Journal of Horticultural Research 2016, vol. 24(1): 93-100
DOI: 10.1515/johr-2016-0011

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EFFECT OF GIBBERELLIC ACID AND POTASSIUM FOLIAR SPRAYS ON PRODUCTIVITY AND PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS OF PARTHENOCARPIC CUCUMBER CV. 'SEVEN STAR F_1'

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Received: January 2016; Accepted: June 2016

ABSTRACT

A study was carried out to evaluate the potential of exogenously applied potassium nitrate [1.0 $g \cdot dm^{-3}$ (K_1), 2.5 $g \cdot dm^{-3}$ (K_2) and 5 $g \cdot dm^{-3}$ (K_3)] plus gibberellic acid (GA_3) [0.005 $g \cdot dm^{-3}$ (G_1), 0.01 $g \cdot dm^{-3}$ (G_2) and 0.015 $g \cdot dm^{-3}$ (G_3)] on the growth and development of the cucumber (*Cucumis sativus* L.) 'Seven Star F_1' during various growth stages (40, 55 and 70 days after sowing). Treatment of plants with K plus GA_3 stimulated growth shortened the fruit maturation period and increased quality compared with non-sprayed control. The combination G_2K_2 resulted in maximum total yield, plant height, and total chlorophyll, phosphorus and nitrogen content in the leaves compared with other treatments. Fruit matured significantly earlier in plants sprayed with G_2K_2. Total yield and fruit quality dry matter, total suspended solids and antioxidant activity percentages were significantly higher in sprayed plants compared with controls. Potassium content in leaves and fruits reached the maximum level with G_3K_3 treatment. The results clearly showed that the foliar application of G_2K_2 proved to be the best choice for growing cucumber in terms of quantity and quality of yield.

Key words: parthenocarpic cucumber; foliar spray; potassium; gibberellic acid; fruit quality

INTRODUCTION

Cucumis sativus L. is one of the most popular and profitable vegetable crops in the world (Food and Agriculture Organization 2013). In terms of economic importance, it is ranked fourth among vegetable crops after tomato, cabbage and onion in Asia (Eifediyi & Remison 2010) and second after tomato in Western Europe (Phu 1997). It contains a wide variety of minerals and biologically active compounds such as alkaloids, flavonoids, tannins, phlobotannins and steroids, imparting health benefits beyond basic nutrition and reducing the risk of many deadly human diseases (Agte et al. 2000; Patil et al. 2012). Exogenous application of plant growth regulators (PGRs) is a strategy to increase yield, improve crop quality and regulate uptake and accumulation of mineral nutrients in plants. Foliar fertilisation is a method of crop feeding that involves applying a solution of micro- and macro-nutrients to the leaves, which allows rapid uptake regardless of soil conditions (Nasiri et al. 2010). Use of foliar feeding during growth and development can improve the nutrient balance of crops, which, in turn, leads to increased yield and quality (Kolota and Osińska 2001). Potassium (K), which is necessary for efficient plant growth and development, exists predominantly as a free or absorptive bound cation (Abbas et al. 2011; Very & Sentenac 2003). It helps in the transport of water and nutrients through the xylem, influencing various biochemical and physiological parameters like photosynthesis, respiration, protein synthesis, cell extension, and wall thickness and stability (Abbas et al. 2011). It not only activates enzymes but its involvement also in the production of adenosine triphosphate (ATP) is important in regulating the rate of photosynthesis (Atkin & Macherel 2009). The plant transport system uses energy in the

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form of ATP. So, if K is inadequate, less ATP will be available, resulting in breakdown of the transport system, which, in turn, would leads to poor yield and quality (Rai et al. 2002).

Gibberellic acid (GA_3) is an important PGR that affects plant growth and development by inducing metabolic activities and regulating nitrogen utilisation (Sure et al. 2012). It also plays a significant role in seed germination, endosperm mobilisation, stem elongation, leaf expansion, reducing the maturation time and increasing flower and fruit set and their composition (Roy & Nasiruddin 2011). GA_3 delays senescence, improves growth and development of chloroplasts, and intensifies photosynthetic efficiency which could lead to increased yield (Yuan & Xu 2001).

