ENHANCEMENT OF PRODUCTIVITY AND STORABILITY OF SNAP BEAN VIA PRE-HARVEST FOLIAR APPLICATION OF TWO CALCIUM SOURCES IN COMPARISON WITH ADENOSINE TRIPHOSPHATE

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Abstract

Two field experiments were carried out during the fall seasons of 2010/2011 and 2011/2012 at the Agriculture Research Farm, El-Kassasien Hort. Res. Station, Ismalia Governorate, Egypt, and storage Lab., Hort. Dept., Fac. of Agric., Zagazig University, to study the effect of pre-harvest foliar spray with two calcium sources (calcium chloride, calcium citrate) in comparison with adenosine triphosphate (ATP) on growth, yield and its quality of snap bean plants (*Phaseolus vulgaris* L.) c.v Paulista. It aimed also to study the effect of the abovementioned treatments on snap bean pods storability during cold storage at different periods, i.e., 7, 14,21 and 28 days. Significant increases in vegetative growth characters, yield and it's components as well as chemical constituents of pods (phosphorus and protein %) were recorded by foliar application of adenosine triphosphate at 150ppm followed by calcium chloride at 1% and calcium citrate at 0.1% compared to untreated plants. Generally, quality parameters of snap bean pods during cold storage at 7 °C and 90-95 RH indicate that weight loss, decay and crude fibers percentage in snap bean pods were increased as the storage period prolonged up to 28 days from the beginning of storage period. Green pods obtained from plants sprayed with calcium chloride at 1% and stored at 7 °C and 90-95 RH for 21 days was the best interaction treatment recorded the lowest values of weight loss, decay and crude fibers percentage.

Key words: calcium chloride, calcium citrate, adenosine triphosphate, snap bean, yield, chemical constituents, storage period.

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) is one of the most important vegetable crops grown in Egypt for both local consumption and exportation. Such importance comes from the fact that legumes are cheap and very rich in protein content, minerals and vitamins which is essential for human nutrition rather than the role of such crops in improving soil fertility (Kerlous, 1997 and Abdel-Hakim *et al.*, 2012). Cultivation of vegetable crops under change climate especially cold weather in old and new reclaimed lands faces a lot of challenges, i.e. unfavorable environmental condition.

This means that most vegetable crops grown under such conditions may suffer from various environmental stresses in the field. Enhancing growth and productivity under these conditions will be a great importance to maximize the yield.

The fall season, under locality, is considered the main season for snap bean exportation, in which plants are periodically exposed to unfavorable wide differences between day and night temperature and afterward to low temperature in advanced fall season. Under such stressful environmental conditions and the consequences of exposure to relatively low temperature, reduction in yield and different performances, could be expected (Greaves, 1996 and Haldiman,1998). Among many physiological mechanisms responsible for these conditions is the potential for damage to the photosynthetic apparatus caused by the combination of low temperature and high light tolerant (Baker, 1994). There was reduction in chlorophyll content, decrease in leaf size and an increase in leaf thickness, all typical of photo acclimation to increase irradiance (Bjorkman,1981).

Calcium ions (Ca^{++}) play an important role in several biochemical processes (Poovaiah, 1993). Many physiological disorders in storage vegetables and fruits are related to low calcium content in plant tissues (Bangerth, 1979). Calcium has been described as an essential element for the maintenance of cell membranes and walls because it takes part in links with pectic substances which help cell to cell adhesion (Heppler ans Wayne, 1985). McKently *et al.* (1982) worked with snap beans grown without calcium, and they recorded 80% decrease in plant growth and 90% reduction in pod number per plant.

Foliar application of sweet pepper plants with calcium citrate at 75ppm greatly improved all growth traits, dry matter, fruit yield and quality (Fathy and Khedr 2005). Spraying pepper plants with calcium chloride at 2% significantly improved growth parameters, yield and cold tolerance (El-Tohamy *et al.*, 2006). There is a direct relation between increasing calcium concentration and improvement yield, weight of pods per plant and average pod length (Favaro *et al.*, 2007). Spraying snap bean with calcium chloride at 0.5% significantly increased plant growth, total dry weight, N, P and K total uptake as well as total yield of snap bean plants, while it reduced weight loss (%), decay (%) and off-oder (Mohammad *et al.*, 2009).

Weight loss and decay (%) of stored green pods of snap bean (Bronco cv.) were increased with the prolongation of storage period and increasing shelf life (El-Mogy, 2001).

