Research Findings

Photo 1. View of the experimental field. Photo by the authors.

Use of Different Potassium and Magnesium Treatments in Watermelon Production by Fertigation

Kappel, N., G. Balazes [(1)], D. Fekete [(1)], and V. Bohm[(1)]

Abstract

Fertigation experiments were conducted in 2009 and 2011 in Hungary on watermelon plants to measure the effects on yield and quality of increasing doses of potassium (K). Potassium was supplied by fertigation together with all other major nutrients, apart from magnesium (Mg) which was applied as a foliar spray with sulphur (S) and some other micronutrients (5% EpsoMicrotop). In 2009, both grafted and non-grafted (cultivar *Crisby*) were used. Two grafted combinations with the following rootstocks: *Strongtosa* (interspecific squash hybrid) and *Nun 3001* (*Lagenaria* type) were investigated. A further experiment was carried out in 2011 using only the non-grafted (cultivar *Crisby*). Plants were grown under low tunnel conditions using intensive technology (soil covering, drip irrigation). Four fertilization treatments supplying different rates of K application were compared. In every treatment half of the plants received foliar Mg fertilizer (5% EpsoMicrotop). Measurement of the yield and

[(1)]Corvinus University of Budapest, Department of Vegetable and Mushroom Growing, 19-43 Villanyi Stree, H-1118 Budapest, Hungary
Corresponding author: kappel@uni-corvinus.hu

fruit weight (kg, average mass) was made in the field. Laboratory analyses of fruit quality included: dry matter content, soluble solid content (Brix %), and sugar content - the most important characteristics of a good-quality watermelon. The results of the 2009 experiments showed that *Strongtosa* interspecific rootstock gave higher yield with higher rates of K application without any loss in fruit quality. In 2011 with only non-grafted plants, yield and total soluble solids (TSS) content ran parallel with the increasing rates of K supply.

Introduction

Watermelon is an important crop for growers in Hungary. It accounts for the third largest horticulture production area, about 6,000 ha, with a significant amount of the crop being exported. In recent years there has been a growing interest in the use of grafted plants and, over the last five years, the size of the grafted watermelon area has expanded considerably from 200-300 ha to 1,000-1,500 ha.

The watermelon crop requires considerable amounts of nitrogen (N), phosphorus (P) and potassium (K). For crops to which 40-50 mt ha^{-1} of manure are applied, an additional 90-110 kg of N ha^{-1}, 50-60 kg of P ha^{-1} and 120-140 kg ha^{-1} of K in some form of inorganic fertilizer is also required. Without manure the quantity suggested is 20 percent greater. Fertilization practice in cultivating watermelon in Hungary varies considerably from conventional mineral fertilizer application to highly controlled sophisticated methods of fertigation. The professional growers use plastic mulch with drip tubing to supply the nutrients. In order to reduce expense, preplant fertilizer can be placed under the mulch in narrow beds during spring. Specialized water soluble fertilizers may also be used, which are specifically formulated for different stages of plant development. A starter fertilizer with an NPK formulation of 15:15:15 is commonly used. Recommendations are different for self-rooted and grafted plants. From what is currently known, it appears that for grafted watermelon lower rates of N should be supplied but higher rates of K.

In order to obtain high yield and good quality watermelon, there is a need to augment the nutrient status of the soil to meet crop demand as well as maintaining soil fertility. Potassium is of particular interest since an adequate supply of this nutrient is associated with increased yields and improved quality features of various vegetable and horticultural crops, including watermelon. These features comprise fruit size, increased soluble solids and ascorbic acid concentrations, better fruit colour, increased shelf life, and shipping quality.

Many changes have occurred in watermelon production practices in the last few years, including new cultural systems such as polyethylene mulch and drip irrigation, changes in cultivars and the use of grafted plants. Seed companies are currently experimenting with grafted plants under Hungarian conditions.

It has been well documented that certain rootstocks show stronger resistance to soil pathogens, greater tolerance of low soil temperatures, as well as to salt stress (Davis *et al.*, 2008; Hoyos, 2001; Oda, 2007). Thus, the selection of rootstocks is rarely based on characteristics related to nutrient utilization but rather almost always on resistance to environmental stress (Ruiz *et al.*, 1997). Knowledge of the rootstock/scion nutritional relationship could be decisive in choosing rootstocks tolerant or resistant to soils that are deficient or toxic in one or more nutrients, as well as in preparing fertilization programmes after the grafted plant is transplanted (Chaplin and Westwood, 1980). Some researchers reported that quality (Brix, firmness, rind thickness etc.) of watermelon is greatly affected by rootstock, but it can also be influenced by nutrient dosage (Gao and Liao, 2006; Lee and Oda, 2003; Masuda *et al.*, 1986; Yamasaki *et al.*, 1994). Watermelon is sensitive to deficiencies of Mg, Boron (B), Iron (Fe) and Zinc (Zn). Foliar sprays of these nutrients in some cases, have proved useful in enhancing the sugar content of the fruit. Since watermelon yield and quality are so greatly influenced by production practices, it is important that watermelon varieties should be tested under conditions of adequate nutrition.

