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Influences of Potassium Chloride and Potassium Sulphate Supplement on Fruit Quality, Yield and Plant Growth of Cherry Tomato in Solution Culture

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水耕ミニトマトの果実品質，収量及び生育に及ぼす塩化カリウム及び硫酸カリウム添加処理の影響

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The objective of this experiment is to investigate influences of potassium chloride (KCl) and potassium sulphate (K_2SO_4) supplement to nutrient solution on fruit quality, yield and plant growth of cherry tomato.

1. In 1.0 unit (standard solution)+KCl 1200 ppm treatment, the soluble solids content, total sugar content, titratable acidity and percent of dry matter of fruit increased remarkably, whereas fruit weight decreased in three cultivars. In 1.0 unit+K_2SO_4 treatment, the soluble solids, total sugar content and percent of dry matter of fruit less increased than in KCl treatment. Fruit weight in K_2SO_4 treatment was equal to that in control or it tended to increase in all the cultivars. As compared with control, in 'Sun Cherry' and 'Akakokko' solid-acid ratio in K_2SO_4 treatment increased, but this ratio in KCl treatment decreased due to increase in titratable acidity. The difference of fruit hardness was not recognized among all the treatments.
2. In KCl treatment yield tended to decrease in all cultivars.
3. Leaf length, leaf width, fresh weight, dry weight and leaf area of cherry tomato plant decreased in KCl treatment but they were equal or increased in K_2SO_4 treatment. Stem diameter did not differ in all the treatments.
4. Thus, it was recognized that fruit quality was improved by the supplement of KCl to the standard solution with decreasing yield compared with control (2.0 units), whereas fruit quality in the supplement of K_2SO_4 to the standard solution was equal to that in control without decreasing yields.

Introduction

Previously we reported that supplement of potassium chloride (KCl) to nutrient solution improved fruit quality, especially soluble solids content and acidity in cherry

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tomato[1]. However, it was shown that fruit weight and yield tended to decrease by this treatment. This was probably due to increase in osmotic pressure of nutrient solution by KCl supplement and the following restriction of water absorption to plant.

On influences of potassium fertilizer on tomato fruit quality, some papers[2),3),4)] reported that high potassium level increased acidity of tomato fruit. Influences of potassium fertilizer on tomato fruit quality have not been clearly studied. But, there is a report[3] that there were no or little influences of potassium level in solution on sugar content. Also on potassium chloride, there is a possibility that chloride ion is inhibitory to plant growth. Therefore, we substituted chloride ion with sulphate ion in this experiment.

This paper describes effect of supplying two potassium salts (potassuim chloride (KCl) and potassium sulphate (K_2SO_4)) to nutrient solution on fruit quality and yield of cherry tomato as well as on shoot and root growth.

Materials and Methods

The cherry tomato cultivars used in this experiment were 'Sugar Lump' (low soluble solids Content), 'Sun Cherry' (intermediate soluble solids content) and 'Akakokko' (high soluble solids content). These cultivars were selected judging from the result of the previous paper[5),6)].

The seeds were sown in March 2nd 1989 and planted to culture bed in April 14th 1989. Four plants were used each treatment. Plant density was 7 plants per 3.3 m^2 Pinching was conducted by remaining three leaves over the second flower truss. Fruits were harvested from June 13 rd to July 17 th 1989.

The standerd nutrient solution (1.0 unit) contained NO_3-N, NH_4-N, P, K, Ca and

Table 1. EC values and osmotic pressure in nutrient solutions supplemented with potassium chloride or potassium sulphate.

Treatment	EC^z(mS/cm)	Osmotic pressure(−MPa)
2.0 units (Control)	4.5±0.3	0.135
1.0 unit+KCl 600ppm	3.5±0.3	0.099
1.0 unit+KCl 1200ppm	4.5±0.3	0.135
1.0 unit+K_2SO_4 700ppm	2.9±0.3	0.077
1.0 unit+K_2SO_4 1400ppm	3.6±0.3	0.103

z : Changes of EC values during culture period.