Adenosine triphosphate (ATP) is a ubiquitous energy source, but acts extracellularly as a neurotransmitter (Roux and Steinebrunner, 2007). The concept of

ATP and purine derivatives as extracellular signaling molecules was born when physiological effects of adenine derivatives were discovered (Ralevic and Burnstock, 1998). ATP and other nucleoside triphosphates not only drive energy-dependent reactions inside cells, but can also function outside the plasma membrane in the extracellular matrix, where they function as agonists that can induce diverse physiological responses without being hydrolyzed. Recent data have shown that ATP and other nucleotides can induce an increase in the cytosolic Ca^{+2} concentration and diverse downstream changes that influence plant growth and defense responses (Demidchik *et al.*,2003).

The use of adenosine triphosphate (ATP) was reported in a narrow scale, Fathy *et al.,* (2000) on tomato found that spraying plants with ATP increased vegetative growth parameters and yield and its components as compared with the untreated plants. Spraying snap bean plants with ATP at 150 ppm significantly increased vegetative growth, pod weight, pod number, total yield per fed. protein content and deacreased fibers % (El-Seifi *et al.*,2009). Also, application of ATP at 60 or 180 ppm enhanced growth, yield and yield components along with the chemical composition of green pods (Abdel-Hakim *et al.*, 2012).

Thus, this work aimed to study the effect of foliar application with two calcium sources, i.e., calcium chloride, calcium citrate as well as adenosine-tri-phosphate on increasing snap bean plants tolerance against adverse environmental stress and improving productivity and quality as well as increasing storability of green snap bean pods.

MATERIALS AND METHODS

Field experiment: This experiment was carried out during the fall seasons of 2010/2011 and 2011/2012 at the Agriculture Research Farm, El-Kassasien Hort. Res. Station, Ismalia Governorate, Egypt, to study the effect of foliar spray with calcium chloride, calcium citrate and adenosine-tri-phosphate on growth, yield and its components of snap bean plants (*Phaseolus vulgaris* L.) c.v Paulista.

The experimental soil was sandy in texture with 96.5 and 95.6% sand, 1.7 and 1.6 % silt, 1.8 and 2.8% clay, 8.1 and 8.1pH, 0.03 and 0.08 % organic matter, 5.4 and 6.9 ppm N, 5.5 and 6.2 ppm P and 52 and 64 ppm K in the 1st and 2nd seasons, respectively.

This experiment included seven treatments as follow: 1- calcium chloride ($CaCl_2$) at 0.5 2- calcium chloride at 1% 3- calcium citrate $Ca_3(C_6H_5O_7)_2$ at 0.1% 4- calcium citrate at 0.2% 5- adenosine triphosphate at 75ppm 6- adenosine triphosphate at 150 ppm and 7- control (spraying with tap water).These treatments were distributed in a randomized complete block design with three replications. Seeds of snap bean were obtained from Hort. Res. Inst., Agric. Res. Center, Egypt, and sown on October19th and 18th in 2010 and 2011, respectively on one side of drippers lines (two seeds /hill) at 10 cm apart. At 15 days from sowing, plants were thinned leaving one plant / hill. The experimental unit area was 10.5m^2, it contained 3 dripper lines with 5m length each with 70 cm wide. One dripper line was left between each two experimental units without spraying as a guard row to avoid the overlapping of spraying solution.

Snap bean plants were sprayed three times during the growth period at 20, 30 and 40 days from sowing. Each experimental unit received 2 L spraying solution using spreading agent (Super Film) in all treatments. The untreated plants (check) were sprayed with 2 L tap water with spreading agent.

All plots received equal amounts of compost at a rate of 20m^3/feddan during soil preparation, The other recommended agricultural practices for commercial snap bean production ,i.e., irrigation, fertilization and weed control were followed.

Table 1. Local meteorological data at El-Kassasin region during 2010/ 2011 and 2011/ 2012 seasons

Parameter / Month	2010/2011			2011/2012		
	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity(%)	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity(%)
October	33.5	18.6	75	28.1	16.8	71
November	26.7	12.9	83	24.9	14.9	80
December	23.3	7.7	84	21.8	6.8	84
January	21.1	6.9	77	21.9	6.1	75
February	26.5	8.7	76	24.7	7.2	71

Data recorded: The obtained data in this study were recorded as follows:

A. Plant growth parameters:

Six plants from each plot were randomly taken at 50 days after sowing to evaluate the following vegetative growth characters: Plant height, number of branches/plant, number of leaves/plant. Leaf area (cm^2/ plant) was calculated according to Koller (1972) using following formula:

$$\text{Plant leaf area cm}^2 = \frac{\text{Dry weight of leaves} \times \text{Disk area of 10 disks (cm}^2)}{\text{Dry weight of 10 disks}}$$

B. Dry weight:

Snap bean shoots (branches and leaves) were oven dried at 70 °C till constant weight, and total dry weight/ plant was recorded.