The cucumber cv. 'Seven Star F_1' is a parthenocarpic, smooth, dark green fruit of length 16-18 cm, with a single fruit per node. It gives a very high yield, is tolerant to powdery mildew and suitable for growing in early spring and late autumn. The effect of simultaneous application of a combination of K and GA_3 on the growth and development of parthenocarpic cucumber has not been fully examined. Therefore, this study was designed with the aim of investigating the promotive effect of foliar application of different combined concentrations of K and GA_3 on growth, development and mineral composition.

MATERIALS AND METHODS

The investigation was carried out in an insect-proof nethouse at the Centre of Excellence for Vegetables, an Indo-Israel project, at Gharaunda (Karnal) located at latitude of 29º32' North and longitude of 76º59' East, from September to December for two consecutive years (2014-2015, 2015-2016) at temperatures of 32 °C-34 °C (day) and 17 °C-27 °C (night). The hybrid parthenocarpic cultivar 'Seven Star' was used. Seeds were obtained from the Centre of Excellence for Vegetables, Gharaunda centre. The physical and chemical properties of soil at the experimental sites up to a depth of 30 cm were estimated according to the procedures by Page et al. (1982), and the results are listed in Table 1.

The experimental layout was in a Complete Randomised Block Design with three replicates. The plants were grown on raised beds of dimension 80 × 30 cm (width × height), separated at a distance of 45 cm from each other. The spacing between two plants on the same bed was 40 cm. Nutrient solution containing nitrogen, phosphorus, and potassium (NPK) in a ratio of 13:0:45 was applied with the drip irrigation system for all the treatments twice a week. The plants were irrigated when required, depending on the soil moisture regime. Treatments included foliar application of four concentrations of GA_3 [0.0 $g \cdot dm^{-3}$ (G_0), 0.005 $g \cdot dm^{-3}$ (G_1), 0.01 $g \cdot dm^{-3}$ (G_2) and 0.015 $g \cdot dm^{-3}$ (G_3)] combined with four concentrations of potassium [0.0 $g \cdot dm^{-3}$ (K_0), 1.0 $g \cdot dm^{-3}$ (K_1), 2.5 $g \cdot dm^{-3}$ (K_2) and 5.0 $g \cdot dm^{-3}$ (K_3)]. So, a total of four different combinations of K and GA_3 were used in the experiment: G_0K_0 (control), G_1K_1, G_2K_2 and G_3K_3. They were prepared with distilled water and sprayed on foliage with a power spray pump until the leaves were completely wet. The leaves were sprayed in the morning, with one day interval between spraying with GA_3 and K. Spraying of K was performed twice a week, first after 20 days of sowing. Spraying of GA_3 was performed twice, first on the 30th day after direct sowing and then on the 60th day. Plant height, leaf chlorophyll, mineral contents and fruit development were evaluated at 40, 55 and 70 days after sowing (DAS). Total yield (fruit number, size and weight), fruit quality parameters – percent of dry matter (DM), total suspended solids (TSS), antioxidant activity and mineral contents of nitrogen, calcium, phosphorous, sodium and magnesium – were determined at final harvest (i.e. at 70 DAS. Total chlorophyll content was estimated in fully expanded leaves (from the upper one-third of plant stems) of the same size according to the method of Arnon (1949). Similar leaves were used to evaluate the mineral content. They were rinsed thrice with distilled water, then dried in a forced air oven at 70 °C for 3 days and ground. Total nitrogen was determined using the micro-Kjeldahl method of the Association of Official Agricultural Chemists (AOAC 1990). Potassium and sodium were assayed using flame spectrophotometer.