Mg at the concentration of 16,1.3,4,8,8 and 4 meq per litter, respectively. In this experiment control was 2.0 units, and KCl (600 or 1200 ppm) or K_2SO_4 (700 or 1400 ppm) were supplied to the standerd solution. The treatments, electrical conductivity (EC) during culture period and osmotic pressure (by Jones's expression[7]) were shown in Table 1. Treatments were carried out from the beginnig of flowering period of the first flower truss to the end of harvest in the second truss. In 1.0 unit+KCl 600 ppm and 1.0 unit+K_2SO_4 700 ppm, potassium level was equivalent to control (2.0 units). In 1.0 unit+KCl 1200 ppm and 1.0 unit+K_2SO_4 1400 ppm, potassium level was 1.5 times of control. The EC of solution was adjusted to original level by water supplement twice a week and the solutions were totally renewed every other week. pH of solutions were adjusted between 5 and 6.5 by addition of either 4 N sulphuric acid or 4 N potsaaium hydroxide.

During flowering time 15 ppm PCPA (p-chlorophenoxyacetic acid) was sprayed twice a week in order to promote fruit set and growth.

The following fruit quality of cherry tomato were checked: the soluble solids content (%, refractometer reading), total sugar content (%, Somogyi-Nelson method), titratable acidity (%, as citric acid by 1/10 N NaOH), solid-acid ratio, fruit weight, percent of dry matter (dried at 80±5°C for 48 hours) and hardness (penetrating stress), which was apparent hardness of fruit skin attached to fruit flesh. Yields and fruit number were investegated. On plant growth, leaf length (leaf just under first-flower truss), leaf width (leaf just under first-flower truss), stem diameter (stem under first leaf), shoot and root fresh weight and their dry weight (dried at 80±5°C for 48 hours) were checked.

Results and Discussion

The fruit quality was shown in Table 2. The soluble solids content was clearly increased by supplying KCl to nutrient solution in three cultivars. Especially in 1.0 unit+KCl 1200 ppm, their content was the highest of all treatments. The degree of increse in the soluble solids content was higher in 'Sun Cherry' than in 'Sugar Lump' and 'Akakokko'. In K_2SO_4 treatment, the soluble solids content did not change

Table 2. Effect of potassium chloride and potassium sulphate supplement to nutrient solution on fruit quality of cherry tomato.

Cultivar	Treatment	Brix	Total sugar (Fruit weight. %)	Titratable acidity (As citric acid, fruit weight. %)	Solid-acid ratio	Weight (g)	percent of dry matter (%)
'Sugar Lump'	2.0 units (Control)	7.0a[z]	4.8b	0.48a	14.5c	22.8b	6.9
	1.0 unit+KCl 600ppm	7.1a	4.1a	0.53b	13.4b	24.0bc	7.6
	1.0 unit+KCl 1200ppm	8.4b	6.0c	0.60c	14.1c	19.9a	9.2
	1.0 unit+K_2SO_4 700ppm	6.9a	4.6ab	0.55b	12.7a	28.2d	6.5
	1.0 unit+K_2SO_4 1400ppm	7.4ab	5.0b	0.58c	13.0a	25.3c	6.8
'Sun Cherry'	2.0 units (Control)	8.5ab	5.5ab	0.53a	16.0b	13.2b	7.5
	1.0 unit+KCl 600ppm	8.9b	5.3a	0.60b	14.8a	12.4b	10.2
	1.0 unit+KCl 1200ppm	10.8c	6.7c	0.68c	15.9b	9.5a	10.5
	1.0 unit+K_2SO_4 700ppm	8.3a	5.4a	0.47a	17.8c	15.5c	7.3
	1.0 unit+K_2SO_4 1400ppm	8.6ab	5.6b	0.50a	17.3c	12.5b	7.4
'Akakokko'	2.0 units (Control)	10.4b	5.7b	0.57b	18.0b	11.4b	8.9
	1.0 unit+KCl 600ppm	10.1ab	5.1a	0.59c	17.1a	11.0b	9.3
	1.0 unit+KCl 1200ppm	10.8c	7.0c	0.61c	17.7b	8.5a	10.3
	1.0 unit+K_2SO_4 700ppm	10.0a	5.3a	0.51a	19.5c	12.2c	8.8
	1.0 unit+K_2SO_4 1400ppm	10.1ab	5.9b	0.55b	18.7c	11.6bc	8.8

z: Different letters in colums of the same cultivar indicate significant differences by Duncan's New multiple range test, 5% level.

compared with control (2.0 units) in three cultivars. The results of total sugar content were similar to those of the soluble solids content.