The paper presented here summarizes the findings of field experiments carried out with watermelon over two growing seasons, grafted and non-grafted in 2009 and non-grafted in 2011; yield and quality of the fruits were investigated in fertigation experiments with increasing levels of K together with addition of all the other major mineral nutrients, with the exception of Mg (and micronutrients) which were applied as a Mg-S micronutrient containing foliar spray (5% EpsoMicrotop).

Material and methods

Plant material and culture conditions

In both experimental years (2009 and 2011) the cultivar used was *Crisby* (seed source: Nunhems). In 2009, besides the non-grafted plants, two grafted combinations were used with the following rootstocks: *Cucurbita maxima* x *Cucurbita moschata* interspecific (squash) hybrid: *Strongtosa* (seed source: Syngenta), and a *Lagenaria* type (bottle gourd): *Nun 3001* (seed source: Nunhems).

In 2009, the experiment was carried out in Békés County in Dombegyház (Hungary 46°20’29.7”N; 21°8’3.3”E; site A), while in 2011 the experiment was set up in Kunágota (Hungary 46°25’24.2”N; 21°2’48.3”E; site B). In both areas the soil type is chernozem (black dirt). Before planting, soil analysis was carried out (Table 1). These results showed that both areas were very well provided in K and Mg. Carbonate and organic matter content were also very high.

Table 1. Results of soil tests from the two sites.

Properties	Site A (2009)	Site B (2011)
	----------------%----------------	
pH (KCl)	7.19	6.98
Soluble salt content	0.02	0.04
Total carbonate content in $CaCO_3$	4.63	4.02
Organic matter	3.17	3.12
	-------------mg kg^{-1}-------------	
(NO_2+NO_3)-N (M KCl soluble)	5.55	7.02
Phosphorus content as P_2O_5 (ammonium lactate extractant)	222.5	222.3
Potassium content as K_2O (ammonium lactate extractant)	318.7	305.0
Magnesium (M KCl soluble)	192	162
Sodium (ammonium lactate extractant)	23.5	19.8
Zinc (EDTA soluble)	1.25	1.08
Copper (EDTA soluble)	1.63	1.32
Manganese (EDTA soluble)	57.4	47.5
Sulphate (M KCl soluble)	<1.5	<1.5

The experiment was conducted on a grower's farm using intensive technology (drip irrigation, plastic soil cover, low plastic tunnel covering). Seedlings were used as propagating material each year. In 2009, the grafting was performed using the one-cotyledon grafting technique. In preparing a field, the land was disked, and rows laid out by the farmer. Beds were then fully shaped, treated for weeds and soil-borne pests, drip irrigation lines run, and plastic placed on top with the edges buried under the soil to hold it in place. Color plastic mulch was laid over each raised bed. Each row was irrigated with one drip tube with drippers spaced on-center 20 cm apart. Irrigation and fertigation was scheduled on visual inspection. Immediately after transplanting, the plants were grown under low tunnels fashioned using wire hoops covered with mono-layer polyethylene (Photo 2). These covers remained on the plants continuously until the first perfect female flower was observed. The watermelons were harvested by hand, beginning in June and continuing through July and into August.

Photo 2. Layout of the experiment (30-05-2009). Photo by the authors.

Optimum plant density is an important factor in maximizing yields in many crops. Currently, commercial watermelon spacing is commonly around 80 cm by 100 cm or approximately 7,000-8,000 cm^2 per plant. Reduction in costs per ha might be achieved using grafted plants if it were possible to reduce plant populations yet attain similar yields compared to non-grafted watermelon seedlings using a traditional planting density. For grafted plants, the recommended density is 3,500-4,000 cm^2 per plant. In 2009, plants were transplanted to the field at 100 cm spacing within the row and 320 cm between rows (3,125 per ha) (Photo 1; see page 8). This density is adequate for grafted plants but, because of the arrangement of the irrigation system, equal spacing of the non-grafted plants was used. The experiment was set up with 448 plants in total. In 2011, non-grafted plants (*Crisby*) were used with a spacing of only 60 cm within the row and 170 cm between the rows (9,804 plant ha^{-1}). In this year 1,800 plants were planted. In both years, the planting took place on the 15th April.