Table 1. Physical and chemical properties of the experimental soil

Physical properties				
Sand (%)	Clay (%)	Silt (%)	Texture	Moisture availability (%)
82.20	11.19	6.11	Sandy loam	12.3

Chemical properties								
pH	Electrical conductivity ($M \cdot m^{-1}$)	Organic carbon (%)	P ($kg \cdot ha^{-1}$)	K ($kg \cdot ha^{-1}$)	S (ppm)	Zn ($mg \cdot kg^{-1}$)	Fe ($mg \cdot kg^{-1}$)	Mg ($mg \cdot kg^{-1}$)
7.70	0.27	0.16	15.23	146.50	52.39	1.13	5.96	3.26

Phosphorous was extracted and measured spectrophotometrically according to the method of Koenig and Johnson (1942). Calcium and magnesium were estimated by atomic absorption spectrometry using the method of AOAC (1990). Also, fruit samples were cleaned, dried and the content of N, P, K, Ca, Na and Mg was determined. TSS % was determined using hand refractometer. DM of fruit tissues was estimated according to the method of Dubois et al. (1959). For the analysis of antioxidant activity, 10 g of the cucumber pulp was mixed with 10 ml of ethanol and stirred with a magnetic stirrer for 6 hours. The suspension was filtered through Whatman No. 1 filter paper (Sengul et al. 2011).The extracts were stored in a freezer at −20 °C until analysis. The antioxidant activity was evaluated using the β-carotene bleaching method (Kaur & Kapoor 2002) with some modifications (Sengul et al. 2011).

Each experiment consisted of three replicates per treatment. Data were analysed as means of 2 years (September-November 2014 and 2015) using one-way analysis of variance and the differences were computed using Duncan's multiple range test at $p = 0.05$. All statistical analyses were performed using the SPSS software (version 11.5).

RESULTS

Plant growth

Throughout the period of measurement, in comparison with other treatments, the maximum plant height, total chlorophyll and NPK content was noticed in plants sprayed with G_2K_2 while the lowest measurements were recorded from control plants (Table 2).

Leaf chlorophyll content

Application of K and GA_3 significantly increased the total chlorophyll content at each measurement point compared to control plants. The most pronounced effect was seen in the plants sprayed with G_2K_2. The chlorophyll content in the tested plants increased up to 55 DAS and declined at 70 DAS in all the treatments (Table 3). Foliar application of G_2K_2 enhanced the chlorophyll content by about 74% and 72% at 55 and 70 DAS, respectively, compared with control. Interestingly, the effect of higher concentration G_3K_3 treatment was negligible in retaining the pigment content at all three stages.

Leaf mineral content

The N and P percent in the DM of leaves increased significantly in the tested plants that were sprayed with a combination of K and GA_3 foliar spray, compared to control plants (Table 4). The highest content of N and P was obtained with G_2K_2 treatment. The N and P content increased up to 55 DAS and declined at 70 DAS in all the treatments (Table 4). K content in leaves of plants that were sprayed was significantly higher compared with control plants at 40, 55 and 70 DAS. The greatest increase in K content was observed with G_3K_3 treatment (77% over the control at 70 DAS), followed by G_2K_2 and G_1K_1 treatments, while the lowest content was observed in control plants. Also, the Na content in leaves varied with the treatment states of growth. The sprays with G_1K_1 and G_2K_2 increased its contents wherein at the G_3K_3 the contents were lower than in control. The highest content of Na coexisted with lowest K in the leaves sprayed by the combination G_3K_3 (Table 4).

