Effects of CPPU on Quality and Postharvest Life of Kiwifruit

T. Cooper and L. González
Universidad de Chile
Facultad de Ciencias Agronómicas
Santiago
Chile

J. Retamales
Valent BioSciences Corporation
Las Condes, Santiago
Chile

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Abstract

Since several years it's common practice to apply CPPU (synthetic cytokinin) in kiwifruit to obtain increased fruit size. However, conflicting results have been reported regarding fruit behaviour during postharvest life. Since softening represents a key limiting factor in quality and storage of kiwifruit, it is relevant to obtain information regarding behaviour of CPPU-treated kiwifruit both at harvest and during postharvest life under normal management conditions. Thus, trials were carried out during two seasons in Central Chile, with CPPU being applied in two different orchards in each season and with fruit being stored both under normal air (first season) and CA (second season) conditions. In the first year (2005/2006), CPPU was applied once at either 5 or 10 mg·L^{-1} and at 2 and 4 weeks after full bloom, while in the second year (2006/2007) CPPU was used only at one date, 4 weeks after bloom, in both concentrations. In the first year, CPPU application resulted in markedly increased fruit growth, shifting the fruit to bigger size categories, while not adversely affecting fruit quality at harvest, with the exception of somewhat reduced dry matter content. Further on during postharvest life, CPPU not only did not result in increased softening, but in some cases it actually reduced it, while it did not cause differences in any of the other quality parameters, with the exception of somewhat reduced final soluble solids in some cases, in general accordance with reduced dry matter content. In the second year similar results were obtained following CPPU applications in terms of fruit growth and quality at harvest. Analogously, no deleterious effects derived from CPPU applications on softening and further quality parameters following postharvest CA conditions were determined, although at harvest time some reduction in fruit dry matter could be found.

INTRODUCTION

The synthetic cytokinin CPPU has already been applied for some years to increase fruit growth in kiwifruit. Despite its regular usage, it is still not clear whether CPPU can result in limitations for postharvest life, particularly regarding the aspect of fruit softening (Iwahori et al., 1988; Antognozzi et al., 1993; Patterson et al., 1993). Since softening represents the key limiting factor in prolonged storage of kiwifruit (Cooper et al., 2007), it is relevant to obtain detailed information regarding the behaviour of CPPU-treated kiwifruit during postharvest life. Therefore, the objective of this research was to evaluate the effects of CPPU on quality and postharvest behaviour of kiwifruit.

MATERIALS AND METHODS

Trials were carried out during two seasons 2005/2006 and 2006/2007 in two kiwifruit orchards (variety 'Hayward') located in the Central Zone of Chile. CPPU (N-(2-chloro-4pyril)-N'-phenylurea) was used as spray application of a commercial product (Caplit WP 1% active ingredient). In the 2005/2006 season trials were composed by 5 treatments including two application dates (2 and 4 weeks after full bloom [WAFB]) and two CPPU concentrations (5 and 10 mg·L^{-1}) plus control treatment without application. In the 2006/2007 season trials were composed by 3 treatments considering only one application date (4 WAFB) and two CPPU concentrations (5 and 10 mg·L^{-1}) plus control

treatment without application. There were four replicates per treatment every year, with one entire plant constituting each replicate. In both seasons fruit were cured prior to storage by keeping them at ambient temperature for 48 hours. In the first season fruit were stored under normal air conditions at 0°C and 95% RH and fruit samples were taken every 15 days to determine flesh firmness and soluble solids (SS) content. In the second season fruit were stored in a controlled atmosphere (CA) chamber for approximately 4 months and thereafter kept at 0°C and 95% RH under normal air conditions. At the end of CA storage and after 30 days of post storage in normal air, samples were taken to determine firmness and soluble solids (SS) content. In both cases kiwifruit were picked when reaching a maturity degree of at least 6.5° Brix as harvest criterion. Fruit size distribution per plant was determined and one box of small (< 100 g), medium (100-120 g) and large (> 120 g) size fruit per replication were taken for storage. For statistical analysis, ANOVA at 0.05 and mean separation by multiple range tests were used. With the aid of the data obtained from storage evaluations, the period (days) elapsed when fruit reach a firmness of 18 N (T18N) was calculated by logarithmic regression.