Some of the most important chemical characteristics of the soils are given in Table 1 as determined by methods of soil testing and advisory practice generally used in Hungary. The methods for these determinations are described in the Hungarian standards (MSZ-08-0206-2:1978; MSZ-08-0205:1978; MSZ-08-0210-2:1977, MSZ-20135:1999).

Treatments

In 2009, both grafted and non-grafted plants were studied and the applied fertilizer dose was calculated on the basis of an average yield of 90 mt ha^{-1}. In 2011, when the experiment included non-grafted plants only, this value was calculated as an average yield of 50 mt ha^{-1}. For each year there were four treatments with increasing rates of K and a control treatment without K as shown in Table 2.

Nutrient application was divided into different development phases (root development, intensive growth, first female flowers, small melons, half size crops). The treatments in 2009 are given in Table 3. Similarly, the nutrient applications for 2011 with grafted plants are given in Table 4.

Applied fertilizers

All fertilizer treatments were in the form of fertigation or foliar application. The soils on the experimental sites used had been treated neither with mineral nor organic fertilizer for the past 10 years. The fertilizers used were all fertigation or fully soluble grade: calcium nitrate (15.5% N + 25% CaO), ammonium nitrate (34% N), NPK 15:30:15 (Ferticare Starter) and potassium sulfate (50% K_2O + 18% S). EpsoMicrotop (15% MgO + 12% S + 1% B + 1% Mn) was used as Mg foliar spray (plus micronutrients).

Foliar application

In every treatment half of the plants received foliar Mg fertilizer (EpsoMicrotop 15% MgO; 12% S; 1% B; 1% Mn). The foliar fertilizer mixtures were diluted with water and applied at 5% concentration.

In 2009, the number of applications varied with the treatments. T_1 was sprayed four times (total 36 kg ha^{-1} of MgO), T_2 three times (total 24 kg ha^{-1}), T_3 twice (total 12 kg ha^{-1}) and T_4 once (total 6 kg ha^{-1}). In 2011, the plants were treated with foliar fertilizer (5% EpsoMicrotop) three times in each treatment (MgO 8 kg ha^{-1}), starting with initial fruit set. All foliar applications were made with a backpack sprayer and hand boom equipped with flat fan nozzles.

Table 2. Fertigation treatments and foliar applications of the experiments in 2009 and 2011.

Treatment	Site A† (2009)			Site B‡ (2011)			Number of foliar applications	
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	2009	2011
	kg ha^{-1}						*5% of EpsoMicrotop§*	
Control	0	0	0	90	28	50	0	3
T_1	145	65	0	80	36	0	4	3
T_2	145	65	160	80	36	90	3	3
T_3	145	65	325	80	36	180	2	3
T_4	145	65	485	80	36	270	1	3

†Grafted and non-grafted plants; ‡Non-grafted plants only; §At 1,000 liters per ha.

Table 3. Application of nutrients (kg ha^{-1}) during growth stages (site A, 2009).

Growth stage	Treatment										
	T_1, T_2, T_3, T_4			T_1		T_2		T_3		T_4	
	N	P_2O_5	CaO	K_2O	MgO†	K_2O	MgO†	K_2O	MgO†	K_2O	MgO†
	kg ha^{-1}										
Root development	20	25	0	0	0	15	0	25	0	45	0
Intensive growth	25	0	0	0	0	25	0	35	0	65	0
First female flowers	25	25	0	0	0	35	0	45	0	85	0
Small melons	35	15	6	0	0/18	35	0/12	65	0/6	125	0
Half size crop	40	0	6	0	0/18	50	0/12	155	0/6	165	0/6
Total	145	65	12	0	0/36	160	0/24	325	0/12	485	0/6

†0 means control treatment without foliar fertilization.
Note: The quantities of the nutrients applied were based on yield target of 90 mt ha^{-1}.

Table 4. Application of nutrients (kg ha^{-1}) during growth stages (site B, 2011).

