruit flesh N% concentration**					
		N Doses						N Doses					
		N0	N6	N12	N18	N24	Mean	N0	N6	N12	N18	N24	Mean
K Doses	K0	2.7	2.9	2.8	3.7	3.6	3.2	2.12	1.98	2.29	2.33	2.59	2.26b
	K6	2.6	3.2	2.8	3.9	3.5	3.2	1.90	1.99	2.21	2.33	2.32	2.15b
	K12	2.5	3.6	3.2	2.9	2.3	2.9	2.21	2.76	2.86	2.51	2.48	2.56a
	K18	2.5	2.7	2.8	2.8	3.6	2.9	1.98	2.33	2.43	2.50	2.38	2.32ab
	K24	3.2	3.1	3.0	2.4	3.3	3.0	2.12	1.99	2.36	2.34	2.50	2.26b
	Mean	2.7	3.1	2.9	3.1	3.3		2.07b	2.21ab	2.43a	2.40a	2.45a	
	K_{dose}: NS, N_{dose}: NS,							K_{dose}: P<0.05, N_{dose}: P<0.05,					
	K_{dose} x N_{dose} :NS							K_{dose} x N_{dose} :NS					

		Fruit rind K% concentration						**Fruit rind N% concentration**					
		N Doses						N Doses					
		N0	N6	N12	N18	N24	Mean	N0	N6	N12	N18	N24	Mean
K Doses	K0	8.9	8.7	8.2	9.1	0.8.7	8.7b	3.15	3.66	3.95	3.86	3.96	3.72b
	K6	9.7	9.2	9.4	9.8	0.8.4	9.3a	3.53	3.62	3.60	3.70	4.00	3.69b
	K12	8.6	8.8	8.7	8.6	0.8.6	8.7 bc	3.58	3.29	3.32	3.44	4.23	3.57b
	K18	8.4	8.4	8.1	8.6	0.8.1	8.3c	3.61	3.72	3.70	3.94	3.89	3.77b
	K24	7.8	75	7.8	7.6	0.8.5	7.8d	3.77	3.80	3.85	4.27	4.29	3.99a
	Mean	8.7	8.5	8.4	8.7	8.5		3.53c	3.62bc	3.68bc	3.84b	4.07a	
	K_{dose}: P<0.01, N_{dose}: NS,							K_{dose}: P<0.01, N_{dose}: P<0.001,					
	K_{dose} x N_{dos}e :NS							K_{dose} x N_{dose} :NS					

CONCLUSION

Overall, when the results were evaluated it has been determined that there have been the effects of K applications on N nutrition. As the level of nutrients was optimized, especially N nutrition was found to increase the concentration of nutrients in the flesh and rind of the fruits although it was limited amount.

It was concluded that optimized plant nutrient levels in growth medium may significantly improve plant growth. There is a need for these studies to be carried out in more controlled conditions and different locations in the future for clearer results.

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