C. Yield and its components:

Green pods of each experimental unit were continuously harvested at suitable maturity stage counted and weighed in each harvest till the end of the experiment and the following data were recorded: Average number of pods/plant, average pod weight (g), green pods yield /plot (kg) and total green pods yield (ton /fed.). At the second harvest, ten pods from each experimental unit were randomly taken to measure average pod length (cm).

D. Pod chemical constituents:

Sample of green pods from each experimental unit was oven dried at 70 °C. It finely ground separately and digested with sulfuric acid and percholoric acid (3:1). Nitrogen%, phosophorus% and potassium % were determined according to the method described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively. crude protein was calculated by multiplying the total nitrogen by 6.25. Total carbohydrates were determined colorimetrically using the method described by Dubois *et al.* (1956).

Storage experiment:

This experiment was conducted to study the effect of foliar spray with calcium chloride, calcium citrate and adenosine triphosphate on keeping quality of snap bean green pods during cold storage. In this experiment, mature green pods from the field experiment, were harvested at suitable maturity stage for marketing on 15th December and transported soon to the handling Lab., Hort. Dept., Fac. of Agric., Zagazig University, Egypt, and kept overnight at 7 °C and 90-95% relative humidity (RH). Healthy green pods were selected in this experiment. Marketable green snap bean pods (250g) packed in micro perforated polypropylene bags 12 × 15 cm (with 30µ thickness) sealed hermetically. Twelve polypropylene bags were prepared for each treatment, placed in carton box (30 × 20 ×10cm), then stored at 7 °C and 90-95% RH for 28 days. Three polypropylene bags were randomly taken from each treatment every 7 days for determining the postharvest measurements. The experimental design was completely randomized with three replicates.

Pod physical and chemical properties were recorded as follow:

Weight loss(%): It was calculated according to the following equation:

$$\text{Weight loss } (\%) = \frac{\text{Initial weight of pods} - \text{Weight of pods at sampling dates}}{\text{Initial weight}} \times 100$$

Decay (%): Snap bean pods showing decay incidence (shrinked, injured, shriveled and spoiled) were counted and percentage of decayed pods was calculated as follows:

$$\textbf{Decay (\%)} = \frac{\text{Number of decay pods}}{\text{Total number of pods}} \times 100$$

Crude fiber: It was determined (as dry weight basis) according to the method of Maynard (1970).

Statistical analysis: data of the field experiment were subjected to proper statistical analysis of variance according to Snedecor and Cochran (1980) and means separation were done according to Duncan (1958). Meanwhile, data of the cold storage experiment(tested the effects of storage period combined with calcium source and ATP as well as their interactions) were statistically analyzed by using MSTAT statistical software and the treatments means were compared by using LSD at 0.5 level of probability according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Growth Characters:

It is obvious from the data presented in Table 2 that spraying snap bean plants with ATP at 150 ppm was the most favorable treatment for enhancing growth characters significantly, on the other hand the lowest values in this respect were recorded generally in case of control. Furthermore, spraying snap bean plants with 75 or 150 ppm ATP and calcium chloride at 1% recorded the highest values regarding number of branches / plant in the two seasons with no significant differences among them. In addition foliar application of Ca increased significantly all studied plant growth parameters, in most cases, compared to control. The favorable effect of Ca on increasing dry weight of snap bean plants may be due to that Ca improving vegetative growth parameters (Table 2) and this in turn increased dry weight as compared to control (Table 2). The increase in dry matter caused by higher doses of calcium in the solution is related to a synergistic effect in the uptake of other nutrients (Fenn *et al.,* 1987). These authors showed a positive correlation between the absorption of total K and NH4 with the increase of available calcium and ascertained that this is due mainly to NH4 accumulation.

These results are in accordance with those of Favaro *et al.,*(2007).