Growth stage	Treatment																								
	N					P_2O_5					CaO					K_2O					MgO†				
	C	T_1	T_2	T_3	T_4	C	T_1	T_2	T_3	T_4	C	T_1	T_2	T_3	T_4	C	T_1	T_2	T_3	T_4	C	T_1	T_2	T_3	T_4
	kg ha^{-1}																								
Root development	12	10	10	10	10	10	14	14	14	14	0	0	0	0	0	5	0	8	16	24	0	0	0	0	0
Intensive growth	15	12	12	12	12	0	0	0	0	0	0	0	0	0	0	8	0	14	28	42	0	0	0	0	0
First female flower	15	12	12	12	12	10	14	14	14	14	0	0	0	0	0	10	0	19	38	57	0	0	0	0	0
Small melons	20	18	18	18	18	8	8	8	8	8	5	5	5	5	5	10	0	19	38	57	0/12	0/12	0/12	0/12	0/12
Half size crop	28	28	28	28	28	0	0	0	0	0	5	5	5	5	5	17	0	30	60	90	0/12	0/12	0/12	0/12	0/12
Total	90	80	80	80	80	28	36	36	36	36	10	10	10	10	10	50	0	90	180	270	0/24	0/24	0/24	0/24	0/24

†0 means control treatment without foliar fertilization.
Note: The quantities of the nutrients were based on 50 mt ha^{-1}.

Irrigation and fertigation

Each treatment was set along one irrigation line. The drip lines for each row were equipped with a valve at the head line. This allowed water/fertilizer to be directed to selected rows during application.

Fungicides and insecticides were applied separately, but in a similar manner as needed throughout the season. For evaluation of the treatments the fruits were collected in every row in four replications.

Measurements

Measurement of yield and fruit weight (kg, average mass) was carried out in the field. Laboratory measurements of fruit quality included:

1. Fruit dry matter (%) (whole fruit (husk+fruit flesh) after drying at 105°C);
2. soluble solid content (Brix %) (from fruit flesh was measured by a manual digital refractometer (Hannah HI96801));
3. sugar content (%) (from fruit flesh by Luff-Schroorl method; Egan et *al.*, 1981):
   a) total sugar content (%),
   b) glucose+fructose content (%),
   c) sucrose content (%).

The mineral content of the fruits were measured using dried plant material. Total N was determined using the Kjeldhal method (Gaspar *et al.*, 1975). Samples of plant material were wet oxidized and P and K determined in soluble form. P was measured colorimetrically using spectrophotometry (Thamm *et al.*, 1968). K was measured by flame photometry (Lasztify and Törley, 1994).

Results

Yields

In 2009, fruit were obtained from multiple harvests, which started with the non-grafted plants in the second half of June and the last harvest date taking place on 15th July. Harvesting the grafted plants of *Crisby* took place over a longer period starting at the beginning of July and continuing until the 15th August. In 2011, when only non-grafted plants were used, the harvest started in mid-June and continued until early August. The harvested fruit were counted and measured in the field as described above.

In 2009, the grafted and the non-grafted plants were planted with equal spacing because of the arrangement of the irrigation system. It thus follows that some parameters are not comparable between grafted and non-grafted plants. A very big difference in yields between the grafted and non-grafted plants (2009) was observed in favour of the grafted plants (Fig. 1). This resulted from the use of the same plant density for both types of plants, a much higher density being required by the non-grafted plants to produce the same yield.

While N and P, as well as N, P and K application to non-grafted plants contributed to yield, the effect on the grafted plants was far greater (Fig. 1). For the grafted plants, yield was positively correlated with the high K dose (T_4). The effects of foliar fertilization on yield of this grafted rootstock were greater for the lower K treatments and especially at the lowest (T_1) K dose. Of the two types of rootstock used, the interspecific squash (*Strongtosa*) generally produced a higher yield.

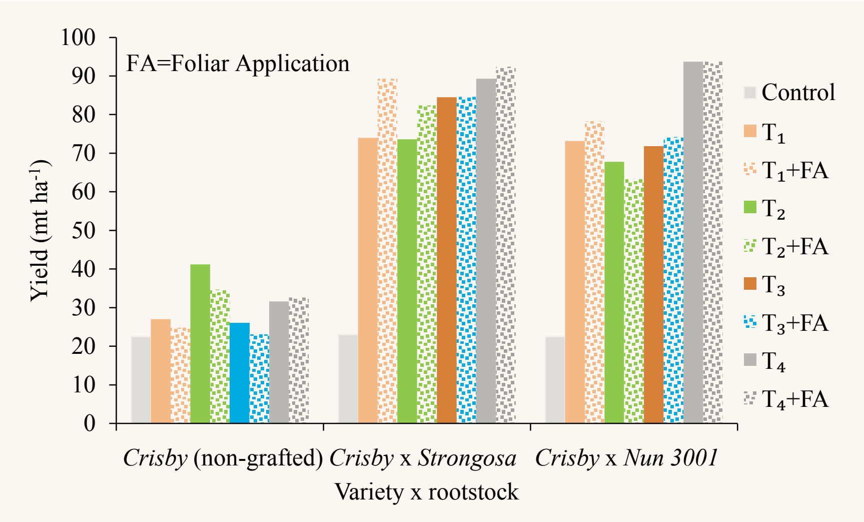

Fig. 1. The effect of K doses and Mg foliar fertilizer on the yield of non-grafted and grafted watermelon plants (site A, 2009).

