Paclobutrazol Can Reduce the Negative Effects of Salinity on Reproductive Growth, Yield and Fruit Quality of Strawberry Plant

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Abstract

Strawberry plants (*Fragaria* × *ananassa* Duch.) are very susceptible to salinity. In order to investigate the interactive effects of paclobutrazol (PP_{333}) and salinity on flowering, yield and fruit quality of strawberry plants, three levels of NaCl [0, 5, 10 mM] were incorporated into the nutrient solution and four levels of PP_{333} [0, 10, 20, 30 mg/L] were sprayed on the plants. PP_{333} application caused reduction in inflorescence length, but increased inflorescence and flower number. Salinity reduced number of achenes per fruit. However a foliar application of 10 mg/L of PP_{333} reduced the effect of salinity at 10 mM NaCl salinity and significantly increased the number of achenes per fruit. PP_{333} at 30 mg/L completely overcame any negative effects of 10 mM NaCl salinity on fruit yield while increasing fruit total soluble solids (TSS). The highest level of PP_{333} (30 mg/L) resulted in reduced titratable acidity (TA) on salt-treated (5, 10 mM) plants. The ratio of TSS/TA tended to increase with increased application rates of PP_{333}. Salinity resulted in reduced vitamin C, but applications of 20 mg/L of PP_{333} significantly increased vitamin C in both levels of salinity (5, 10 mM).

INTRODUCTION

Strawberry is an important crop and its cultivation is expanding in open field and greenhouse in Iran. However, saline soil and irrigation water threaten the production of this crop as strawberry is quite sensitive to salinity (Awang et al., 1993) and decreased strawberry fruit quality has been reported by Saied et al. (2005). Since flowering is an important step in crop production and in this stage salinity has a deleterious effect on fruit production, researchers have attempted to find a solution to this problem (Eshghi and Tafazoli, 2006). The most common practice is to increase leaching, however this method is often expensive and impractical. Few studies have focused on application of growth regulators to induce tolerance. There is a report that PP_{333} promoted salt stress tolerance in peach (*Prunus persica* L.) (Abou El-Khashab et al., 1997). These results suggest that using growth regulators such as triazoles may be an effective way of improving plant stress tolerance. The aim of this study was to determine the effect of PP_{333} on reproductive growth, fruit quality and yield of salt stressed strawberry plants under salinity in hydroponic systems.

MATERIALS AND METHODS

Cold stored runner strawberry plants (*Fragaria* × *ananassa* Duch.) of 'Selva' cultivar were planted in 2 L containers filled with a mixture of perlite and peatmoss. Plants were fed continuously from the start of the experiment with nutrient solution (Melspray). Sodium chloride (NaCl) was incorporated into the nutrient solution. Three levels of NaCl [0, 5, 10 mM] and four levels of PP_{333} [0, 10, 20, 30 mg/L] were imposed at the beginning of the experiment. A hand sprayer was used to apply PP_{333} to the point of runoff. The design of the experiment was a complete randomized with twelve treatments and five replications.

Inflorescence length, inflorescence number, flower number, number of achenes per fruit and fruit yield were measured and counted. TSS (refractometry), TA (titrasion), TSS/TA and Vitamin C (oxidation/reduction procedure) was determined. Data were analyzed using MSTATC software and means were compared by Duncan 's test.