Table 2. Effect of spraying with two calcium sources in comparison with ATP on vegetative growth characters of snap bean plants during fall season of 2010/ 2011 and 2011/2012

Parameters / Treatments	Growth characters / plant									
	Plant height (cm)		Leaves No.		Branches No.		Leaf area (cm^2)		Total dry weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	34.7cd	33.3c	9.3c	9.7c	3.3cd	3.3c	448.7c	453.9c	6.53c	6.51d
Calcium chloride at 0.5%	35.3b-d	33.7c	10.7b	11.3bc	3.7bc	4.0a-c	521.8b	525.4a-c	7.64b	7.58b
Calcium chloride at 1%	37.7bc	36.0bc	11.0b	11.7bc	4.0ab	4.3ab	539.3b	547.6ab	7.95b	7.91b
Calcium citrate at 0.1%	36.7bc	37.7b	10.7b	10.7bc	3.7bc	4.3ab	523.2b	495.4bc	7.67b	7.08c
Calcium citrate at 0.2%	32.3d	33.0c	11.3b	11.7bc	3.0d	3.7bc	549.2b	546.4ab	8.10b	7.83b
Adenosine triphosphate at 75ppm	38.3b	38.1b	11.0b	11.3bc	4.0ab	4.0a-c	542.7b	530.7a-c	7.99b	7.60b
Adenosine triphosphate at 150ppm	42.7a	41.3a	12.7a	13.0a	4.3a	4.7a	615.9a	607.1a	9.12a	8.71a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

The enhancement effect of ATP on growth characters of snap bean might be due to that ATP foliar spray activated all of ATP dependent metabolic process during stress (Mengel and Kirkby, 1982). Hydrolysis of ATP known to be a main process which readily and currently participated releasing the required energy, also ATP, ADP, AMP, which links to alteration of gene expression to cold tolerance during stress via its role in signal transduction system (McClure *et al.,*1989). All of these discussed critical functions and advantages of ATP treatment confirmed the suggestion of the essentially of ATP exogenous application to counteract the adverse effect of cold stress and to enquired and alter snap bean plants to cold tolerance case.

The obtained results are in harmony with those of El-Seifi *et al.,*(2009) and Abdel-Hakim *et al.*, (2012) on snap bean and Fathy *et al.,* (2000) on tomato.

Yield and its components:

It is obvious from the data in Table 3 that spraying snap bean plants with all tested substances at different concentrations enhanced significantly all studied yield traits, except number of pods in the second season and average pod weight in the first one which did not reach the 5% level of significace . The superior treatments for increasing yield/plot and total yield/feddan were ATP at 150 ppm followed by ATP at 75 ppm and calcium citrate at 0.2% as well as calcium chloride at 1% without significant differences among them. In addition, all used treatments increased significantly number of pods/plant, except Ca citrate at 0.1% which did not reflected any significant effect regarding number of pods/plant and calcium chloride at 0.5% regarding average pod weight. The simulative effect of Ca on snap bean yield may be due to that the uptake rate of both ammonium and nitrate nitrogen by plants increased by increasing the concentration of calcium ion in the rhizosphere (Fenn *et al.,*1987).

This indicate that these plants are dramatically and adversely affected by the prevailing low temperature (cold stress) during the two growing seasons (Table1).

Table 3. Effect of spraying with two calcium sources in comparison with ATP on yield and its components of snap bean plants during fall season of 2010/ 2011 and 2011/2012

Parameters / Treatments	Yield and its components									
	No. of pods/ plant		Aver. pod weight(g)		Yield / plot (kg)		Total yield (ton/ fed.)		Pod length (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	19.3c	19.1a	3.33a	3.16b	9.655c	9.070d	3.862c	3.628d	9.7c	8.3e
Calcium chloride at 0.5%	21.8ab	20.7a	3.36a	3.25b	10.950ab	10.115c	4.380ab	4.045c	10.7b	10.0d
Calcium chloride at 1%	22.7a	21.4a	3.40a	3.28ab	11.550ab	10.497a-c	4.619ab	4.199a-c	11.0b	11.3a-c
Calcium citrate at 0.1%	21.0b	21.0a	3.44a	3.29ab	10.890b	10.420bc	4.357b	4.167bc	11.1a	10.7cd
Calcium citrate at 0.2%	21.9ab	21.4a	3.50a	3.42ab	11.512ab	11.080a-c	4.605ab	4.432a-c	11.3a	11.0bc
Adenosine triphosphate at 75ppm	21.6ab	21.9a	3.52a	3.40ab	11.435ab	11.155ab	4.573ab	4.462ab	12.3a	11.7ab
Adenosine triphosphate at 150ppm	21.7b	21.3a	3.65a	3.59a	11.840a	11.465a	4.735a	4.586a	12.7a	12.0a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test

The improving effect of ATP on yield and its components might be attributed to its positive role on enhancing photosynthesis, biosynthesis of proteins and carbohydrates assimilation diverted to the pods (El-Seifi *et al.,* 2009). The obtained results are in harmony with those reported by Abdel-Hakim *et al.*, (2012) on snap bean and Fathy *et al.,* (2000) on tomato regarding ATP effects and Fathy and Khedr (2005) and El-Tohamy *et al.*, (2006) on pepper and Favaro *et al.*, (2007) and Mohammad *et al.,* (2009) on snap bean regarding calcium effects.

