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Foliar Application of Some Chemical Treatments and Planting Date Affecting Snap Bean (*Phaseolus vulgaris* L.) Plants Grown in Egypt

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Abstract: Seeds of snap bean cv. Poulista were planted in two planting dates, October 25th and November 15th (relatively cold weather), in two successive seasons of 2009/2010 and 2010/2011 in Minia, Egypt. Plants were foliar sprayed with different concentrations of yeast, potassium chloride (KCL), adenosine triphosphate (ATP), salicylic acid (SA) and water (as control) to examine the effect of these substances on plant growth, chemical composition and pod marketable yield of the snap bean plants grown under these open field cool growing conditions. Results revealed that the snap bean plants grew well when seeds were planted in the first date than the second one. Moreover, ATP, KCL and yeast in low and high concentrations enhanced growth, yield and yield components along with the chemical composition of fresh and/or dry plants and green pods. For SA, only the low concentrations used promoted the plant growth but high concentrations retarded plant growth, yield and chemical composition of minerals and protein contents. Hence, it is clear that these used substances play a role in cold stress tolerance of snap bean plants, promote plant growth and increase marketable yield.

Key words: Snap bean · Yeast · Potassium chloride (KCL) · Adenosine triphosphate (ATP) · Salicylic acid (SA) · Planting date · Cold growing seasons

INTRODUCTION

Phaseolus vulgaris L. which commonly known in Egypt as Phasolia is a member of Fabaceae (Papilionaceae) family. It is known as Common, Snap, Kidney, French or Haricot beans [1-3]. The Kidney bean is a tender annual, cultivated as a food crop in many parts of the world including the temperate, sub-tropical and tropical zones [4]. The bean plant is of two types; dwarf or bush type and pole or climbing type. Bush varieties have a short growing period and they are commonly grown in Egypt. It is one of the most important food crops in Egypt and consumed as a cooked vegetable either as dry seeds or green pods. It plays an important role in human nutrition as a cheap source for protein, carbohydrates, vitamins and minerals and is considered one of the most important vegetable crops cultivated in Egypt for exportation and for local market as well. Increasing yield of Kidney bean in Egypt is highly recommended to meet the increasing demand.

Bean plants are relatively sensitive to environmental stresses that may occur in the field compared to the other vegetable crops which negatively affect its growth, yield and even the quality of pods. Many investigations indicated that bean plants are very sensitive to chilling [5, 6]; drought [5, 7, 8] and heat stress [9]. Hence, improving tolerance of bean plants to the possible environmental stresses by using different treatments is important to enhance its growth and maximize the yield.

Plant growth and development is known to be under the control of extremely minute quantity of endogenous hormones produced within the plant. Recently, a great attention has been paid on the possibility of using natural and safe substances which are rich sources of

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phytohormones in order to improve plant growth, flowering and fruit setting. In this regard, yeasts have been reported to be a rich source of phytohormones (especially cytokinins), vitamins, enzymes, amino acids and minerals [10- 13]. It has stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation [14, 15]. It participates in a beneficial role during stress due to its cytokinins content [10].

ATP (adenosine triphosphate) is a ubiquitous energy source, but acts extracellularly as a neurotransmitter [16]. The concept of ATP and purine derivatives as extracellular signaling molecules was born in the late 1920s and early 1930s when physiological effects of adenine derivatives were discovered [17]. 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. This external role of ATP is well established in animal cells but only recently has become apparent that extracellular ATP (eATP) can also function as a signaling agent in plants [16]. Recent data have shown that eATP and other nucleotides can induce an increase in the cytosolic Ca^{2+} concentration and diverse downstream changes that influence plant growth and defense responses [18].

Salicylic acid (SA) is a phenolic derivative, distributed in a wide range of plant species. It is a natural product of phenylpropanoid metabolism. Decarboxylation of transcinnamic acid to benzoic acid and its subsequent 2- hydroxylation results to SA. It undergoes metabolism by conjugating with glucose to SA glucoside and an ester [19]. SA has direct involvement in plant growth, thermogenesis, flower induction and uptake of ions. It affects ethylene biosynthesis, stomata movement and also reverses the effects of ABA on leaf abscission. Enhancement of the level of chlorophyll and carotenoid pigments, photosynthetic rate and modifying the activity of some of the important enzymes are other roles assigned to SA [20, 21]. Salicylic acid (SA), at one stage of time, was the world's best selling drug synthesized in 1898 in Germany [22]. However, John Buchner in 1928 isolated salicyl alcohol glucoside (Salicine) from willow bark at Munich that was later named by Rafaele Piria in 1938 as salicylic acid. The word salicylic acid (SA) was derived from Latin word _gsalix_hmeaning willow tree. It is ubiquitously distributed in the whole plant kingdom [23] and is classified under the group of plant hormones [24]. SA is assigned diverse regulatory roles in the metabolism of plants [19]. This work aimed to study the effect of foliar application of some different materials and two planting dates on snap bean plants under the Middle Egypt growing conditions and study the effect of these materials on plant growth behavior, yield and cold stress tolerance.