In 2011, the highest yield was obtained from the higher K dose (180 and 270 kg K_2O ha^{-1}; T_3 and T_4, respectively; Fig. 2). The applied doses gave higher values compared to the control (the grower's technology; 50 kg ha^{-1}). In all treatments, the addition of foliar spray (FA) slightly increased both yield and fruit weight (Fig. 2). Omission of K (T_1) resulted in a steep decline in yield. The overall benefit from applying K (as compared to T_1, K=0) was approximately 50 percent. The evaluation of fruit weight result shows the same tendency as with fruit yield.

Quality parameters

In general, lower fruit quality reported for watermelon due to grafting includes reduced soluble solids content, insipid taste, and poor texture (Traka-Mavronaet *et al.*, 2000). Our results confirm these findings: in all treatments, the non-grafted plants had higher soluble solid, dry matter, total sugar, glucose, fructose and sucrose concentrations (Table 5). Increasing levels of applied

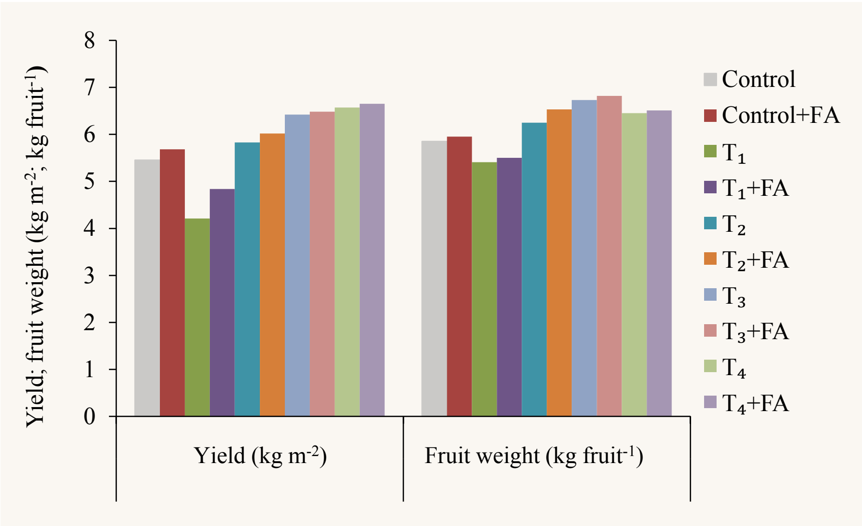

Fig. 2. The effect of K doses and Mg foliar fertilizer on yield and fruit weight of *Crisby* (non-grafted) watermelon plants (site B, 2011).

K improved these in non-grafted and grafted plants, but the effect of FA was small (Table 5).

In 2009, differences were observed between the two different rootstock types. The mature fruit from the *Crisby/Nun 3001* combination had significantly lower soluble solid content compared to that from the *Crisby/Strongtosa* combination (Table 5.). The higher K dose resulted in higher TSS content, and EpsoMicrotop treatments raised this even more.

There are conflicting reports on changes of fruit quality due to grafting. Reports vary on whether grafting effects are advantageous or deleterious, but most agree that the rootstock/scion combination must be carefully chosen for optimal fruit quality. If the effects of rootstocks on fruit quality are detrimental, recommendations are aimed at minimizing these effects.

Table 5. The effect of K doses and Mg foliar fertilizer on total soluble solid (TSS), dry matter (DM), and sugar content of grafted and non-grafted *Crisby* (site A, 2009).