Chemical constituents of pods:

Presented data in Table 4 indicate that spraying snap bean plants with ATP at 150 ppm significantly increased nitrogen and protein percentage. Also, spraying snap bean plants with ATP at 75 or 150 ppm and calcium citrate at 0.2% and calcium chloride at 1% increased P% in pods in the two seasons. On the other hand, foliar application with all tested treatments did not reflected any significant effect on potassium (%) and total carbohydrates (%) in both seasons of study. Present results are confirmed by the findings of El-Seifi *et al.,*(2009) and Abdel-Hakim *et al.*, (2012) on snap bean and Fathy *et al.,* (2000) on tomato.

Cold storage Experiment:

Weight loss percentage:

It is obvious from the data in Table 5 and Figure 1 that preharvest spraying snap bean plants with all tested substances at different concentrations had significant effect on decreasing weight loss (%) as compared to control treatment. The superior treatments in this respect were calcium chloride at 0.5% and 1% which significantly reduced weight loss (%) in the cold stored snap bean pods, where calcium chloride at 1% recorded 5.02 and 5.42%, nevertheless calcium chloride at 0.5% gave 5.14 and 5.60 % reduction in weight loss in 1^{st} and 2^{nd} seasons, respectively. Similar results were obtained by Mohammed *et al.,*(2009) on snap bean.

Table 4. Effect of spraying with two calcium sources in comparison with ATP on chemical constituents of snap bean pods during fall season of 2010/ 2011 and 2011/2012

Parameters / Treatments	Chemical constituents (%)									
	N		P		K		Protein		Total carbohydrates	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	2.30d	2.26d	0.32c	0.28b	2.11a	2.00a	14.38d	14.13d	30.00a	28.44a
Calcium chloride at 0.5%	2.32d	2.28d	0.35bc	0.30b	2.18a	2.11a	14.50d	14.26d	30.00a	29.00a
Calcium chloride at 1%	2.43c	2.40c	0.39ab	0.32ab	2.23a	2.17a	15.19c	15.00c	30.46a	29.62a
Calcium citrate at 0.1%	2.42c	2.45bc	0.36a-c	0.29b	2.17a	2.09a	15.13c	15.31bc	30.72a	28.64a
Calcium citrate at 0.2%	2.63b	2.50b	0.41ab	0.34ab	2.18a	2.11a	16.44b	15.63b	31.04a	28.84a
Adenosine triphosphate at 75ppm	2.61b	2.52b	0.36a-c	0.32ab	2.20a	2.22a	16.31b	15.75b	31.64a	29.84a
Adenosine triphosphate at 150ppm	2.73a	2.63a	0.42a	0.38a	2.50a	2.35a	17.06a	16.44a	32.44a	31.24a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test

Table 5. Effect of spraying with two calcium sources in comparison with ATP on weight loss of snap bean pods during cold storage (at 7° and 90-95 RH %) for 28 days in 2010/2011and 2011/2012 seasons

Characters / Treatments (T)	Weight loss (%)											
	Season 2010/2011						Season 2011/2012					
	Days of cold storage											
	0	7	14	21	28	Mean	0	7	14	21	28	Mean
Control	-	2.58	4.69	6.66	8.90	5.71	-	3.70	4.32	7.00	10.53	6.40
Calcium chloride at 0.5%	-	2.29	4.38	5.90	8.00	5.14	-	3.35	4.25	6.34	8.46	5.60
Calcium chloride at 1%	-	2.15	4.36	5.79	7.77	5.02	-	3.29	3.85	6.22	8.32	5.42
Calcium citrate at 0.1%	-	2.33	4.50	6.40	8.29	5.38	-	3.46	4.40	6.55	8.71	5.78
Calcium citrate at 0.2%	-	2.24	4.51	6.32	8.30	5.34	-	3.39	4.33	6.50	8.56	5.69
Adenosine triphosphate at 75ppm	-	2.50	4.60	6.52	8.43	5.51	-	3.63	4.60	6.96	9.57	6.19
Adenosine triphosphate at 150ppm	-	2.54	4.55	6.59	8.33	5.50	-	3.55	4.68	6.83	9.00	6.02
Mean	-	2.38	4.51	6.31	8.29	-	-	3.48	4.35	6.63	9.03	-
LSD at 0.05%	T = 0.12 S = 0.16 T X S = 0.23						T = 0.15 S = 0.15 T X S = 0.26					