Table 2. Effect of foliar spray of gibberellic acid and potassium on the plant height ± SE (cm) of cucumber cv. 'Seven Star' (n=3)

Treatment	Growth stage		
	40 DAS	55 DAS	70 DAS
Control	179 ± 0.5^d	234 ± 1.2^d	292 ± 1.2^d
G_1K_1	238 ± 0.6^b (32%)	296 ± 0.8^b (26%)	342 ± 0.6^b (17%)
G_2K_2	252 ± 0.5^a (41%)	312 ± 0.6^a (33%)	364 ± 0.2^a (25%)
G_3K_3	230 ± 1.1^c (28%)	288 ± 0.8^c (23%)	338 ± 0.5^c (16%)
F	1666.7***	1344.1***	1641.3***

In parentheses is the percentage increase in value relative to the control.
G_1: 0.005 g·dm^{-3}, G_2: 0.01 g·dm^{-3}, G_3: 0.015 g·dm^{-3}, K_1: 1.0 g·dm^{-3}, K_2: 2.5 g·dm^{-3}, K_3: 5.0 g·dm^{-3}, DAS: days after sowing
Values within a column followed by the same letter are not significantly different from each other according to Duncans Multiple Range Test at the p = 0.05 level. *F*-value of *F* statistics from analysis of variance with significance $^{***}p < 0.001$

Table 3. Effect of foliar spray of gibberellic acid and potassium on the total chlorophyll ± SE (mg·g^{-1} fresh weight) of cucumber leaves (n=3)

Treatment	Growth stage		
	40 DAS	55 DAS	70 DAS
Control	1.92 ± 0.01^d	2.48 ± 0.02^d	1.83 ± 0.07^d
G_1K_1	2.36 ± 0.02^b (23%)	3.47 ± 0.01^b (40%)	2.46 ± 0.06^b (34%)
G_2K_2	2.57 ± 0.01^a (34%)	4.01 ± 0.01^a (62%)	3.21 ± 0.01^a (75%)
G_3K_3	2.22 ± 0.02^c (16%)	3.13 ± 0.04^c (26%)	2.16 ± 0.06^c (18%)
F	148.7***	507.1***	96.3***

Note: see Table 2

Fruit growth and maturation

The time to fruit initiation had a significant effect on the time taken for fruit maturation. Time to fruit initiation, maturation and harvest differed significantly between the treatments (Table 5). The minimum number of days to fruit initiation, fruit maturation and harvest was recorded in plants sprayed with G_2K_2 whereas the maximum values was recorded for control plants.

Fruit yield

Table 6 shows that spraying with G + K significantly enhanced cucumber productivity (fruit length and width, average fruit weight, number of fruits per plant and total yield). Among all treatments, foliar application of G_2K_2 proved to be the best in increasing the fruit length (by 50%), fruit width (by 42%), average fruit weight (by 54%), number of fruits per plant (by 27%) and total yield (by 96%), compared with controls.

Fruit quality parameters

Foliar application of G + K caused an increase in fruit DM, TSS and antioxidant activity, compared with controls (Table 7). The combination G_2K_2 led to the greatest increment in DM (by 30%) and TSS (by 34%). The lowest values for these traits were obtained in fruits from control plants.

Fruit mineral content

The content of all analysed fruit minerals was significantly higher in fruits from plants sprayed with G + K compared with controls (Table 8). The greatest increase in N (by 57%), P (by 31%) and Ca (by 54%) content was observed with G_2K_2 treatment. Compared with control, the maximum increment of K content (by 67%) was recorded in fruits from plants treated with G_3K_3, whereas maximum increment of Na and Mg was recorded in fruits from plants treated with G_1K_1.

Table 4. Effect of foliar spray of gibberellic acid and potassium on the leaf mineral composition ± SE (% dry matter) of cucumber cv. 'Seven Star' (n=3)

