Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 2 (11) October 2013: 15-18

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com

ORIGINAL ARTICLE

Response of Cucumber Plants to Foliar Application of Calcium Chloride and Paclobutrazol under Greenhouse Conditions

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ABSTRACT
In order to study the effect of calcium chloride and paclobutrazol foliar application on growth, yield and yield components of cucumber plants as a completely randomized experimental design with six replications. These factors included paclobutrazol in 3 levels (2.5, 5 and 10 mg/ L) and calcium chloride in 2 levels (7.5 and 15 mM) spray on cucumber. Results indicated that paclobutrazol reduced vegetative growth by reducing both plant height and dry weights while simultaneously some such fruit length, fruit diameter, fruit weight and yield were increased. Paclobutrazol combined with potassium nitrate (10 mg/ L paclobutrazol +7.5 mM calcium chloride) had positive effects on fruit quality. Calcium chloride alone had effect on photosynthetic pigments and minerals. In conclusion, application of calcium chloride and paclobutrazol in low concentration improved the yield contributing factors that resulted in significant increase in cucumber fruit yield.
Keywords: *Calcium chloride, Paclobutrazol, Yield, growth*

Received 10/08/2013 Accepted 17/09/2013

INTRODUCTION

Cucumber plant (*Cucumis sativus* L.) is one of the important vegetable crops in Iran. The fruits are highly nutritive and have very high water content and very low calories. The fruit is used as a vegetable or salad. It is rich in minerals, thiamine, niacin and vitamin C. Paclobutrazol is a triazol that reduces vegetative growth in most plant species. Paclobutrazol not only controls growth, but also influences cropping and fruit characteristics [1]. PBZ role as anti-gibberellin is considered sufficient for the induction of higher yield and for improvement of the quality. The reduction in vegetative growth by altering relative sink strengths within the plant had an indirect consequence of allowing a greater partition of the assimilates to reproductive growth, to flower bud formation, fruit formation and fruit growth. PBZ increased achenes per fruit of strawberry but decreased yield [2]. Nazarpour [3] indicated that PBZ application resulted in increased TSS in the 'Camarosa' cultivar of strawberry. It has also been reported that PBZ treatment significantly increases tuber fresh mass of potato, dry matter content, and specific gravity, regardless of the method of application (spraying or drenching) [4]. Calcium ions perform multiple roles in plant cell physiology. They are important intracellular messengers, mediating responses to hormones, biotic and abiotic stress signals and a variety of developmental processes [5]. Calcium plays an important role in plant growth and in many physiological activities of bulbous flowers [6]. Direct application of calcium to the fruit is the most effective method for increasing fruit calcium content [7]. It is well known that calcium have an important role in maintaining quality of fruits and vegetable. Calcium treatment helps to retain fruit firmness and increase vitamin C content [8].

MATERIALS AND METHODS

A filed experiment was conducted at main agricultural research station, Ilam during summer (2013-2014) with an objective to find out the effect of paclobutrazol in 3 levels (10, 15 and 20 mg/ L) and calcium chloride in 2 levels (7.5 and 15 mM) on growth, physiological parameters, yield and quality in cucumber (*Cucumis sativus* L.) cv. Mostar. All foliar spraying was carried out early in the morning. Plant height was determined for 5 plants in the middle row in each treatment after the first picking. For this purpose, the plant height from the soil line to the top was determined with a measuring tape and averaged to represent corresponding treatments. Total nitrogen of the sample was determined by Kjeldahl method [9]. For determination of K contents of leaf, plant samples were air-dried and were then

ground. K was determined after dry digestion of dry and sub-samples in a HCL preparation. Potassium was determined by flame photometry. The total yield for each treatment was calculated by weighing the fruit picked in each treatment and converting the weight to yield (kg/plant). The average fruit weight was estimated by weighing 10 fruits in each treatment, with the help of an electronic balance measuring in grams to the third decimal place, and then converting to average fruit weight. Total soluble solids were determined on a portable refractometer 300003 (Sper Scientific Ltd., Scottsdale, Ariz.) standardized with distilled water. Photosynthetic pigments chlorophyll was determined using chlorophyll meter (SPAD-502, Minolta Co. Japan), which is presented by SPAD value. Average of 3 measurements from different spots of a single leave was considered. The experimental design was a complete randomized blocks with four replications for each treatment.. Data were analyzed by SPSS 16 software and and comparing averages was done by Duncan's test and a probability value of %5