T= Treatments S= Storage period (7, 14, 21 and 28 days from the begging of storage)

As for cold storage period, it is clear from the same data that there was a considerable increase in weight loss percentage of snap bean pods as the cold storage period prolonged, where the maximum values of weight loss was occurred at the end of cold storage period (28 days). It reached 8.29 and 9.03 % in the 1st and 2nd seasons respectively. This continues loss in weight during cold storage resulted from the loss of water by transpiration and dry matter by respiration (Atta-Aly, 1998). Similar results were obtained by El- Mogy, (2001) and Mohammad *et al.,*(2009) on snap bean. With regard to the interaction between foliar application and cold storage period the same results in Table 5 show significant effect in both seasons, the minimum weight loss percentage at the end of cold storage period (28 days) were noted in pods obtained from snap bean plants sprayed with calcium chloride at 1% which gave 7.77 and 8.32 % weight loss in the first and second seasons, respectively.

Decay percentage:

Data in Table 6 and Figure 2 reveal that preharvest spraying snap bean plants with the all tested substances at different concentrations had significant effect on decay (%) as compared to untreated plants. The superior treatments for reducing decay % were calcium chloride at both tested concentrations (0.5 and 1%). The two calcium chloride concentrations reduced decay (%) in the stored pods by about (2.59 and 2.53 %) and (2.72 and 2.61 %) with 1% and 0.5% in 1st and 2nd seasons, respectively followed by calcium citrate at 0.2% in the two seasons. Similar results were obtained by Mohammed *et al.,*(2009) on snap bean.

These results might be attributed to the fact that Ca is known to be a retardant of senescence and is a major factor in preventing physiological disorders in fruits and other plant tissues (Cheour, *et al.,* 1990). Similar results were obtained by Mohammed *et al.,*(2009) on snap bean.

Regarding cold storage period, it is clear from the same data that there was a considerable increase in decay percentage of stored snap bean pods as the cold storage period prolonged, where the maximum values of decay was occurred at the end of cold storage period (28 days) 4.68 and 4.59 % in the first and second seasons, respectively. This increase in decay (%) at the longest storage period might be due to the decrease of the biological activity of snap bean pods which in turn facilities infection of pods by microorganisms.

Concerning the interaction between foliar application and cold storage period the same results in Table 6 show significant effect in both seasons. The lowest values of decay (%) at the end of cold storage period (28 days) were noted in pods obtained from snap bean plants preharvest sprayed with calcium chloride at 1% which scored 3.97 and 4.11 % in the first and second seasons, respectively.

Table 6. Effect of spraying with two calcium sources in comparison with ATP on decay of snap bean pods during cold storage (at 7° and 90-95 RH %) for 28 days in 2010/2011and 2011/2012 seasons

Characters / Treatments (T)	Decay (%)									
	Season 2010/2011					Season 2011/2012				
	Days of cold storage									
	7	14	21	28	Mean	7	14	21	28	Mean
Control	1.00	2.53	4.56	5.26	3.51	1.00	2.66	4.72	5.65	3.34
Calcium chloride at 0.5%	1.00	1.83	3.39	4.23	2.72	1.00	2.09	3.42	4.35	2.61
Calcium chloride at 1%	1.00	1.65	3.48	3.97	2.59	1.00	1.88	3.39	4.11	2.53
Calcium citrate at 0.1%	1.00	2.40	3.76	4.51	2.90	1.00	2.33	3.61	4.66	2.87
Calcium citrate at 0.2%	1.00	2.36	3.82	4.60	2.82	1.00	2.25	3.50	4.52	2.87
Adenosine triphosphate at 75ppm	1.00	2.60	3.55	4.74	3.02	1.00	2.40	3.87	4.79	3.03
Adenosine triphosphate at 150ppm	1.00	2.83	3.51	4.80	2.99	1.00	2.47	3.78	4.70	3.11
Mean	1.00	2.30	3.76	4.68	-	1.00	2.31	3.72	4.59	-
LSD at 0.05%	T = 0.13 S = 0.14 T X S = 0.24					T = 0.12 S = 0.12 T X S = 0.21				

T= Treatments S= Storage period (7, 14, 21 and 28 days from the begging of storage)