MATERIALS AND METHODS

This work aimed to study the effect of foliar application of some different chemicals and two planting dates (two successive cool seasons on25th October and 15th November of 2009/2010 and 2010/2011, respectively) on snap bean (*Phaseolus vulgaris* L. cv. Poulista.). Two field experiments were carried out at the experimental farm in Mallawy Agricultural Research Station, Minia, Egypt. Soil samples analyses were carried out at the Soil Analysis Laboratory, Faculty of Agriculture, Minia University, Minia, Egypt according to Wilde *et al*. [25] and the average of the obtained data are shown in Table 1. Means of day temperatures are shown in Table 2.

Experimental Design: The experiments were carried out in a Randomized Complete Block Design (RCBD) with three replicates in split plots. Each plot consisted of five rows (4m length X 0.7m wide), so, the plot area was 14m^2. Two rows were used for vegetative growth trails and the other three rows were used for yield and chemical analyses. The study included twenty six treatments (two planting dates x13 treatments including the control treatment). All foliar treatments were applied three times at 30, 40, 50 days after plantation of the snap bean seeds. Details of the treatments are shown in Table 3.

Recorded Data

Vegetative Characteristics

The Following Characteristics Were Recorded:

- Plant height (cm)
- Number of branches/plant
- Plant fresh weight (g)
- Plant dry weight (g)

Yield Recorded Data: At the proper maturity stage and in each harvest from each sub-plot, the following parameters were estimated.

Table 1: Physical and chemical analyses of the experimental soil

Soil constituent	Value	Soil constituent	Value
Texture grade	Clay loam	$CaCO_3$	3.18%
Sand	7.13%	Organic matter	1.35%
Silt	56.07%	Available N	45.13 ppm
Clay	36.80%	P	11.25 ppm
pH (1.2.5 soil suspension)	8.22	K	79.15 ppm
E.C. (dslm, 1:5 soil water extract)	1.16		

E.C. = Electrical conductivity

Table 2: Monthly means of day temperatures during the fall seasons of 2009/2010 and 2010/2011 at Malawy city, Minia governorate, Egypt

	Temperature °C			
	2009 / 2010		2010 / 2011	
Month	Maximum	Minimum	Maximum	Minimum
September	35.2	19.3	34.8	20.3
October	32.9	18.1	33.5	18.6
November	25.7	11.2	26.7	12.9
December	22.4	7.5	23.3	7.7
January	22.6	6.3	22.3	6.4
February	25.8	8.8	26.0	8.9

Table 3: Chemical substances and their concentrations used in this study

Ser.	Treatments	Concentration
1	Control	Water
2	KCL	20 mM
3	KCL	30 mM
4	KCL	40 mM
5	Yeast	4.0 g/L
6	Yeast	8.0 g/L
7	Yeast	12.0 g/L
8	ATP	60 ppm
9	ATP	120 ppm
10	ATP	180 ppm
11	SA	0.5 mM
12	SA	1.0 mM
13	SA	2.0 mM

KCL: potassium chloride, ATP: adenosine tri phosphate, SA: salicylic acid.

- Average pod length (cm)
- Average pod weight (g)
- Marketable yield (ton/fed.)
- Non- marketable yield (ton/fed.)

Leaf Samples and Chemical Composition of Green Pods

Laboratory Analyses: Leaves collected 60 days after sowing were oven dried at 70 oC and digested with H_2SO_4 and H_2O_2 until constant weight according to the method of Bremner and Malvaney [26]. Total nitrogen was colorimetrically determined using a spectrophotometer according to Novozamsky *et al*. [27]. Phosphorus was colorimetrically determined using spectrophotometer according to Wilde *et al*. [25]. Potassium content was determined using a flamephotometer according to Black [28]. Some chemical composition of samples of green pods from each experimental plot were taken randomly to determine the crude protein (% N x 6.25), total carbohydrates, crude fibers, which were determined according to AOAC [29]. All determinations were performed in triplicates and the means were calculated.