Treatment	Total Soluble Solid (Brix)			Dry Matter			Total Sugar			Glucose+Fructose			Sucrose (%)		
	NG	ST	NU	NG	ST	NU	NG	ST	NU	NG	ST	NU	NG	ST	NU
	--------------------							%							--------------------
Control	10.60			8.02			8.02			3.89			4.13		
T_1	10.90	11.18	5.10	8.22	7.48	4.47	8.54	9.06	3.68	4.74	5.58	3.48	3.80	3.48	0.20
T_1+FA	12.50	11.33	11.28	9.90	8.64	7.76	10.83	10.00	7.24	4.14	4.04	3.08	6.69	5.96	4.16
T_2	11.30	10.15	6.80	8.85	7.64	6.04	9.69	8.54	4.63	3.84	5.78	4.18	5.85	2.76	0.45
T_2+FA	11.25	10.73	7.30	9.70	8.35	5.83	10.10	8.86	4.88	4.98	4.24	4.38	5.12	4.61	0.50
T_3	11.68	10.38	9.00	9.21	7.61	6.83	9.27	8.96	5.13	4.24	5.08	3.78	5.03	3.88	1.35
T_3+FA	12.45	10.68	8.08	10.87	8.14	6.84	11.47	8.96	5.93	5.38	3.94	3.78	6.09	5.02	2.15
T_4	12.50	11.45	9.85	10.56	8.25	8.01	10.62	9.58	6.88	5.88	4.88	3.98	4.74	4.70	2.90
T_4+FA	12.50	11.30	10.13	10.68	8.82	8.95	10.94	9.27	8.08	4.54	4.14	3.78	6.40	5.13	4.30

Note: NG = non-grafted; ST = grafted on '*Strongtosa*' rootstock; NU = grafted on '*Nun 3001*' rootstock.

Table 6. The effect of K doses and Mg foliar fertilizer on TSS, DM and sugar content of non-grafted *Crisby* watermelon (site B, 2011).

Treatment	Total Soluble Solid (Brix)	Dry matter	Total Sugar	Glucose+Fructose	Sucrose
	--------------------		%		--------------------
Control	10.20	8.50	8.90	4.77	4.13
T_1	10.35	8.60	9.30	4.85	4.45
T_1+FA	8.90	8.02	8.20	4.30	3.90
T_2	9.50	8.90	8.45	4.20	4.25
T_2+FA	11.30	8.85	9.69	4.07	5.62
T_3	11.55	9.70	10.15	4.30	5.85
T_3+FA	11.68	9.21	10.20	3.99	6.21
T_4	12.25	10.87	10.78	4.46	6.32
T_4+FA	12.50	10.56	10.62	4.20	6.42
Control	12.70	10.68	11.30	4.55	6.75

Watermelons respond well to fertilizer: ususally, inreasing rates of supply of K and Mg speed up fruit ripening and increase sugar content. In 2011, measuring the total sugar content (%) and the different sugar fractions, we found that the increased K doses, and also application of Mg, increased sugar content of fruits (Table 6). K rate and the Mg raised sucrose content, but there was no effect on glucose+fructose content. Nutrient removal from the experimental plots in 2009 was calculated by N, P and K content in fruit (Table 7) multiplied by yield and presented as nutrient removed per ha (Table 8). Nutrient content did not change much between the different types of plants and with different treatments (Table 7). Hence, nutrient removal increased as a function of yield (Table 8 and 9), so that the much higher yields of grafted plants removed more than twice the N, P and K compared to non-grafted plants. This obviously has a significant implication on soil fertility and the consequent nutrient management of these plants.

Table 7. N, P and K content in grafted and non-grafted *Crisby* fruit (site A, 2009).

Treatment	N			P			K		
	NG	ST	NU	NG	ST	NU	NG	ST	NU
	mg g⁻¹								
Control	23.2	23.2	23.2	2.1	2.1	2.1	26.0	26.0	26.0
T_1	31.9	34.3	35.7	4.6	4.1	3.8	43.0	32.0	31.0
T_1+FA	34.6	32.9	35.0	5.0	4.3	4.0	34.0	29.0	45.0
T_2	31.9	28.7	38.5	5.1	3.1	4.6	46.0	29.0	34.0
T_2+FA	28.4	29.8	34.6	3.4	3.6	2.9	32.0	31.0	35.0
T_3	29.1	31.9	32.6	3.8	3.9	3.3	38.0	31.0	32.0
T_3+FA	31.2	35.0	35.3	4.4	4.6	3.3	35.0	38.0	29.0
T_4	33.6	29.6	24.6	3.4	3.4	2.9	30.0	35.0	27.0
T_4+FA	35.3	30.5	33.2	4.2	3.4	3.7	35.0	35.0	38.0

Note: NG = non-grafted; ST = grafted on '*Strongtosa*' rootstock; NU = grafted on '*Nun 3001*' rootstock.