RESULTS AND DISCUSSION

Vegetative Growth, Chlorophyll and mineral elements

The growth parameters of cucumber plants (number of leaf, plant height and dry weight) were significantly increased by foliar applications with calcium chloride (Table 1). The maximum stimulatory effect existed in plants treated with 7.5 mM calcium chloride as foliar application. Application of PBZ alone significantly influenced plant height and dry weight (Table 1). Application of higher concentrations of PBZ (10 mg/L) reduced plant height (75.21 cm) and dry weight (2.54 g) as compared to control (Table 1). It is evident that increase in PBZ concentration (from 2.5 and 5 to 10 mg/L) reduced plant height and dry weight (Table 1). Ca alone significantly affected chlorophyll content and leaf-NK content (Table 1). The highest chlorophyll content (23.16 SPAD), N (3.14 %) and K (3.4 %) were obtained at 7.5 mM Ca. PBZ had no significant effect on leaf-NK content. PBZ application significantly increased chlorophyll content when accompanied by K treatment (Table 1). Our results showed that lower concentrations of PBZ must be used together with low Ca concentrations (Table 1). Smolen and Sady [10] reported that Ca application caused an increase in the concentration of N-total in storage roots in comparison with control plants. Similar results were obtained in our research so that total NK in fruits increased when sprayed with higher level of Ca. These results are in agreement with those obtained by Del-Amor and Marcelis [11]. They reported Ca significantly increased mineral -nutrients uptake. The results found are in agreement with the findings of Yaseen *et al*., [12] and Kashif *et al*., [13] who observed that application of Ca improved growth parameters. Paclobutrazol, a powerful growth retardant, has been observed to reduce vegetative growth [14]. This was in agreement with Nishizawa [15] who reported a significant decrease in vegetative characteristics (number of branches and leaf, total leaf area, chlorophyll content and dry weight of leaf per plant) of strawberry after paclobutrazol treatment. Vegetative growth components were reduced after annually application of paclobutrazol in apples [16].

Mean fruit weight, fruit length, fruit diameter per plant and Yield

PBZ application significantly increased fruit diameter and yield when accompanied by Ca treatment (Table 1). PBZ and Ca combination had significant effect on mean fruit weight, fruit length. The highest fruit diameter (3.31) and yield per plant (6) observed when 2.5 mg/L PBZ and 7.5 mM Ca were used together (Table 1). Increase in PBZ and Ca concentration significantly reduced mean fruit weight and fruit length. Our results were in agreement with that of Muromtsev *et al*., [17] who observed that, application of Ca can significantly increased the reproductive growth and yield. Application of Calcium carbide also stimulates root growth and early onset of flowering in agronomic and vegetable crops [12-13]. Our results is supported by the finding of Hao and Papadopoulos [18] who reported that Ca sprays increased fruit yield and reproductive growth of tomato. These results was in agreed with Tegopati *et al.,* [19] that observed PBZ application increased reproductive growth and yield. In greenhouse-grown 'Shuksan' and 'Totem' strawberry, applications of PBZ resulted in a greater number of achenes per fruit [20]. Kirschbaurn [21] reported that application of PBZ increased total yield. Martinez *et al.,* [22] indicated the number of inflorescences increased when paclobutrazol applied;also the number of flowering plants increased by 50% compared with control group. The high yield of crops with paclobutrazol application has also been reported by previous researchers; Tandel and Patel [23] noticed PBZ application will increase the number of fruits and total production per tree for Alphonso, Kesar and Rajapuri cultivars. Besides improving results, Martinez *et al.,* [22] perceived that application of paclobutrazol also increased yield and quality of mango. It is possible that the application of PBZ caused an early reduction of endogenous gibberellins levels within the shoots, that causes them to reach maturity earlier. Flowering is normally associated with reduced vegetative growth, often induced by lower activity of gibberellins [24]. Therefore assimilates normally are consumed to vegetative growth which have been divert in order to flowering. This was demonstrated by a higher level of total non-structural carbohydrate in shoots prior to flowering [25]. Similar results have been reported by Sansavini *et al.,* [26] for apple.