Statistical Analysis: All recorded data were subjected to the analysis of variance procedures and treatment means were compared using the L.S.D. at 95% of confidence as described by Gomez and Gomez [30]. The statistical analysis was done by using the computer program MSTATC software version 4.

RESULTS AND DISCUSSION

Generally, snap bean seeds planted on October 25th (the first planting date) gave plants with better performance, higher yield values and higher protein and minerals content compared with those planted on 15th November (the second planting date) of the two successive growing years. This maybe due to snap bean plants were subjected to the cold stress during these growing seasons particularly at the flowering stages as snap bean plants are known as sensitive to cold stress.

Horticultural Characteristics

Plant Height (cm) and No. Of Branches/Plant: Snap bean plants treated with the different used substances showed significant different performances after application. Plants treated with the ATP at a concentration of 180 ppm showed high values of plant height (58.4 and 44.4 cm) in the first and second planting dates of the first season and (57.2 and 43.6 cm) in the second season, respectively, while plants treated with water or those treated with SA at a concentration of 2.0mM gave shorter plants (46.1 and 35.3 cm) and (47.2 and 34.6 cm) in the first and second planting dates of the first season and (40.0 and 32.7) and (42.8 and 30.4 cm), in the second season, respectively (Table 4). The other treatments e.g. yeast and KCL at all concentrations gave plants with values in between of the aforementioned treatments.

Table 4: Effect of different treatments on plant height (cm) and No. of branches/plant of snap bean planted in two planting dates in two successive seasons of 2009/2010 and 2010/2011

	Plant height (cm)						No. of branches / plant					
	2009/2010			2010/2011			2009/2010			2010/2011		
Treatments	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)
Control	46.1	35.3	40.7	47.2	34.6	40.9	4.3	3.7	4.0	4.7	3.8	4.2
Yeast (4 g/L)	57.4	42.3	49.9	55.8	41.8	48.8	6.3	5.3	5.8	6.6	5.5	6.0
Yeast (8 g/L)	48.7	36.4	42.5	50.1	45.5	47.8	5.2	4.6	4.9	5.6	4.8	5.2
Yeast (12 g/L)	55.4	41.1	48.2	53.3	40.2	46.7	6.0	5.0	5.5	6.1	5.1	5.6
KCL (20mM)	48.2	35.4	41.8	46.5	34.5	40.5	4.3	3.7	4.0	4.5	3.8	4.1
KCL (30mM)	51.5	36.2	43.8	47.0	34.8	40.9	5.0	3.9	4.4	5.1	4.1	4.6
KCL (40mM)	52.4	38.6	45.5	50.2	37.8	43.8	5.1	4.4	4.7	5.2	4.5	4.8
ATP (60 ppm)	56.3	41.5	48.9	54.6	41.3	47.9	6.1	5.0	5.5	6.2	4.7	5.4
ATP (120 ppm)	54.4	39.0	46.7	52.8	39.1	45.9	5.7	4.6	5.1	5.5	4.1	4.8
ATP (180 ppm)	58.4	44.4	51.4	57.2	43.6	50.4	6.8	5.1	5.9	6.6	5.0	5.8
SA (0.5 mM)	52.4	37.4	44.9	49.2	38.2	43.7	5.2	4.5	4.8	5.4	4.6	5.0
SA (1.0 mM)	54.0	38.5	46.2	51.3	39.5	45.4	5.9	4.9	5.4	6.0	4.9	5.4
SA (2.0 mM)	40.0	32.7	36.3	42.8	30.4	36.6	3.6	3.0	3.3	3.9	2.9	3.4
Mean of planting dates (A)	51.9	38.3		49.9	37.9		5.1	4.3		5.4	4.3	
L.S.D. at 0.05 for: A		0.38			0.72			0.4			0.14	
: B		0.60			0.57			0.3			0.39	
:AB		1.04			0.75			N.S.			0.40	

Table 5: Effect of different treatments on plant fresh weight (g) and plant dry weight (g) of snap bean planted in two planting dates in two successive seasons of 2009/2010 and 2010/2011