Table 8. N, P and K removal by grafted and non-grafted *Crisby* fruit (site A, 2009).

Treatment	N			P			K		
	NG	ST	NU	NG	ST	NU	NG	ST	NU
	kg ha⁻¹								
Control	52.2	52.2	52.2	4.8	4.8	4.8	58.5	58.5	58.5
T_1	86.1	253.8	261.2	12.3	30.0	27.8	116.1	236.8	226.9
T_1+FA	85.9	293.9	274.0	12.2	38.2	31.4	84.3	258.9	352.3
T_2	82.9	243.0	276.1	13.4	26.5	33.2	119.6	245.0	244.1
T_2+FA	65.6	252.1	257.1	7.9	30.3	21.4	73.9	262.3	259.7
T_3	119.9	234.6	220.8	15.6	29.2	22.5	156.6	228.2	216.9
T_3+FA	108.2	288.4	223.7	15.4	38.1	20.9	121.4	313.1	183.6
T_4	106.0	274.7	171.5	10.7	31.5	20.0	94.8	324.8	188.2
T_4+FA	115.2	281.7	311.6	13.6	31.8	34.3	114.1	323.4	356.1

Note: NG = non-grafted; ST = grafted on '*Strongtosa*' rootstock; NU = grafted on '*Nun 3001*' rootstock.

Table 9. N, P and K content and removal by grafted and non-grafted *Crisby* fruit (Site B, 2011).

Treatment	Nutrient content			Nutrient removal		
	N	P	K	N	P	K
	mg g⁻¹			*kg ha⁻¹*		
Control	30.8	2.1	31.0	167.9	11.6	168.9
Control+FA	31.1	2.2	32.0	176.6	12.8	181.8
T_1	29.8	4.6	24.0	125.4	19.3	101.0
T_1+FA	28.7	4.9	27.0	138.9	23.9	130.7
T_2	29.5	5.1	35.0	171.9	30.0	204.1
T_2+FA	29.7	4.9	36.0	178.8	29.5	216.7
T_3	29.1	4.9	38.0	186.9	31.3	243.9
T_3+FA	30.1	4.4	38.0	195.0	28.8	246.2
T_4	30.4	4.6	40.0	199.7	29.9	262.8
T_4+EpsoTop	30.5	4.2	38.0	202.8	27.9	252.7

Conclusions

The main aim of this experiment was to investigate the effects on fertigated grafted and self-rooted watermelon of KCl application at various levels, with or without a Mg containing foliar fertigation. The results of this study are in agreement with some earlier findings that K in the fertigation solution enhances fruit appearance and improves fruit quality.

In our study the beneficial effect of K in raising yield was more conspicuous in the interspecific squash rootstock (*Strongtosa*). In 2009, with only non-grafted *Crisby* plants, the lowest K dose (T_2; 160 kg ha^{-1}) resulted the highest yield, whereas in the 2011 experiment, yield increased with increasing K application. The highest K dose enhanced the yield by 20 percent compared to the control (grower's technology). The benefits of K on watermelon growth have been documented by numerous previous investigators, such as Okur and Yagmur (2004) who found that 240 kg ha^{-1} of K_2O produced the highest yield of watermelon at 54,320 kg ha^{-1}. In order to obtain high yields with grafted watermelon a high K dose is specifically required.

Based on the results of 2009 with grafted and non-grafted plants, application of the Mg foliar fertilizer (EpsoMicrotop) enhanced yields especially at lower rates of K. Knowledge of this relationship may be very useful to the growers who may be able to compensate lower rates of K application by additional foliar Mg fertilization to increase yield.

Both yield and fruit quality are important parameters in watermelon. For grafted plants, the question of fruit quality is of particular interest. Sugar content appears to be one of the most important characteristics of a good-quality watermelon, based on the fruit quality indices routinely measured by scientists. Some previous research has generally shown that grafting has a negative effect on TSS content in watermelon fruit when grafting watermelon onto *C. maxima* x *C. moschata*, or *L. siceraria* rootstocks (Ioannouet *et al*., 2002). In our experiment we obtained similar results, but higher rates of K application could to some extent offset this decrease. For the non-grafted plants, increasing K dose resulted in higher sugar content in both experimental years.

Considering the opportunities for growers of the many plant mineral nutrients, K and Mg stand out as having a very strong influence on quality attributes that determine fruit marketability. As for effect of K, it was clear that the medium and high levels of application raised the number of fruits/plant, fruit weight, total yield and TSS (%) compared with low level treatment. In most cases for the two seasons the best gains financially were recorded with the medium K level with Mg and micronutrient supplement.

