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COMPARISON OF WATERMELON YIELDS UNDER CONDITIONS OF DRIP IRRIGATION CONNECTED WITH NITROGEN FERTIGATION IN VICINITIES OF BYDGOSZCZ (POLAND) AND CUKUROVA (TURKEY)

Summary

The paper is based on the chosen results of two one-year field experiments which were conducted in the vicinity of Bydgoszcz (Poland) and in the vicinity of Cukurova (Turkey). The aim of the study is to present the comparison of yields of chosen watermelon cultivars grown in the different climatic-soil conditions under drip irrigation with N fertigation. The experiment in Turkey was carried out under better soil conditions than in Poland – watermelon plants were cultivated on the clay loam and fine sand, respectively. 'Crimson Sweet' and 'Sugar Baby' cultivars were tested in the experiment in Poland, and two other cultivars ('Madera-F_1', 'Paladin-F_1') were examined in the experiment in Turkey. Nitrogen of 120 kg N was applied in two different nitrogen forms (G – granule nitrogen; L – liquid nitrogen). In the second treatment (L), the liquid N fertilizer was given with irrigation water (fertigation). All plots were drip irrigated. Higher irrigation water rate was supplied in Turkey (251.7 mm) than that in Poland (157.5 mm). Average yields of watermelon ranged from 32.62 to 37.87 $t \cdot ha^{-1}$, and from 29.09 to 30.35 $t \cdot ha^{-1}$, in the experiment in Poland and in the experiment in Turkey, respectively. Yields were dependent on cultivar and treatment (experimental variant). The yields of 'Crimson Sweet' and 'Madera-F_1' cultivars in treatment with combined N application (granule and liquid N) were higher than these of treatment with granule N source. Fruit weight ranged in both the trials from 3.0 to 5.5 kg. 'Sugar Baby' and 'Madera-F_1' cultivars were characterized by the highest fruit weight (5.5 kg and 5.2 kg, respectively) under combined N application. From results, it can be concluded that watermelon yield could be increased by application of liquid N fertilizer. Amongst the four cultivars, 'Crimson Sweet' and 'Madera-F_1' gave higher yields under conditions of applications of granule together with liquid nitrogen form.

Key words: watermelon, cultivar, drip irrigation, N fertigation

INTRODUCTION

Production of watermelon has taken important place in agriculture of the world. World production is estimated about 77.5 million tons fruit from 3.1 million ha [FAOSTAT, 2001] or 29.7 million t from 1.8 million ha [Erdem and Yuksel, 2003]. The production – under irrigated and rainfed conditions in Turkey is estimated about 3.9 million t of fruit from 146 000 ha [Erdem and Yuksel, 2003]. In Poland, watermelon is not grown in a large but rather in an amateur scale [Gajc-Wolska, 2004; Kaniszewski, 2005].

Irrigation in Poland has supplementary character, so the irrigation is the measure to supplement the rainfall deficiency during the vegetation period. The usage of irrigation is much often during the dry and very dry years which occurred in Poland very often during the last years. From among of all the irrigated plants, cucurbit vegetables have the highest water needs during the vegetation period, so the irrigation should be used to supplement the rainfall deficit. In Turkey approximately 90% of precipitation is received in winter months, so the irrigation should be the basic factor for covering the water needs of plants during the vegetation period.

Seasonal irrigation rate during the vegetation period in Poland should amount approximately from 100 to 200 mm in order to create optimum water conditions for stable and high yields of vegetables [Kaniszewski, 2005; Kaniszewski and Knaflewski, 1997]. Because water resources in Poland are limited, irrigation should be carried out with the use of water-saving systems (micro-irrigation) such as drip (trickle) irrigation and micro-sprinkler (micro-jet) irrigation.

The aim of the paper was to compare fruit yields of chosen watermelon cultivars grown under drip irrigation with N fertigation in the vicinity of Bydgoszcz (Poland) and in the vicinity of Cukurova (Turkey).