Growth stage treatments	N	P	K	Na
40 DAS				
Control	3.03 ± 0.02^{d}	0.38 ± 0.004^{c}	3.24 ± 0.11^{b}	0.32 ± 0.023^{b}
G_1K_1	3.58 ± 0.06^{b} (18%)	0.54 ± 0.006^{b} (42%)	3.56 ± 0.11^{b} (10%)	0.38 ± 0.008^{a} (19%)
G_2K_2	3.92 ± 0.04^{a} (29%)	0.64 ± 0.007^{a} (68%)	4.28 ± 0.06^{a} (32%)	0.37 ± 0.005^{a} (16%)
G_3K_3	3.37 ± 0.03^{c} (11%)	0.53 ± 0.009^{b} (39%)	4.44 ± 0.11^{a} (37%)	0.30 ± 0.003^{b}
F	62.4^{***}	172.1^{***}	32.3^{***}	9.1^{**}
55 DAS				
Control	3.18 ± 0.05^{d}	0.41 ± 0.005^{c}	3.69 ± 0.12^{c}	0.34 ± 0.012^{a}
G_1K_1	3.94 ± 0.02^{b} (24%)	0.63 ± 0.010^{a} (57%)	4.25 ± 0.11^{b} (15%)	0.37 ± 0.005^{a} (9%)
G_2K_2	4.25 ± 0.06^{a} (37%)	0.65 ± 0.005^{a} (59%)	4.49 ± 0.11^{b} (22%)	0.36 ± 0.005^{a} (6%)
G_3K_3	3.63 ± 0.02^{c} (14%)	0.57 ± 0.009^{b} (39%)	5.12 ± 0.07^{a} (39%)	0.29 ± 0.011^{b}
F	103.6^{***}	135.3^{***}	29.4^{***}	14.8^{**}
70 DAS				
Control	1.33 ± 0.05^{c}	0.40 ± 0.008^{d}	3.08 ± 0.10^{c}	0.24 ± 0.011^{b}
G_1K_1	2.63 ± 0.11^{a} (10%)	0.51 ± 0.003^{b} (28%)	4.59 ± 0.13^{b} (49%)	0.29 ± 0.005^{a} (21%)
G_2K_2	2.80 ± 0.06^{a} (11%)	0.57 ± 0.005^{a} (42%)	4.72 ± 0.05^{b} (53%)	0.28 ± 0.005^{a} (17%)
G_3K_3	2.25 ± 0.12^{b} (7%)	0.43 ± 0.004^{c} (7%)	5.44 ± 0.11^{a} (77%)	0.20 ± 0.003^{c}
F	48.5^{***}	150.3^{***}	91.1^{***}	29.9^{***}

In parentheses is the percentage increase in value relative to the control.
G_1: 0.005 g·dm^{-3}, G_2: 0.01 g·dm^{-3}, G_3: 0.015 g·dm^{-3}, K_1: 1.0 g·dm^{-3}, K_2: 2.5 g·dm^{-3}, K_3: 5.0 g·dm^{-3}, DAS: days after sowing
Values within a column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at the p = 0.05 level. *F*-value of *F* statistics from analysis of variance with significance $^{**}p < 0.01$, $^{***}p < 0.001$

Table 5. Effect of foliar spray of gibberellic acid and potassium on time to anthesis, time to fruit maturity and time to first harvesting of cucumber cv. 'Seven Star' (means ± SE, n=3)

Treatment	Time taken to fruit initiation (days)	Time taken to edible maturity (days)	Time to first harvesting (days)
Control	33.1 ± 0.105^{d}	10.9 ± 0.59^{c}	43.4 ± 0.12^{d}
G_1K_1	30.1 ± 0.063^{b} (9%)	8.1 ± 0.38^{ab} (34%)	38.5 ± 0.08^{b} (12%)
G_2K_2	29.3 ± 0.005^{a} (12%)	7.2 ± 0.57^{a} (51%)	37.3 ± 0.07^{a} (16%)
G_3K_3	31.5 ± 0.061^{c} (5%)	9.3 ± 0.06^{b} (17%)	39.7 ± 0.09^{c} (9%)
F	585.6^{***}	11.2^{**}	791.9^{***}

In parentheses is the percentage increase in value relative to the control.
G_1: 0.005 g·dm^{-3}, G_2: 0.01 g·dm^{-3}, G_3: 0.015 g·dm^{-3}, K_1: 1.0 g·dm^{-3}, K_2: 2.5 g·dm^{-3}, K_3: 5.0 g·dm^{-3}
Values within a column followed by the same letter are not significantly different from each other according to Duncans Multiple Range Test at the p=0.05 level. *F*-value of *F* statistics from analysis of variance with significance $^{**}p < 0.01$, $^{***}p < 0.001$