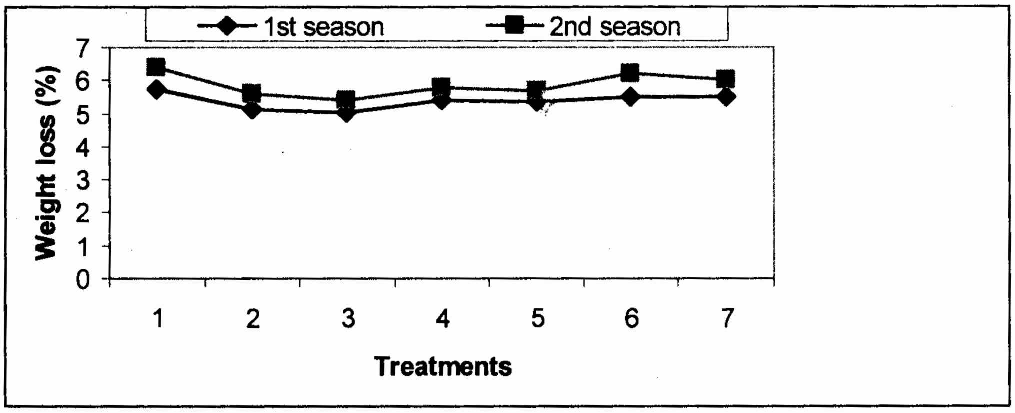

Fig.(1): Effect of spraying with two calcium sources in comparison with ATP on weight loss (%) of snap bean pods during cold storage in 2010/2011and 2011/2012 seasons

1=Control , 2= Calcium chloride 0.5% , 3= Calcium chloride 1% , 4= Calcium citrate 1% , 5= Calcium citrate 2% ,6= ATP 75ppm,7= ATP 150ppm.

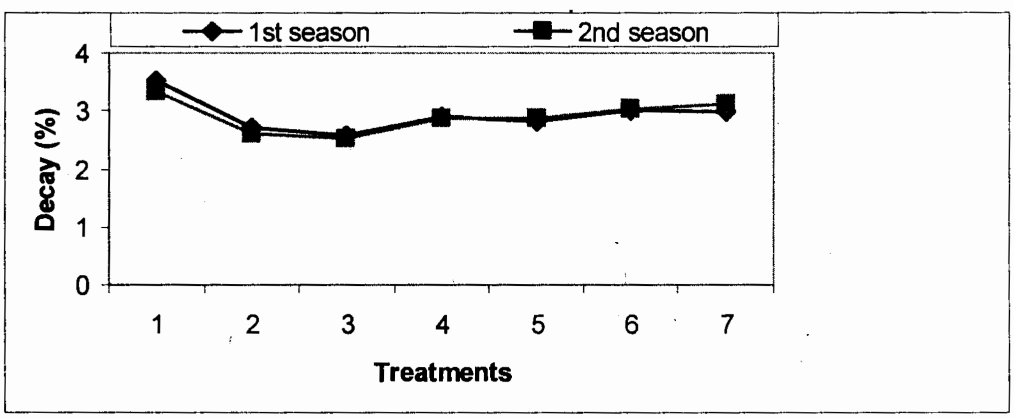

Fig.(2): Effect of spraying with two calcium sources in comparison with ATP on decay (%) of snap bean pods during cold storage in 2010/2011and 2011/2012 seasons

1=Control , 2= Calcium chloride 0.5% , 3= Calcium chloride 1% , 4= Calcium citrate 1% , 5= Calcium citrate2% ,6= ATP 75ppm,7= ATP 150ppm.

Table 7. Effect of spraying with two calcium sources in comparison with ATP on crude fiber of snap bean pods during cold storage (at 7° and 90-95 RH %) for 28 days in 2010/2011and 2011/2012 seasons

Characters / Treatments (T)	Crude fiber (%)											
	Season 2010/2011						Season 2011/2012					
	Days of cold storage											
	0	7	14	21	28	Mean	0	7	14	21	28	Mean
Control	14.43	15.26	15.94	16.61	16.94	15.34	14.75	15.34	15.80	16.43	16.65	15.79
Calcium chloride at 0.5%	13.25	14.18	14.68	15.34	15.83	14.65	13.64	14.17	14.54	15.27	15.55	14.63
Calcium chloride at 1%	12.47	13.05	13.69	14.40	15.00	13.72	12.37	13.22	13.71	14.50	15.04	13.77
Calcium citrate at 0.1%	13.86	14.50	15.21	15.72	16.22	15.10	13.81	14.66	15.09	15.71	16.18	15.07
Calcium citrate at 0.2%	13.35	14.20	14.96	15.59	16.08	14.84	13.69	14.45	14.83	15.63	16.00	14.92
Adenosine triphosphate at 75ppm	14.01	14.57	15.22	15.93	16.43	15.23	14.00	14.71	15.27	15.83	16.35	15.23
Adenosine triphosphate at 150ppm	13.92	14.48	15.10	15.86	16.39	15.15	13.86	14.64	15.13	15.75	16.29	15.13
Mean	13.61	14.32	14.97	15.64	16.13	-	13.73	14.44	14.91	15.59	16.01	-
LSD at 0.05%	T = 0.18 S = 0.17 T X S = 0.34						T = 0.19 S = 0.18 T X S = 0.35					