MATERIAL AND METHODS

Some field experiments on watermelon grown under irrigation were carried out in 1996-2010 in Poland and Turkey. This paper contains only chosen results from two one-year field trials which were conducted under drip irrigation and nitrogen fertigation, using comparable experimental design (Table 1). The experiment in Turkey was carried out under better soil conditions as compared to that in Poland – watermelon plants were cultivated on clay loam and fine sand, respectively. The soil of the experiment in Turkey was characterized, among others, by a higher water capacity than that in Poland. In these experiments, two different nitrogen forms (G – granule nitrogen; L – liquid nitrogen) were considered. In the second treatment (L), the liquid N fertilizer was given with irrigation water (fertigation).

Table 1. Description of experiments on watermelon

Specification	I	II
Country	Poland	Turkey
Locality	Kruszyn Krajeński	Cukurova
Coordinates: Latitude Longitude Altitude	 53º04'N 17º52'E 65 a.s.l.	 36º59'N 35º18'E 20 a.s.l.
Soil	Mollisols	Vertisols
Texture	Fine Sand	Clay Loam
Field capacity ($g \cdot g^{-1}$): 0-30 cm	7.33	30.40
30-60 cm	2.70	29.50
Cultivars	'Crimson Sweet', 'Sugar Baby'	'Madera-F_1', 'Paladin-F_1'
Row spacing	1.0 m	2.0 m
Plant spacing	0.7 m	0.5 m
Fertilization	120 kg N ha^{-1} 100 kg P_2O_5 ha^{-1} 150 kg K_2O ha^{-1}	120 kg N ha^{-1} 100 kg P_2O_5 ha^{-1} 100 kg K_2O ha^{-1}
Treatments: nitrogen-application types	G – granule N source; GL – a part of N – by granule; another part of N – from liquid N source	G – granule N source; GL – a part of N – by granule; another part of N – from liquid N source
No. of replications	4	3
Irrigation	Drip – in line drippers	Drip – in line drippers
Seasonal irrigation dose (mm)	157.5	251.7
Transplanting of seedlings	16 June	29 April
Last harvesting	28 August	08 July
Length of vegetation period (days)	73	70

'Crimson Sweet' and 'Sugar Baby' cultivars were tested in the experiment in Kruszyn Krajeński, and two other cultivars ('Madera-F_1', 'Paladin-F_1') were examined in the experiment in Cukurova. The seedling growth technique was used to decrease seed losses in expensive cultivars and stimulate earliness. The seeds were sown in the peat blocks with 7x7x7 cm and 5x5x7 cm dimension in the first and the second experiment, respectively. Then, when the seedlings reached a sufficient size, they were transplanted onto the experimental area. The seedlings were planted with a row spacing of 1.0 m and 2.0 m, in Poland and Turkey, respectively. The plant spacing was 0.7 m and 0.5 m, respectively.

The drip irrigation in Polish experiment was done with the use of drip line 'T-Tape'. Terms of irrigation and water rates were established according to tensiometer indications. The irrigation was started at the moment when the soil water tension shown by the tensiometer was close to – 0.04 MPa.

In the Turkish experiment the irrigation water rates were calculated using cumulative evaporation (Ep) from Class-A pan measurements taken between consecutive irrigations. The irrigation was done with the lateral drip lines.

The phosphorus of 100 kg P_2O_5 ha^{-1} and potassium of 100-150 kg K_2O ha^{-1} were applied by hand or by fertilizer spreader to all plots. Then, they were mixed with soil by hoe or by harrow before transplanting of seedlings [Gunay, 1993; Rolbiecki et al., 2009].

CLIMATIC CONDITIONS AND IRRIGATION

Values of air temperature for particular months as well as during the year or in the vegetation period were higher in the Cukurova vicinity than in the vicinity of Bydgoszcz (Table 2). Total annual precipitation amounted to 705.2 mm in the vicinity of Bydgoszcz and 655 mm in the vicinity of Cukurova. These amounts were higher than the adequate long-term average by 253 mm (55.9 %) and 7.9 mm (1.2 %), respectively. From among months, May, July, August and November were characterized by especially high rainfall amounts as compared to many-year averages for the vicinity of Bydgoszcz.