RESULTS AND DISCUSSION

Regarding fruit size distribution, in both orchards a clear shift of the fruits to higher size categories was evident (Table 1). Moreover, in both years and for both orchards CPPU application resulted in increased fruit size, as expressed by mean fruit weight, compared to non-treated controls, being particularly significantly when 10 $mg \cdot L^{-1}$ CPPU at 4 WAFB were applied (Table 2). Although increased fruit weight is important, it is also relevant that this additional fruit growth in kiwifruit should not occur at the expense of altering fruit shape. Measurements of the ratio of fruit length to diameter showed only a slight, non significant increase in CPPU treated fruit (data not shown). Referring to fruit firmness at harvest no differences were visible in the first season, however in the second season fruit from control treatment in general showed higher firmness (Table 1). There were significant, although moderate, reductions in dry matter content at harvest in CPPU-treated fruit in both years. Consequently, no major reductions in final soluble solids were evident in the first year with only significant difference between the control and the 10 $mg \cdot L^{-1}$ CPPU application at 4 WAFB. In the second year, however, differences in final soluble solids could be demonstrated for control fruit as compared with both CPPU treatments, although not proportional to the major increases in fruit growth caused by CPPU (Table 1). Anyway, this finding can be relevant for orchards known to produce fruit with rather low soluble solids, since this is an important criterion in terms of fruit quality and consumer acceptance of kiwifruit.

Referring to the effect of the CPPU treatment on the firmness retention of the fruit under cold storage, it should be considered, as also confirmed by these trials, that in kiwifruit smaller fruit tend to show increased softening. Taking this into consideration, and from the data shown in Tables 3 and 4, it can be concluded that enlarged fruit due to CPPU treatment does not lead to increased softening during postharvest as compared to non-treated fruit, but rather on the contrary. As a matter of fact, when softening of the fruit was calculated in the first season as the number of days to be elapsed until reaching 18 N firmness (this being considered as the threshold for the fruit to be able to be exported/commercialized), it could be deduced that by applying CPPU, instead of inducing softening, such fruit, particularly those belonging to the larger size categories, could be stored for a more prolonged period as compared to non-treated fruit (in some cases being statistically significant).

In the second year, following CA storage, in fruit from Quinta de Tilcoco orchard a trend to higher fruit firmness after CPPU-application could be shown, although this was only significant for small fruit size category right after CA, and for both small and large sized fruit after 30 days of extended storage under normal air conditions (Table 4). In the Rudnick orchard no significant differences were available at this stage (data not shown). Further, no deleterious effects could be determined in additional parameters as a consequence of CPPU application on kiwifruit (data not shown). Thus, the final acceptability

score used for ranking of kiwifruit and ranging from 1 (free of problems) to 4 (severe incidence of problems), did not show any differences between treatments.

CONCLUSIONS

CPPU increased the mean fruit size by reducing the percentage of smaller fruits and increasing the percentage of larger fruit. At harvest, fruit quality was not affected by CPPU, with the exception of some reduction in firmness and in percentage of dry matter. Fruit softening in postharvest was not adversely affected by CPPU and, on the contrary, in some cases softening rate even significantly decreased.

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Tables

Table 1. Quality parameters at harvest time of large size fruit, final soluble solids and % large fruit. Quinta de Tilcoco orchard.