Table 6. Effect of foliar spray of gibberellic acid and potassium on fruit length and diameter, average fruit weight (g), number of fruits per plant and total yield of cucumber cv. 'Seven Star' (means ± SE, n=3). In parentheses is the percentage increase in value relative to the control

Treatment	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Average number of fruits per plant	Total yield (kg/plant)
Control	13.7 ± 0.46^{c}	2.9 ± 0.06^{c}	134 ± 0.2^{d}	25.9 ± 0.6^{c}	3.46 ± 0.08^{d}
G_1K_1	19.9 ± 0.05^{ab} (45%)	3.9 ± 0.06^{b} (34%)	161 ± 1.2^{b} (21%)	37.1 ± 1.0^{ab} (43%)	5.98 ± 0.21^{b} (72%)
G_2K_2	20.9 ± 0.58^{a} (53%)	4.6 ± 0.12^{a} (58%)	171 ± 0.4^{a} (28%)	39.9 ± 0.9^{a} (54%)	6.80 ± 0.17^{a} (96%)
G_3K_3	19.0 ± 0.58^{b} (45%)	3.7 ± 0.03^{b} (28%)	147 ± 1.5^{c} (10%)	35.6 ± 0.8^{b} (38%)	5.24 ± 0.18^{c} (51%)
F	47.0^{***}	79.0^{***}	244.9^{***}	48.2^{***}	69.8^{***}

In parentheses is the percentage increase in value relative to the control.

G_1: 0.005 g·dm^{-3}, G_2: 0.01 g·dm^{-3}, G_3: 0.015 g·dm^{-3}, K_1: 1.0 g·dm^{-3}, K_2: 2.5 g·dm^{-3}, K_3: 5.0 g·dm^{-3}

Values within a column followed by the same letter are not significantly different from each other according to Duncans Multiple Range Test at the p = 0.05 level. *F*-value of *F* statistics from analysis of variance with significance $^{***}p < 0.001$

Table 7. Effect of foliar spray of gibberellic acid and potassium on fruit quality parameters of cucumber cv. 'Seven Star' (means ± SE, n=3)

Treatment	% Dry matter	Antioxidant activity (%)	TSS %
Control	3.78 ± 0.063^{d}	34.1 ± 0.61^{b}	3.06 ± 0.04^{c}
G_1K_1	4.64 ± 0.014^{b} (23%)	38.8 ± 0.11^{a} (13%)	3.88 ± 0.11^{a} (27%)
G_2K_2	4.97 ± 0.008^{a} (31%)	39.4 ± 0.06^{a} (15%)	4.12 ± 0.05^{a} (35%)
G_3K_3	4.48 ± 0.050^{c} (18%)	38.4 ± 0.25^{a} (12%)	3.57 ± 0.10^{b} (17%)
F	134.5^{***}	50.3^{***}	27.7^{***}

Note: see Table 6

Table 8. Effect of foliar spray of gibberellic acid and potassium on the fruit mineral composition (% dry matter) of cucumber cv. 'Seven Star' (means ± SE, n=3)