T= Treatments S= Storage period (7, 14, 21 and 28 days from the begging of storage)

Crude fiber percentage:

It is obvious from the data in Table 7 that spraying snap bean plants with all tested substances and at different concentrations had significant effect on decreasing crude fiber (%) as compared to untreated plants, except ATP at 75ppm in the first season. The superior treatments were calcium chloride at 1% which reduced significantly crude fiber (%) in the stored pods by 13.72 and 13.77 % followed by calcium chloride at 0.5% (14.65 and 14.63 fiber %) in 1st and 2nd seasons, respectively.

Concerning cold storage period, it is clear from the same data that there was a considerable increase in crude fiber percentage of stored snap bean pods as the cold storage period prolonged, where the maximum crude fiber percentage (16.13 and 16.01%) were occurred at the end of cold storage period (28 days) in the 1st and 2nd seasons, respectively, this may be due to moisture loss during cold storag.

Data in Table 7 show significant interaction effect in both seasons regarding crude fiber %. The lowest values of crude fiber percentage at 28 days from cold storage period were noted in pods harvested from snap bean plants preharvest sprayed with calcium chloride at 1% (15.00 and 15.04 %) in the first and second seasons, respectively.

CONCLUSION

From the previous results of this investigation, it could be concluded that preharvest spraying of snap bean plants with adenosine triphosphate (ATP) at 150 ppm or calcium chloride at 1% was the best treatments for maximizing yield and maintained snap bean pods with high quality during cold storage (at 7 °C and 90-95 RH) for 21 days, respectively.

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تحسين الإنتاجية والقدرة التخزينية للفاصوليا الخضراء عن طريق الرش الورقى بمصدرين للكالسيوم مقارنة بالأدينوسين ثلاثى الفوسفات

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أجريت هذه الدراسة خلال خريف موسمى ٢٠١٠/٢٠١١ ، ٢٠١١ / ٢٠١٢ فى مزرعة التجارب البحثية ، محطة بحوث البساتين بالقصاصين ، مركز البحوث الزراعية ، محافظة الأسماعيلية ، ومعمل معاملات مابعد الحصاد بقسم البساتين ، كلية الزراعة ، جامعة الزقازيق . يهدف هذا العمل لدراسة تأثير الرش الورقى بمصدرين للكالسيوم (كلوريد الكالسيوم ، و سترات الكالسيوم) مقارنة بالأدينوسين ثلاثى فوسفات على المحصول ومكوناته و جودة قرون الفاصوليا صنف بوليستا. كما تهدف أيضا إلى دراسة تأثير المعاملات سابقة الذكر على القدرة التخزينية لقرون الفاصوليا الخضراء خلال التخزين المبرد عند ٧ ، ١٤، ٢١، ٢٨ يوما من بداية فترة التخزين.

أدى رش نباتات الفاصوليا بمركب أدينوسين ثلاثى فوسفات بتركيز ١٥٠ جزء فى المليون إلى زيادة معنوية فى المحصول ومكوناته والمحتوى الكيماوى للقرون (الفوسفور ، والبروتين %) مقارنة بالنباتات غير المعامله ، يليه الرش بكلوريد الكالسيوم بتركيز ١% ثم سترات الكالسيوم بتركيز ٠,١%.

بصفة عامة ، أدى تخزين قرون الفاصوليا الخضراء على درجة ٧° مئوية ورطوبة جوية نسبية من ٩٠- ٩٥% إلى إنخفاض تدريجى فى صفات الجودة متمثلة فى زيادة النسبة المئوية للفقد فى الوزن ، ونسبة القرون التالفه ، ونسبة الألياف الخام بزيادة مدة التخزين حتى ٢٨ يوما.

سجلت معاملة التفاعل بين الرش بكلوريد الكالسيوم بتركيز ١% والتخزين لمدة ٢١ يوما (على درجة ٧° مئوية ورطوبة جوية نسبية من ٩٠- ٩٥%) أقل القيم بالنسبة للفقد فى الوزن ، نسبة القرون التالفه ، ونسبة الألياف الخام بقرون الفاصوليا.