The titratable acidity increased clearly in KCl treatment in three cultivars. In 'Sugar Lump' the titratable acidity became higher in K_2SO_4 treatment than in control. However, in 'Sun Cherry' and 'Akakokko' the titratable acidity in K_2SO_4 treatment

Table 3. Effect of potassium chloride and potassium sulphate supplement to nutrient solution on yield and fruit number of cherry tomato.

Cultivar	Treatment	Yield (g/plant)	Fruit number (fruit/plant)
'Sugar Lump'	2.0 units (Control)	796	33.5
	1.0 unit+KCl 600ppm	642	25.0
	1.0 unit+KCl 1200ppm	545	26.8
	1.0 unit+K_2SO_4 700ppm	760	29.0
	1.0 unit+K_2SO_4 1400ppm	728	28.5
'Sun Cherry'	2.0 units (Control)	569	38.3
	1.0 unit+KCl 600ppm	519	44.5
	1.0 unit+KCl 1200ppm	365	39.0
	1.0 unit+K_2SO_4 700ppm	637	37.8
	1.0 unit+K_2SO_4 1400ppm	497	37.0
'Akakokko'	2.0 units (Control)	742	73.5
	1.0 unit+KCl 600ppm	816	77.8
	1.0 unit+KCl 1200ppm	469	53.8
	1.0 unit+K_2SO_4 700ppm	906	96.8
	1.0 unit+K_2SO_4 1400ppm	579	55.7

Table 4. Effect of potassium chloride and potassium sulphate supplement to nutrient solution on growth and development of cherry tomato.

Cultivar	Treatment	Leaf length[z] (cm)	Leaf width[z] (cm)	stem diameter[y] (mm)	Fresh weight		Dry weight		Leaf area (cm^2)
					shoot (g)	root (g)	shoot (g)	root (g)	
'Sugar Lump'	2.0 units (Control)	40.4cd[x]	52.9b	14.3	921	98	114	24	10460
	1.0 unit+KCl 600ppm	34.9ab	29.6a	15.2	634	82	62	20	8027
	1.0 unit+KCl 1200ppm	31.8a	28.4a	15.2	587	84	57	16	6525
	1.0 unit+K_2SO_4 700ppm	44.0d	51.4b	15.0	907	110	108	24	9257
	1.0 unit+K_2SO_4 1400ppm	36.3bc	43.6b	15.7	893	110	118	28	9374
				(n. s.)					
'Sun Cherry'	2.0 units (Control)	40.5c	39.9bc	13.1	619	150	104	22	8566
	1.0 unit+KCl 600ppm	32.2ab	26.0a	12.8	542	138	73	21	6513
	1.0 unit+KCl 1200ppm	28.9a	23.3a	12.9	440	93	51	14	5427
	1.0 unit+K_2SO_4 700ppm	44.7d	45.2c	13.1	865	156	129	24	10039
	1.0 unit+K_2SO_4 1400ppm	35.2bc	31.1b	13.5	663	102	78	18	7730
				(n. s.)					
'Akakokko'	2.0 units (Control)	44.5c	46.7b	13.0	724	141	107	20	9340
	1.0 unit+KCl 600ppm	38.4ab	28.0a	13.8	513	135	79	21	7720
	1.0 un}i+KCl 1200ppm	35.0a	28.2a	13.5	436	109	72	15	6031
	1.0 unit+K_2SO_4 700ppm	46.2c	45.4b	13.9	882	166	118	23	12798
	1.0 unit+K_2SO_4 1400ppm	39.3bc	43.2b	14.3	745	155	102	24	9809
				(n. s.)					

z : Leaf just under first truss.
y : Stem diameter under first leaf.
x : Different letters in colums of the same cultivar indicate significant differences by Duncan's New multiple range test, 5% level.

was equal to control. Therefore, in 'Sun Cherry' and 'Akakokko' solid-acid ratio was a little higher in K_2SO_4 treatment than in KCl treatment, but in 'Sugar Lump' this result was reverse.