RESULTS AND DISCUSSION

Application of PP_{333} caused reduction in inflorescence length, and interaction of the highest levels of PP_{333} and salinity significantly reduced inflorescence length (Table 1). Salinity had no effect on inflorescence number but PP_{333} application significantly increased the number of inflorescences (Table 1), as reported in a previous study (Fletcher et al., 2000). Maximum flower number resulted from the interaction of 10 mM NaCl and 10 mg/L of PP_{333} (Table 1). Salinity resulted in reduced numbers of achenes per fruit, but application of PP_{333} at 10 mg/L along with 0 mM NaCl salinity resulted in significant increases in the number of achenes per fruit (Table 1). In greenhouse-grown 'Shuksan' and 'Totem' strawberry, applications of PP_{333} resulted in a greater number of achenes per fruit (Fletcher et al., 2000). Salinity reduced yield, however 20 and 30 mg/L of PP_{333} negated diverse effects of 5 mM NaCl, while application of 30 mg/L of PP_{333} suppressed yield reductions resulting from 10 mM NaCl (Table 1). Similarly it has been reported that increased salinity had a negative impact on strawberry fresh fruit yield (Ondrasek et al., 2006), while Kirschbaurn (1998) reported that application of PP_{333} increased total yield. Salinity had no effect on TSS, whereas PP_{333} caused an increase in TSS. Interaction of PP_{333} and salinity showed that highest level of PP_{333} (30 mg/L) resulted in increased TSS in salt treated (5 and 10 mM) plants (Table 1). It has been reported that fruits from a processing tomato cultivar exposed to various levels of salinity had greater TSS content (Mizrahi and Pasternak, 1985). Nazarpour (2005) indicated that PP_{333} application resulted in increased TSS in the 'Camarosa' cultivar of strawberry. Application of the highest level of PP_{333} (30 mg/L) resulted in a significant decrease in TA for salt-treated plants (5 and 10 mM) (Table 1). Increased TA has been reported in a processing tomato cultivar in saline conditions (Mizrahi and Pasternak, 1985). As indicated by Keutgen and Keutgen (2003) TA was decreased by salinity in the 'Elsanta' cultivar of strawberry. Organoleptic (taste) quality of strawberries depends strongly on the TSS/TA ratio. This ratio tended to rise with application of 30 mg/L of PP_{333} in salt treated (5 and 10 mM) plants (Table 1). Increased fruit quality (as indicated by TSS/TA ratio) due to salinity has been reported by Awang et al. (1993) but Saied et al. (2005) indicated that this ratio decreased significantly with increasing salinity in the cultivars 'Elsanta' and 'Korona' of strawberry. Teferi Belayneh (2005) observed that the TSS/TA ratio in mango fruits increased as a result of PP_{333} application. Salinity resulted in reduced vitamin C, however application of 20 mg/L of PP_{333} resulted in significant increases in vitamin C in both levels of salinity (5 and 10 mM) (Table 1). It has been shown that concentration of vitamin C was not significantly affected by NaCl salinity in both 'Elsanta' and 'Korona' cultivar of strawberry (Keutgen and Keutgen, 2003).

It is possible that the application of PP_{333} caused an early reduction of endogenous gibberellins levels within the shoots, causing them to reach maturity earlier. Flowering is normally associated with reduced vegetative growth, often induced by lower activity of gibberellins (Tehranifar, 1998). Therefore assimilates normally expended for vegetative growth were diverted to flowering. This was demonstrated by a higher level of total non-structural carbohydrate in shoots prior to flowering (Teferi Belayneh, 2005).

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Tables

Table 1. The effect of NaCl and PP_{333} treatments on different traits of strawberry plants.

PP_{333} (mg/L)	Salinity (mM)	Inflorescence length (cm)	Inflorescence No.	Flower No.	Fruit achene No.	Fruit yield(g)	Fruit TSS(%)	Fruit TA(%)	Fruit TSS/TA	Fruit vitamin C
	0	14.22 bc*	5.2 c	16.2 d	270.2 b	57.71 de	7.0 f	0.34 c	20.10 c	26.25 i
0	5	15.64 a	5.2 c	13.20 e	141.0 g	54.84 e	7.62 ef	0.44 b	17.28 cd	33.0 ghi
	10	15.0 ab	5.4 bc	11.20 f	99.80 h	44.47 f	7.87 def	0.46 b	17.01 cd	29.25 d
	0	14.40 ab	6.2 abc	22.40 b	309.2 a	166.1 a	8.12 def	0.46 b	17.38 cd	50.25 bcd
10	5	13.60 c	6.8 ab	9.60 g	164.4 g	65.89 d	8.27 de	0.45 b	18.65 cd	49.25 bcde
	10	11.36 d	6.8 ab	24.0 a	208.8 cde	58.49 de	7.87 def	0.47 b	16.53 cd	46.0 cdef
	0	11.20 d	6.6 abc	18.20 c	231.8 c	119.3 c	9.0 bed	0.54 a	16.69 cd	75.0 a
20	5	10.70 d	7.0 a	21.60 b	190.4 def	94.49 c	8.62 cde	0.54 a	15.91 d	58.0 b
	10	10.0 d	7.2 a	21.20 b	164.6 fg	67.33 d	8.12 def	0.44 b	18.34 cd	53.25 bc
	0	11.20 d	7.0 a	18.20 c	222.4 cd	94.30 c	10.63 a	0.35 c	30.41 a	43.0 def
30	5	10.90 d	7.6 a	21.0 b	89.8 h	85.08 c	9.87 ab	0.35 c	28.23 ab	39.75 efg
	10	8.52 e	6.2 abc	20.80 b	172.4 efg	85.86 c	9.50 bc	0.36 c	26.39 b	37.0 fgh

*Means with the same letter in each column are not significantly different at 5% level of probability using DMRT.