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THE EFFECTS OF DIFFERENT FERTIGATION TREATMENTS ON YIELD AND NUTRIENT UPTAKE OF WATERMELON PLANTS GROWN AS SECOND CROP IN CUKUROVA REGION

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Abstract

The present study was conducted to investigate the effects of different fertigation treatments (25, 50, 75 and 100 %) on yield and nutrient uptake of watermelon as the second crop and to compare with conventional practices. Experiments were conducted over the experimental fields of Çukurova University, Agricultural Faculty Soil Science and Plant Nutrition Department under field conditions. Experiment was conducted in randomized blocks split plots design with three replications. A total of 160 kg ha^{-1} nitrogen (N) as ammonium sulphate, 100 kg ha^{-1} phosphorus (P) as MKP and 200 kg ha^{-1} potassium (K) as KNO_3 were applied. Seedlings were planted in peat/perlite mixture (1:1 V/V) and transplanted to experimental plots following with wheat harvest in June. The watermelon plants were irrigated 9 times during the growing season in one week intervals. Current findings revealed that 75% fertigation treatment (120 kg ha^{-1} N, 75 kg ha^{-1} P, 150 kg ha^{-1} K) had the greatest yield (48.38 t ha^{-1}). Also, it increased N (%3.78), P (%0.31), Zn (45.7 mg kg^{-1}), Mn (43.1 mg kg^{-1}) and Cu (17.6 mg kg^{-1}) contents of plants.

Key words: *Fertigation, watermelon, yield, nutrient uptake.*

INTRODUCTION

Watermelon production had a significant place in world agriculture. Worldwide, watermelon is produced over 1.8 million hectares and annual production is around 29.7 million tons. Turkey has the second place worldwide after China in melon and watermelon production. Despite decreasing production lands in Turkey, annual production is increasing with incresing yields through proper cultural practices (Taşkaya and Keskin, 2004). The watermelon (*Citrullus lunatus* (Thunb.) is commonly grown in Turkey and fruits are consumed. Annual watermelon production of Turkey in 2008 from 123.000 ha was 3.5 million tons. In annual watermelon production Turkey, Çukurova with 678.73 thousand tons had the first place (Anonymous, 2008).

Just because of availability for production over large areas, easy marketing and high return rates per unit area; watermelon is also commonly produced in high or low tunnels (Yetişir and Sarı, 2004).

Watermelon has quite fast growing rate, short vegetation period and contains about 90-92% water. Therefore, irrigation is a must for high yield levels (Miller, 2002). Watermelon requires more frequent irrigation intervals because of excessive evaporations and low precipitation rates throughout the growing season (Doorenbos and Kassam, 1979).

Therefore, drip irrigation recommended for watermelon irrigation (Srinivas et al., 1989). Fertilizers are usually applied through drip lines together with irrigation water. This practice is called fertigation (Bar-Yosef, 1991). It is a new agricultural technique that provides fertilizer and water concurrently (Majahan and Singh, 2006; Castellanos et al., 2012). In this way, it is possible to control timing, amount and concentration of fertilizers (Hagin et al., 2002). It can provide water and fertilizer in a timely and correctly and increases nutrient uptake. Through fertigation, fertilizer contact with soil is minimized, fertilizers are directly applied to plant root zones and significant savings are achieved in water and fertilizers (Mohammad and Zuraiqi, 2003; Beyaert et al., 2007).

Fertigation is able to meet nutrient requirements of almost all plants, thus almost entire plant water requirement of watermelon is met over the low yield fields poor in nutrients

and in places with irregular precipitations (Fernandes and Prado, 2004).
In this study, effects of different fertigation treatments on plant yield and nutrient uptake of watermelon grown as a second crop in Çukurova region with a semi-arid climate were investigated.

MATERIALS AND METHODS

The present research was conducted in summer season of 2012 over the experimental fields of Çukurova University Agricultural Faculty Soil Science and Plant Nutrition Department under field conditions. Soil characteristics are provided in Table 1.

Table 1. Physical and chemical characteristics of experimental soils.

Soil Property	Depth (0-30 cm)
pH (H_2O)	7.59
Lime (%)	24.1
Salt (%)	0.039
Organic matter (%)	1.30
Texture	CL
Total N (%)	0.10
Available P (kg ha^{-1})	24.2
Available K (kg ha^{-1})	1010.5
Available Fe (mg kg^{-1})	4.01
Available Mn (mg kg^{-1})	1.12
Available Zn (mg kg^{-1})	0.51
Available Cu (mg kg^{-1})	0.31

Experiments were conducted in randomized blocks split plots experimental design with 3 replications. Together with conventional method (0% fertigation), different fertigation doses as of 25% (40 kg N ha^{-1}, 25 kg P ha^{-1}, 50 kg K ha^{-1}), 50% (80 kg N ha^{-1}, 50 kg P ha^{-1}, 100 kg K ha^{-1}), 75% (120 kg N ha^{-1}, 75 kg P ha^{-1}, 150 kg K ha^{-1}) and 100% (160 kg N ha^{-1}, 100 kg P ha^{-1}, 200 kg K ha^{-1}) were experimented.
Just based on fertigation doses, remaining fertilizers were applied to soil with conventional method as follows:

- 25% fertigation - 75% conventional,
- 50% fertigation - 50% conventional,
- 75% fertigation - 25% conventional and
- 100% fertigation - 0% conventional.