Percent of dry matter became higher in KCl treatment, whereas it was equal to control in K_2SO_4 treatment in all the cultivars.

It was shown that fruit weight decreased remarkably in KCl treatment in three cultivars, whereas in K_2SO_4 treatment it was equal or greater compared with control.

On fruit hardness, no significance was recognized in these treatments (data not shown), although penetrating stress tended to increase in KCl and K_2SO_4 treatment compared to control. On deformation and penetrating energy, there was no significance in these treatments.

Yields and fruit numbers in this experiment were shown in Table 3. Although a certain trend was not recognized on fruit numbers in these treatments, it was' shown that yields in KCl treatment tended to decrease as decreasing fruit weight in all the cultivars. On the other hand, in K_2SO_4 treatment, such a trend was not recognized on yields.

The growth of cherry tomato plant in this experiment was shown in Table 4. The leaf length, leaf width, fresh weight, dry matter weight and leaf aera in KCl treatment decreased compared with control. Whereas, those of K_2SO_4 treatment was equal to or increased compared with control. About stem diameter there was no difference between these treatment.

The same results as previous paper[1] were obtained on the effect of KCl supplement on improvement of fruit quality. However, supplement of K_2SO_4 to nutrient solution induced some different results on fruit quality in this experiment. Furthermore, taking the results of both yield and plant growth into consideration, it is probable that these results were due to the difference between chloride ion and sulphate ion and due to the difference between osmotic pressures. Osawa[8] reported that in some vegetables the plant growth was influenced especially by the difference between osmotic pressures. In this experiment osmotic pressure in KCl treatment was higher than that in K_2SO_4 treatment. And osmotic pressure in 1.0 unit+KCl 1200 ppm treatment was equal to that in control (2.0 units). In spite of low osmotic pressure compared with control, fruit quality in K_2SO_4 treatment was equal to that in control and solid-acid ratio in K_2SO_4 treatment was higher than that in control (2.0 units). It is recognized that K_2SO_4 supplement to the standard solution is more desireble than KCl supplement for improving fruit quality without decreasing yield.

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摘　要

水耕ミニトマトにおいて培養液に塩化カリウム及び硫酸カリウムを添加し，果実品質，収量及び生育について検討した．

1. 1.0単位（園試処方標準濃度）に塩化カリウム 1200 ppm を添加した場合，供試した3品種いずれも，果実の糖度，全糖含量，滴定酸度及び乾物率は著しく上昇した．しかしながら，3品種いずれも果実重は減少した．一方，硫酸カリウムを添加した場合，果実の糖度，全糖含量，滴定酸度及び乾物率は塩化カリウム添加区程上昇しなかった．果実重はやや増加する傾向にあった．‘サンチェリー’及び‘アカコッコ’における糖酸比は硫酸カリウムの添加により，対照区（2.0単位）に比べ高くなったが，塩化カリウムの添加により低下した．また，果実の硬さは処理による差がみられなかった．
2. 収量は3品種いずれも塩化カリウム添加によって減少傾向を示した．
3. 葉長，葉幅，新鮮重，乾物重及び葉面積は3品種いずれも塩化カリウム添加によって減少した．硫酸カリウム添加によって同等あるいは増加傾向を示した．しかしながら，茎径はいずれの添加処理によっても変わらなかった．
4. 以上の結果，培養液（1.0単位）に塩化カリウムを添加した場合，収量は低下するものの2.0単位以上の品質の果実が得られた．一方，硫酸カリウムを添加した場合，収量の低下は少なく2.0単位と同等の品質の果実が得られた．