Treatment	2005/2006				
	SS[w] (at-harvest) °Brix	Firmness at harvest (N)	Dry matter[x] (%)	FSS[x] °Brix	Large fruit (%)
Control	7.1 a[y]	83.5 b	17.2 b	14.5 b	30.4 a
5 mg·L^{-1} 2 WAFB[z]	6.8 a	90.2 c	15.2 a	14.1 ab	32.9 ab
5 mg·L^{-1} 4 WAFB	6.7 a	79.9 ab	14.5 a	13.8 ab	45.3 ab
10 mg·L^{-1} 2 WAFB	6.6 a	89.8c	15.1 a	14.1 ab	36.7 ab
10 mg·L^{-1} 4 WAFB	6.6 a	76.7 a	14.8 a	13.5 a	49.8 b

Treatment	2006/2007				
	SS[w] °Brix	Firmness at harvest (N)	Dry matter (%)	FSS[x] °Brix	Large fruit (%)
Control	6.6 a	75.8 b	16.1 b	13.5 b	12.2 a
5 mg·L^{-1} 2 WAFB[z]	-	-	-	-	-
5 mg·L^{-1} 4 WAFB	6.3 a	67.3 a	14.6 a	11.9 a	25.5 ab
10 mg·L^{-1} 2 WAFB	-	-	-	-	-
10 mg·L^{-1} 4 WAFB	6.2 a	67.3 a	14.8 a	12.2 a	32.5 b

[w] SS: Soluble solids (at harvest).
[x] FSS: Final soluble solids.
[y] Different letter means significant differences (α= 0,05).
[Z] WAFB: Weeks after full bloom.

Table 2. Mean fruit weight per treatment in both orchards, 2005/2006 and 2006/2007.

Treatment	2005/2006		2006/2007	
	Quinta de Tilcoco (g)	Teno (g)	Quinta de Tilcoco (g)	Rudnick (g)
Control	105.4 a[y]	96.2 a	101.8 a	88.5 a
5 mg·L^{-1} 2 WAFB[z]	112.2 a	117.3 b	-	-
5 mg·L^{-1} 4 WAFB	115.1 ab	113.5 b	113.9 ab	117.8 b
10 mg·L^{-1} 2 WAFB	112.9 ab	107.3 ab	-	-
10 mg·L^{-1} 4 WAFB	124.7 b	117.4 b	128.3 b	112.0 b

[y] Different letter means significant differences (α= 0,05).
[Z] WAFB: Weeks after full bloom.

Table 3. Days calculated by logarithmic regression to be elapsed until fruit of three size categories reach 18 N firmness, (Quinta de Tilcoco and Teno orchard, season 2005/2006).

Treatment	Quinta de Tilcoco			Teno		
	Small	Midsize	Large	Small	Midsize	Large
Control	108.3 a[y]	114.3 ab	115.7 a	100.3 a	99.8 a	102.3 a
5 mg·L^{-1} 2 WAFB[z]	107.3 a	112.5 ab	111.1 a	101.9 a	104.0 ab	106.0 a
5 mg·L^{-1} 4 WAFB	104.5 a	107.3 a	113.4 a	99.2 a	100.6 a	106.1 a
10 mg·L^{-1} 2 WAFB	102.9 a	109.8 ab	118.7 a	108.0 a	110.2 b	107.9 a
10 mg·L^{-1} 4 WAFB	109.7 a	126.7 b	131.6 b	97.6 a	101.2 ab	106.7 a

[y] Different letter means significant differences (α= 0,05).
[z] WAFB: Weeks after full bloom.

Table 4. Fruit firmness (in N) after CA storage and CA plus 30 days cold storage under normal air for three fruit size categories (Quinta de Tilcoco orchard, season 2006/2007).

Treatment	After CA storage			CA + 30 days cold storage in air		
	Small	Midsize	Large	Small	Midsize	Large
Control	28.7 a[y]	34.1 a	44.9 a	20.2 a	22.9 a	26.0 a
5 mg·L^{-1} 4 WAFB[z]	38.1 ab	46.2 a	51.2 a	28.7 b	31.9 a	38.1 b
10 mg·L^{-1} 4 WAFB	42.6 b	46.7 a	49.4 a	35.0 b	34.1 a	37.3 b

[y] Different letter means significant differences (α= 0,05).
[z] WAFB: Weeks after full bloom.