	Plant fresh weight (g)						Plant dry weight (g)					
	2009/2010			2010/2011			2009/2010			2010/2011		
Treatments	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)
Control	93.5	72.5	83.0	90.1	63.5	76.8	17.9	13.0	15.4	17	12.0	14.5
Yeast (4 g/L)	101.8	78.6	90.2	95.9	71.3	83.6	20.1	14.8	17.4	19.2	12.8	16.0
Yeast (8 g/L)	97.2	76.3	86.7	93.8	68.4	81.1	20.4	14.9	17.6	19.4	12.9	16.1
Yeast (12 g/L)	98.0	75.5	86.7	94.1	65.5	79.8	19.2	13.5	16.3	18.2	12.3	15.2
KCL (20mM)	94.6	73.3	84.1	92.3	64.8	78.5	18.5	13.5	16.0	17.4	12.3	14.8
KCL (30mM)	96.8	74.6	85.7	93.4	65.9	79.6	18.9	13.7	16.3	17.8	12.5	15.1
KCL (40mM)	95.5	75.0	85.2	94.1	65.7	79.9	19.2	13.9	16.6	18.1	12.7	15.4
ATP (60 ppm)	98.3	75.3	86.8	93.2	66.7	79.9	19.5	14.5	17.0	18.4	12.5	15.5
ATP (120 ppm)	102.8	78.2	90.3	94.8	67.4	81.1	20.6	14.9	17.8	19.1	12.4	15.7
ATP (180 ppm)	103.7	79.0	91.3	97.3	73.0	85.2	21.3	15.3	18.3	19.4	13.0	16.2
SA (0.5 mM)	95.7	74.0	84.9	93.2	65.3	79.2	20.1	14.6	17.3	18.1	12.4	15.2
SA (1.0 mM)	98.5	75.2	86.8	94.5	67.4	80.9	19.2	14.2	16.7	17.4	12.3	14.8
SA (2.0 mM)	82.0	63.1	72.5	78.2	53.1	65.6	17.2	12.3	14.7	14.5	10.7	12.6
Mean of planting dates (A)	96.1	74.3		92.2	65.5		19.1	13.9		17.8	12.3	
L.S.D. at 0.05 for: A		0.79			0.14			0.18			0.25	
: B		0.64			0.11			0.40			0.39	
:AB		0.84			0.21			NS			0.45	

The treatments application also affected the No. of branches/plant characteristic by the same way did with the plant height characteristic as yeast, ATP and KCL applications gave higher values of No. of branches/plant at all concentrations compared with those of the SA and control treatments which ranged from (5.9 to 3.3) and (6.0 to 3.4) branches/plant in the first and second planting dates of the two seasons, respectively (Table 4).

Plant Fresh and Dry Weights (g): Whole plant fresh and dry weights were also significantly affected positively or negatively by foliar application of the chemical and bio treatments. The ATP, yeast, KCL and SA (in low concentrations) increased snap bean fresh and dry weights, whereas the SA treatments (in high concentrations e.g., 2.0mM) decreased these weights comparing to the control treatment (Table 5). The highest values of the two characteristics were obtained from plants foliar treated with ATP (180 ppm) and the lowest values were obtained from those treated with SA (2.0mM). Also, data obtained from the first planting date showed significant higher values than that obtained from the second planting date as same as the other characteristics.

Pod Length (cm) and Average Pod Weight/Plant (kg): All the treatments affected the pod length and average pod weight/plant characters. Both ATP (180 ppm) and yeast (4g/L) increased the values of these characters in both seasons and the average of pod length values were 14.2 and 14.1 cm in the first season and 14.7 and 14.0 cm

Table 6: Effect of different treatments on pod length (cm) and average pod weight/plant (kg) of snap bean planted in two planting dates in two successive seasons of 2009/2010 and 2010/2011

	Pod length (cm)						Average pod weight/plant (kg)					
	2009/2010			2010/2011			2009/2010			2010/2011		
Treatments	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)
Control	12.5	9.0	10.7	13.0	8.5	10.7	5.1	3.4	4.2	4.8	3.0	3.9
Yeast (4 g/L)	15.4	12.8	14.1	15.7	12.4	14.0	5.6	3.7	4.6	5.4	3.6	4.5
Yeast (8 g/L)	14.8	11.5	13.1	15.2	11.5	13.3	5.4	3.6	4.5	5.3	3.4	4.3
Yeast (12 g/L)	14.5	11.4	12.9	15.0	11.9	13.4	5.5	3.5	4.5	5.4	3.5	4.4
KCL (20mM)	13.1	10.4	11.7	13.3	9.4	11.3	5.2	3.3	4.2	5.1	3.1	4.1
KCL (30mM)	13.4	11.2	12.3	13.7	10.5	12.1	5.2	3.3	4.3	5.2	3.2	4.2
KCL (40mM)	13.8	11.6	12.7	14.1	11.1	12.6	5.3	3.3	4.3	5.3	3.3	4.3
ATP (60 ppm)	15.1	12.6	13.8	15.4	12.0	13.7	5.4	3.6	4.5	5.3	3.5	4.4
ATP (120 ppm)	14.6	12.0	13.3	14.5	11.5	13.0	5.3	3.6	4.4	5.3	3.4	4.4
ATP (180 ppm)	15.7	12.8	14.2	16.2	13.2	14.7	5.6	3.7	4.6	5.6	3.8	4.7
SA (0.5 mM)	13.9	11.3	12.6	13.6	10.3	11.9	5.3	3.4	4.4	5.1	3.2	4.2
SA (1.0 mM)	14.3	11.6	12.9	14.4	11.2	12.8	4.8	3.2	4.0	5.3	3.4	4.4
SA (2.0 mM)	9.2	7	8.1	11.4	6.0	8.7	3.4	3.2	3.3	3.2	2.3	2.7
Mean of planting dates (A)	13.6	10.7		14.0	10.3		5.1	3.4		5.0	3.2	
L.S.D. at 0.05 for: A	0.08			0.43			0.05			0.04		
: B	0.42			0.43			0.09			0.08		
:AB	0.49			0.66			0.11			0.08		