Table 2. Climatic conditions in the years of the study

Specification	I				II			
Country	Poland				Turkey			
Locality	Vicinity of Bydgoszcz				Vicinity of Cukurova			
Air temperature and rainfall amount	t (ºC)		P (mm)		t (ºC)		P (mm)	
Period	meas-ured	norm	meas-ured	norm	meas-ured	norm	meas-ured	norm
I	-7.8	-2.2	22.0	24.3	9.2	9.9	38.2	111.7
II	-2.7	-1.5	20.1	19.1	8.0	10.4	67.0	92.8
III	2.4	1.9	28.6	24.6	10.2	13.1	19.4	67.9
IV	7.8	7.4	33.8	27.6	14.2	17.1	104.4	51.4
V	11.5	12.8	92.6	42.4	22.6	21.4	20.1	46.7
VI	16.7	16.2	18.1	53.5	25.5	25.2	11.4	22.4
VII	21.6	18.0	107.4	71.6	28.7	27.7	0.9	5.4
VIII	18.4	17.4	150.7	51.4	26.6	28.1	6.2	5.1
IX	12.2	13.2	74.7	40.9	24.4	25.4	12.6	14.8
X	5.5	8.2	2.3	33.3	20.2	21.0	89.7	43.6
XI	4.1	3.1	115.0	31.8	15.4	15.1	107.3	67.2
XII	-6.7	-0.5	39.9	31.7	10.7	11.1	177.8	118.1
I –XII	6.9	7.9	705.2	452.2	18.0	18.8	655.0	647.1

Seasonal irrigation water doses were inversely proportional to the rainfall amounts during the vegetation period (Table 1 and Table 2). Higher irrigation water rate was supplied in Turkey (251.7 mm) than that in Poland (157.5 mm). But the total amount of rainfall in the first two months of the watermelon vegetation in Turkey (May-June) was only 31.5 mm, and that of suitable months for the experiment in Poland (July-August) was 258.1 mm. On the other hand, it

should be noted that the very low amount of rainfall occurred during initial weeks of the last trial (June).

RESULTS AND DISCUSSION

Fruit yields and some parameters related to quality properties are given in Table 3. Average yields of watermelon ranged from 32.62 to 37.87 t·ha^{-1}, and from 29.09 to 30.35 t·ha^{-1}, in the first and in the second experiment, respectively. The yields were dependent on the cultivar and treatment (experimental variant). Yields of 'Crimson Sweet' and 'Madera-F_1' cultivars in treatment GL were higher than these in treatment G. Differences between the treatments amounted to 6.84 t·ha^{-1} and 2.77 t·ha^{-1}, respectively for the above cultivars.. The opposite tendency occurred in the case of 'Sugar Baby' and 'Paladin-F_1' cultivars – the yields of the G variants were higher in comparison to those in the GL treatment, but the differences were lower – they amounted only to 0.54 t·ha^{-1} and 2.17 t·ha^{-1}, accordingly. In the field trial conducted in Trakya by Erdem and Yuksel [2003], the 'Crimson Sweet' cultivar fruit yield was higher and varied – as based on twenty five irrigation treatments –from 46.8 to 103.7 t·ha^{-1} and from 41.6 to 89.8 t·ha^{-1}, in 1998 and 1999, respectively. For comparison, in the experiments conducted by Romic et al. [2003] in Croatia, the highest watermelon yields were achieved on black film and drip irrigation (104.5 t·ha^{-1} in 1995 and 79 t per ha in 1996), and in trials carried out by Wang et al. [2004] in China, watermelon yields ranged under irrigation from 44.6 t·ha^{-1} to 58.5 t·ha^{-1}, depending on irrigation quantity and the studied year. In the other experiment carried out by Khade et al. [1995] the highest fruit yield of 'Sugar Baby' cultivar was received from the plots with irrigation and the 120 kg N + 100 kg K_2O ha^{-1}. Fruit yields of Polish cultivar 'Bingo' grown under drip irrigation in the vicinity of Bydgoszcz ranged from 29.8 to 61.3 t·ha^{-1} [Rolbiecki et al., 2009; Rolbiecki et al., 2011].