Fruit quality

Different PBZ and Ca levels alone or in combination had significant effect on fruit quality (Table 1). TSS content increased when plants were sprayed with 2.5 mg/ L PBZ and 7.5 mM Ca (Table 1). Combination between factors was significant in TSS contents. Highest amount of TSS (3.5 %) was observed from sprayed at 2.5 mg/ L PBZ + 7.5 mM Ca. In general, TSS is an important quality factor which influences the palatability and acceptability of fruit. The presented data in this study agreed with that found by Kadir [27] who showed that preharvest tree sprays with Ca have been used commercially to improve ratio of soluble solid concentration to titralable acidity of apple fruits. Nazarpour [28] indicated that paclobutrazol application resulted in increased TSS in the 'Camarosa' cultivar of strawberry. Organoleptic quality of strawberries depends strongly on the TSS/TA ratio. Teferi Belayneh [25] observed that the TSS/TA ratio in mango fruits increased as a result of paclobutrazol application. According to the results significant improvement on cucumber quality characteristics was observed. It seems that under lower concentration of Ca and PBZ could find a better relation between spraying and quality.

Table 1- Effect of foliar spraying of PBZ and Ca on growth, yield and quality of cucumber plants during 2012 and 2013 seasons.

Treatments (mmolL-1)	Plant height (cm)	Dry weight of leaves (g)	Number of leaves per plant	Chlorophyll (SPAD)	Fruit length (cm)	Mean fruit weight (g)	Fruit diameter (cm)	Total yield (kg/Plant)	N(%)	K(%)	TSS (%)
Control	147.54b	3b	20b	19b	15b	80.65bc	1.89c	2c	2.7b	2.6bc	2c
2.5 mg/ L PBZ	122c	2.81c	20.8b	16.87bc	19.56a	90.5b	2.78ab	5.78ab	2.31c	2.45c	3.4a
5 mg/ L PBZ	90cd	2.5c	17.65bc	14.76c	16.12b	78.65bc	2.34b	4.37b	2.3c	2.4c	2.81b
10 mg/ L PBZ	75.21d	2.04cd	15.98bc	14c	15.5b	78bc	2.3b	3bc	2.3c	2.36c	2.73b
7.5 mM Ca	201.12a	5.12a	30.13a	23.16a	20.13a	100.11a	2.81ab	5.8ab	3.14a	3.4a	3.1a
15 mM Ca	155.12b	4.02b	21.13b	19.14b	15.12b	89.7b	2.13b	4.5b	2.87b	2.9b	2.7b
2.5 mg/ L PBZ+ 7.5 mM Ca	131bc	3.41bc	17bc	15.12bc	15b	91.34b	3.31a	6a	2.32c	2.43c	3.5a
2.5 mg/ L PBZ+ 15 mM Ca	130bc	3.3bc	16.89bc	15bc	14.65b	87.67b	2.4b	4.76b	2.3c	2.4c	2.5b
5 mg/ L PBZ+ 7.5 mM Ca	121.11c	3bc	15.67cd	13.54c	13.12bc	82.67b	2.32b	4.5b	2.35c	2.34c	2.43b
5 mg/ L PBZ+ 15 mM Ca	118c	2.8c	14.6d	13.5c	13bc	76.56bc	2.3b	4.46b	2.22c	2.32c	2.35b
10 mg/ L PBZ+ 7.5 mM Ca	90.45cd	2.76c	14d	13.34c	12.58bc	76bc	2.3b	4.4b	2.25c	2.25c	2.3b
10 mg/ L PBZ+ 15 mM Ca	88.43cd	2cd	13.67d	13.3c	12.6bc	74.34bc	2.34b	4.39b	2.21c	2.3c	2.3b

Means followed by same letter are not significantly different at 5% probability using Duncan's test.

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Mohsen Kazemi. Response of Cucumber Plants to Foliar Application of Calcium Chloride and Paclobutrazol under Greenhouse Conditions. Bull. Env. Pharmacol. Life Sci., Vol 2 (11) October 2013: 15-18