Treatments	N	P	K	Ca	Na	Mg
Control	3.16 ± 0.05^{d}	0.48 ± 0.004^{c}	3.43 ± 0.04^{c}	0.98 ± 0.01^{c}	0.15 ± 0.003^{c}	0.20 ± 0.011^{c}
G_1K_1	4.54 ± 0.05^{b} (44%)	0.55 ± 0.006^{b} (14%)	4.48 ± 0.01^{b} (30%)	1.28 ± 0.02^{b} (30%)	0.23 ± 0.008^{a} (53%)	0.28 ± 0.012^{a} (40%)
G_2K_2	4.97 ± 0.05^{a} (57%)	0.63 ± 0.005^{a} (31%)	4.53 ± 0.03^{b} (32%)	1.51 ± 0.06^{a} (54%)	0.22 ± 0.003^{a} (46%)	0.27 ± 0.005^{a} (35%)
G_3K_3	4.18 ± 0.05^{c} (32%)	0.54 ± 0.001^{b} (13%)	5.75 ± 0.06^{a} (67%)	1.16 ± 0.02^{b} (18%)	0.18 ± 0.008^{b} (20%)	0.23 ± 0.003^{b} (15%)
F	202.4^{***}	171.0^{***}	487.8^{***}	38.5^{***}	31.8^{***}	17.6^{***}

Note: see Table 6

DISCUSSION

The increase in plant growth might be attributed to increased cell division and cell elongation induced by the application of K and GA_3 (Shah et al. 2006; Roy & Nasiruddin 2011). Kazemi (2014) also observed the positive effect of combination of GA_3 and K on plant height, number of branches, and chlorophyll and NPK content in tomato. It was found that higher content of N, P and K was recorded with treatments that supplemented K for leaves, indicating the role of K in plant metabolism and its involvement in many related processes (Marschner 2012). GA_3 was also found to play an important role in enhancing the N, P and K content (Sayed 2001; Soad & Ibrahim 2005). On the other hand, Na content in plant decreased with an increase of K and GA_3 concentration in the treatment. Antagonistic correlations between K and Na were also reported by Song and Fujjiyama (1996).

Foliar application of G_2K_2 significantly increased the mineral content of leaves, resulting in an increase in the mineral content of fruit.

K plus GA_3 treatments shortened the period of fruit ripening and accelerated the harvesting time. K and GA_3 enhanced the NPK and chlorophyll content of leaves, causing earlier fruit set and fruit maturation, and acceleration of harvest time (Zhang et al. 2002; Lin & Danfeng 2003).

The present findings are in agreement with the results of Kazemi (2014) and Mazumdar (2013), which revealed an increase in fruit weight, number of fruits per plant and total yield of tomato and cabbage using different combinations of K and GA_3. This increment might be interpreted that plants during flowering and fruit setting stages need a high amount of K and other nutrients to perform the biological operations as increase in photosynthesis due to couple with chlorophyll synthesis (Ding et al. 2006). An adequate quantity of K plays a major role in crop growth and development by activating abundant enzymes that control cell osmoregulation and the stomatal movement during photosynthesis (Broadley et al. 2009; Coskun et al. 2014).

Increase in TSS depends on higher sugar import and accumulation, as reported by Balibrea et al. (2006). K plays an important role in enhancing the quality of tomato fruit by increasing TSS and reducing sugars and titratable acidity (Caretto 2008). Both K and GA_3 are related to the storage of sugars and starch and the synthesis of proteins and carbohydrates stimulating growth (Faquin 1994). Application of K plus GA_3 increases the DM in fruit by promoting RNA and protein synthesis, and accelerating enzymes activity responsible for biomass accumulation (Marschner 2012).

From the grower's perspective, foliar application twice (at 30 and 60 DAS) of 0.005 $g\cdot dm^{-3}$ GA_3 and twice a week application of K at a concentration 1 $g\cdot dm^{-3}$ beginning with 20 DAS assures the best balance between K and GA_3, showing pronounced effects on plant growth, fruit set and development, and hastens fruit quality and benefits marketability.

Acknowledgements
The authors are grateful to Kurukshetra University, Kurukshetra, India for providing laboratory facilities and other institutional support. The authors thank Dr. Satyender Yadav and Dr. Dharam Singh, Centre of Excellence for Vegetables, an Indo-Israel project, Gharaunda (Haryana), India for assistance during the project. Thanks are owed to Dr. Ashwani Kumar, Plant Physiology Laboratory, CSSRI, Karnal, for applied research and assistance.

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