The findings of this study help to improve the quality of watermelon fruits as well as the quantity. However, this study also indicates the need for further investigation concerning the interaction between K-Mg in watermelon fertigation, especially using grafted plants. It also has to be taken into account in these field experiments that supplying foliar Mg, in the form of EpsoMicrotop, provides the crop with additional S and micronutrients which may possibly influence the K/Mg interaction.

References

Chaplin, M.H., and M.N. Westwood. 1980. Nutritional Status of ‘Barlett’ Pear on Sydonia and Pyrus Species Rootstock. Journal of the American Society for Horticultural Science Number 105. p. 60-63.

Davis, A.R., P. Perkins-Veazie, Y. Sakata, S. López-Galarza, J.V. Maroto, S.G. Lee, Y.C. Huh, Z. Sun, A. Miguel, S.R. King, R. Cohen, and J.M. Lee. 2008. Cucurbit Grafting Critical Reviews. Plant Sciences.

Egan, H., R. Kirk, and R. Sawyer. 1981): The Luff Schoorl Method. Sugars and Preserves. *In:* Pearson’s chemical analysis of foods. 8th edition, Longman Scientific and Technical: Harlow, UK. p. 152-153.

Gao, J.H., and H.J. Liao. 2006. Effect of Grafting on Watermelon Quality. China. Cucurbits and Vegetables Number 5. p. 12-14.

Gáspár, L., H. Kalász, I. Kerese, Ö. Takács, and E. Tyihák. 1975. Fehérjevizsgálati módszerek. Műszaki Könyvkiadó, Budapest.

Hoyos Echebarria, P. 2001. Influence of Different Rootstocks on the Yield and Quality of Greenhouses Grown Cucumbers. ActaHorticulturae Number 559. p. 139-144.

Ioannou, N., M. Ioannou, and K. Hadjiparaskevas. 2002. Evaluation of Watermelon Rootstocks for Off-Season Production in Heated Greenhouses. ActaHorticulturae, Number 579. p. 501-506.

Lásztify, R., and D. Törley. 1994. Élelmiszerkémiai és Technológiai Gyakorlatok. Műegyetem Kiadó, Budapest. 129 p.

Lee, J.M., and M. Oda. 2003. Grafting of Herbaceous Vegetable and Ornamental Crops. Horticultural Reviews, Number 28. p. 61-124.

Masuda, M., T. Takamori, T. Tanaka, H. Takahashi, and M. Sugio. 1986. Studies of the Characteristics of Nutritional Uptake of the Rootstocks of Grafted Crop Fruits. Fruit Quality and Water and Mineral Absorption in Watermelon Grafted to Squash and to Bottle Gourd Interstock. Journal of the Japanese Society of Horticultural Science. Spring Meeting. p. 180-181.

Oda, M. 2007. Vegetable Seedling Grafting in Japan. ActaHorticulturae, Number 759. p. 175-180.

Okur, B., and B. Yagmur. 2004. Effects of Enhanced Potassium Doses on Yield, Quality and Nutrient Uptake of Watermelon. IPI Regional Workshop on Potassium and Fertigation Development in West Asia and North Africa; Rabat, Morocco, 24-28 Nov. 2004. p. 36-43.

Ruiz, J.M., A. Belakbir, I. López-Cantarero, and L. Romero. 1997. Leaf-Macronutrient content and yield in Grafted Melon Plants. A model to evaluate the influence of rootstock genotype. ScientiaHorticulturae, Number 71. p. 227-234.

Thamm, F.NÉ., M. Krámer, and J. Sarkadi. 1968. Növények és Trágyaanyagok Foszfortartalmának Maghatározása Ammonium-Molibdo-Vanadátos Módszerrel. Agrokémia és Talajtan Tankönyv. 17. p. 1-2.

Traka-Mavrona, E., M. Koutsika-Sotiriou, and T. Pritsa. 2000. Response of Squash (*Cucurbita spp.*) as Rootstock for Melon (*Cucumis melo* L.). Scientia Hort., Number 83. p. 353-362.

Yamasaki, A., M. Yamashita, and S. Furuya. 1994. Mineral Concentrations and Cytokinine Activity in the Xylem Exudate of Grafted Watermelons as Affected by Rootstocks and Crop Load. Journal of the Japanese Society of Horticultural Science, Number 62. p. 817-826.

The paper “Use of Different Potassium and Magnesium Treatments in Watermelon Production by Fertigation” also appears on the IPI website at:

Regional activities/Central Europe