The fruits of watermelon in the first experiment had smaller diameter and length than these obtained in the second experiment. Generally, the fruit diameter ranged – depending for different cultivar and treatment – from 15.6 to 18.5 cm in the experiment near Bydgoszcz, and from 18.2 to 21.1 cm in the experiment near Cukurova. In the first experiment (Bydgoszcz, sandy soil), the fruits from the GL treatment had higher weight than those from the G treatment. The same tendency was in the second experiment (Cukurova) only in the case of the 'Madera' cultivar, whereas for 'Paladin' the tendency was opposite. Fruit weight ranged in the both trials from 3.0 to 5.5 kg. In the field experiment carried out in Trakya [Erdem and Yuksel, 2003], the 'Crimson Sweet' fruit weight was higher and ranged – under conditions of drip irrigation – from 3.9 to 6.2 kg and from 3.2 to 5.4 kg, in 1998 and 1999, respectively. In the experiments conducted by Wang et al. [2004] in China, watermelon fruit weight ranged under

irrigation from 2.62 kg to 3.79 kg, depending on irrigation quantity and the year of the study.

Table 3. Yields and quality properties of watermelon as dependent on cultivar and treatment

Specification		I				II			
Country		Poland				Turkey			
Locality		Vicinity of Bydgoszcz				Vicinity of Cukurova			
Cultivars		'Crimson Sweet'		'Sugar Baby'		'Madera-F_1'		'Paladin-F_1'	
Marketable yield amount		kg·da^{-1}	t·ha^{-1}	kg·da^{-1}	t·ha^{-1}	kg·da^{-1}	t·ha^{-1}	kg·da^{-1}	t·ha^{-1}
Treatment	G	2920	29.20	3814	38.14	2897	28.97	3018	30.18
	GL	3604	36.04	3760	37.60	3174	31.74	2801	28.01
Average		3262	32.62	3787	37.87	3035	30.35	2909	29.09
Fruit size (cm)		dia-meter	length	dia-meter	length	dia-meter	length	dia-meter	length
Treatment	G	17.2	17.9	15.6	18.1	20.7	22.6	18.5	25.8
	GL	18.5	19.6	16.8	16.2	21.1	22.4	18.2	23.4
Average		17.8	18.7	16,2	17.2	20.9	22.5	18.3	24.6
Fruit weight		(g)		(g)		(g)		(g)	
	G	3090		3440		4996		4687	
	GL	4290		5530		5236		4099	
Average		3690		4485		5116		4393	

Seasonal water rate in the trial conducted in Turkey was higher (251.7 mm) than that in the experiment in Poland (157.5 mm). Previous studies on the irrigation of watermelon in different locations of Turkey indicated that the needs of water ranged from 226 mm to 560 mm [Gunduz et al., 1997; Cetin and Nacar, 1997; Sezgin et al., 1997; Eylen and Tok, 1988]. Lower amounts of water – in the range 47-187 mm – were required in the studies of Erdem and Yuksel [2003] in Trakya. In another trial conducted by Erdem et al. [2005] on 'Crimson Sweet' the total amount of irrigation water ranged – as dependent on irrigation treatment – from 193 to 342 mm. Earlier investigations on drip irrigation of watermelon in Poland indicated that 81-147 mm of irrigation water was required in the vicinity of Bydgoszcz [Rolbiecki et al., 2009; Rolbiecki et al., 2011]. The differences can be explained by the different course and amount of rainfall during the vegetation period of watermelon.

CONCLUSIONS

Watermelon yield could be increased by application of liquid N fertilizer. On the other hand, the yield response to liquid N source was dependent on the cultivar tested. Amongst the four cultivars, 'Crimson Sweet' and 'Madera-F_1' gave higher yields under conditions of applications of granule together with

liquid nitrogen form. The fruit weight ranged in both trials from 3.0 to 5.5 kg. 'Sugar Baby' and 'Madera-F_1' cultivars were characterized by the highest fruit weight (5.5 kg and 5.2 kg, respectively) under combined N application (granule together with liquid nitrogen form).

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