In conventional method (0% fertigation) 160 kg N ha^{-1}, 100 kg P ha^{-1}, 200 kg K ha^{-1} were also applied. P and K were applied at planting and N was applied in 3 portions. Irrigations were applied in the same fashion and same number of irrigations was performed. N was applied in ammonium sulphate form, P in MKP and K in KNO_3 form.
Crisby watermelon cultivar was used as the plant material. Seedlings were planted in peat:perlite (1/1 V/V) medium under greenhouse conditions. Then the seedlings were transplanted to field conditions as the second crop after wheat harvest on 15th of June. Each plot had 4 rows and each row had 4 plants. Therefore, each treatment had 16 plants. Row spacing was 1.80 m, on-row plant spacing was 1 m and total plot size was 16.2 m^2. There was 2 m spacing between the adjacent plots to prevent interactions among treatments. A total 9 irrigations were performed throughout the experimental period in 1 week intervals. Water was not supplied for 15 days during shoot elongation period. Leaf samples were taken from watermelon plants at the beginning of flowering. Samples were ground in a plant grinder and N content was determined with modified Kjeldahl method (Bremner, 1965). For P, K, Fe, Mn, Zn and Cu contents, 0.200 g plant samples were ashed at 550 ºC for 5.5 hours in an ash oven. Then the samples were supplemented with 1/3 HCl and distilled water. Readings were performed in resultant extract at P 882 nm in a UV-spectrophotometer (Murphy and Riley, 1962). K, Fe, Mn, Zn and Cu contents were determined with an Atomic Absorption Spectrophotometer (AAS) (Güzel et al., 1992).
Watermelon plants were harvested 77 days after transplantation into field. Following the harvest, yields were determined.
Experimental results were subjected to analysis of variance (ANOVA) by using SPSS 22.0 Windows software. The difference between treatments means were tested with Tukey's test.

RESULTS AND DISCUSSIONS

The effects of different fertigation doses on yields of watermelon plants are presented in Figure 1. Current findings revealed that 75% fertigation treatment had the greatest effect on yield of watermelon plants (48.38 t ha^{-1}). It was followed by 100% fertigation treatment with a yield of 48.14 t ha^{-1}. Bhat et al (2007) carried out a study with data palm plants between the years 1996-2006 and applied 4 different fertigation doses (25, 50, 75 and 100 of recommended fertilizer dose). Researchers reported the greatest yield for 75% fertigation treatment (75:13.5:87.7 g N, P, K year^{-1}) with a yield of 37.21 t ha^{-1}. The 0% fertigation dose (conventional fertilizer application) with a yield of 44.29 t ha^{-1} had higher yield than 25 and 50% fertigation treatments and the differences from 75% fertigation treatment were not significant. The yield of watermelon plants grown as second crop varied between 27.46–48.38 t ha^{-1}. In previous studies, based on climate conditions and water management systems, watermelon yields were reported as between 50 t ha^{-1} and 80 t ha^{-1} (Srinivas et al., 1989; Gündüz et al., 1996; Simsek et al., 2004).

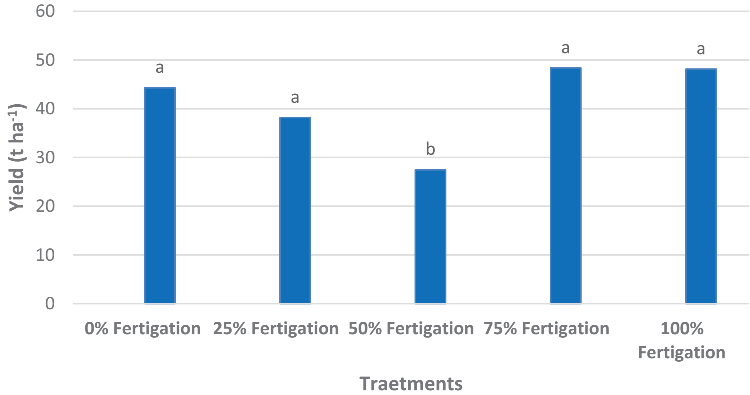

Figure 1. Effects of different fertigation doses on yields of watermelon plants (t ha^{-1})

Considering the effects of treatments on N contents of watermelon plants (Table 2), it was observed that 75% fertigation doses had the greatest N content with 3.78%. The 0% fertigation doses (conventional method) had the lowest N content with 3.43%. As compared to 0% fertigation dose, other treatments increased N contents of plants more. Similar to N contents, 75% fertigation treatments had the greatest P content with 0.31% and 0% fertigation treatment had the least P content with 0.25%. Such a case may be resulted from direct application of plant nutrients, especially hard-to-transport phosphorus to soil through fertigation. Again as it was in N and P contents, all fertigation treatments, except for 0%, increased plant K contents. Among the fertigation treatments, 50% treatment had the greatest K content (3.62%), because N promoted only the vegetative growth and eased the uptake of other nutrients like P and K (Riley and Barber, 1971; Soon and Miller, 1977). Such a synergic impact of nitrogen on other plant nutrients also supports the P uptake within the root zone (Drew, 1975; Anghinoni and Barber, 1988). Potassium (K) and nitrogen (N) are the mostly used nutrients in watermelon (Grangeiro and Cecílio Filho, 2004; Vidigal et al., 2009; Silva et al., 2012). When these nutrients were taken through fertigation, they are distributed uniformly and thus improve fruit quality and yield levels (Hochmuth, 1992), and reduce production costs and prevent various environmental problems.

Table 2. Effect of different fertigation treatments on N, P and K contents of watermelon plants (%)

Treatments	**N**		**P**		**K**	
0% Fertigation	3.43	±0.02 c	0.25	±0.02 c	3.13	±0.02 d
25% Fertigation	3.75	±0.18 a	0.27	±0.00 bc	3.21	±0.04 cd
50% Fertigation	3.53	±0.06 bc	0.29	±0.01 ab	3.62	±0.15 a
75% Fertigation	3.78	±0.00 a	0.31	±0.00 a	3.52	±0.15 ab
100% Fertigation	3.70	±0.13 ab	0.29	±0.01 ab	3.38	±0.13 bc

$P<0.05$

Considering the effects of different fertigation treatments on microelement content of watermelon plants, it was observed that the greatest Fe content was obtained from 50% fertigation treatment with 135.5 mg kg^{-1} and it was followed by 0% fertigation treatment (conventional method) with 129.1 mg kg^{-1} (Table 3).

Table 3. Effect of different fertigation treatments on Fe, Zn, Mn and Cu contents (mg kg^{-1})

Treatments	**Fe**		**Zn**		**Mn**		**Cu**	
0% Fertigation	129.1	±1.62 ab	36.5	±0.72 c	36.4	±0.40 b	14.5	±1.71 c
25% Fertigation	118.7	±3.74 c	41.3	±0.19 b	36.2	±0.14 b	15.7	±1.06 a-c
50% Fertigation	135.5	±3.60 a	41.1	±0.36 b	37.4	±3.31 b	15.6	±0.82 bc
75% Fertigation	125.1	±2.12 bc	45.7	±2.35 a	43.1	±3.83 a	17.6	±0.34 a
100% Fertigation	108.2	±5.23 d	41.4	±1.28 b	35.9	±1.06 b	17.3	±0.33 ab

P<0.05

The lowest Fe content was obtained from 100% fertigation treatment (108.2 mg kg^{-1}). Considering the N contents, similar to N, P and K contents, the greatest value was observed in 75% fertigation treatment (45.7 mg kg^{-1}) and 0% fertigation treatment (36.5 mg kg^{-1}) did not have significant effects on Zn contents as compared to other treatments. Again 75% fertigation treatment had the greatest Mn content (43.1 mg kg^{-1}) and Cu content (17.6 mg kg^{-1}). The relations between the parameters are presented in Table 4.

Table 4. Correlation among variables tested in the experiment

	Yield	N	P	K	Fe	Zn	Mn
Yield							
N	0.185						
P	0.097	-0.392					
K	-0.360	-0.444	0.754**				
Fe	-0.584*	0.361	-0.090	0.322			
Zn	0.153	-0.181	0.869**	0.629*	-0.155		
Mn	0.231	0.150	0.609*	0.397	0.220	0.723**	
Cu	0.311	-0.460	0.800**	0.456	-0.467	0.759**	0.464

*Significant at P<0.05
**Significant at P<0.01

Positive correlation was determined between P and K, Zn, Cu concentrations (p<0.01) and Mn concentrations (p<0.05). Also between Zn and Mn, Cu concentrations (p<0.01) positive correlation was determined. Generally, the other relations were found to be insignificant (p>0.05).

CONCLUSIONS

Considering the entire results of the present study, it was concluded that nutrient supply through fertigation significantly improved yields and N, P, K, Zn, Mn and Cu contents of watermelon plants as compared to conventional method of nutrient supply (0% fertigation).

Especially 75% fertigation treatment (25% from the soil) had greater impacts on watermelon plants than the other fertigation treatments. In general, irrigation improves yields and yield components of watermelon plants grown in semi-arid climate conditions.

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