Table 7: Effect of different treatments on marketable and non-marketable yield of snap bean planted in two planting dates in two successive seasons of 2009/2010 and 2010/2011

	Marketable yield (ton/fed)						Non-marketable yield (ton/fed)					
	2009/2010			2010/2011			2009/2010			2010/2011		
Treatments	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)
Control	3.9	2.6	3.3	3.7	2.5	3.1	0.8	0.6	0.7	0.7	0.6	0.6
Yeast (4 g/L)	5.1	3.4	4.2	4.7	3.3	4.0	0.3	0.3	0.3	0.3	0.3	0.3
Yeast (8 g/L)	4.7	3.1	3.9	4.4	3.0	3.7	0.3	0.3	0.3	0.3	0.3	0.3
Yeast (12 g/L)	5.0	3.2	4.1	4.5	3.1	3.8	0.4	0.4	0.4	0.4	0.4	0.4
KCL (20mM)	4.2	2.8	3.5	3.9	2.6	3.2	0.6	0.5	0.5	0.5	0.5	0.5
KCL (30mM)	4.4	2.9	3.7	4.1	2.8	3.4	0.5	0.4	0.4	0.4	0.4	0.4
KCL (40mM)	4.5	3.1	3.8	4.3	3.0	3.6	0.4	0.4	0.4	0.4	0.4	0.4
ATP (60 ppm)	4.4	3.0	3.7	4.1	2.8	3.4	0.4	0.4	0.4	0.4	0.4	0.4
ATP (120 ppm)	4.8	3.2	4.0	4.5	3.1	3.8	0.4	0.3	0.3	0.4	0.3	0.3
ATP (180 ppm)	5.6	3.8	4.7	4.9	3.4	4.2	0.3	0.2	0.2	0.2	0.2	0.2
SA (0.5 mM)	4.4	3.0	3.7	4.0	2.8	3.4	0.5	0.4	0.4	0.4	0.4	0.4
SA (1.0 mM)	4.8	3.3	4.0	4.5	3.1	3.8	0.4	0.3	0.3	0.3	0.3	0.3
SA (2.0 mM)	2.6	2.3	2.4	2.9	2.0	2.4	0.5	0.4	0.5	0.5	0.4	0.4
Mean of planting dates (A)	4.4	2.9		4.1	2.8		0.5	0.4		0.4	0.4	
L.S.D. at 0.05 for: A	0.09			0.11			0.05			0.03		
: B	0.08			0.18			0.05			0.04		
:AB	0.14			0.27			N.S.			0.05		

in the second season, respectively for the two treatments comparing with the control treatment which gave 10.7 cm in the two seasons with significant differences among them. The average pod weight/plant showed almost the same trend as both ATP (180 ppm) and yeast (4g/L) increased the values of this characteristic in both seasons. The average values were 4.6 kg for both of them in the first season and 4.7 and 4.5 kg in the second season, respectively comparing to the control treatment (4.2 and 3.9 kg in both seasons, respectively). For both characteristics, the lowest values were given by the SA (at 2.0mM) treatment (8.1 and 8.7cm and 3.3 and 2.7 kg, respectively) with significant differences when comparing with the other treatments (Table 6).

Marketable and Non-marketable Yield (Ton/Fed): Data in Table 7 showed that treating the plants with all described treatments in different concentrations increased the obtained marketable snap bean yield comparing to the control treatment except for the SA treatment (at 2.0mM) concentration. The ATP treatment gave the highest values (4.7 and 4.2 ton/fed) in the first and second seasons, respectively followed by the yeast treatments, the KCL treatments and the SA treatments. On the contrary, the oboist trend was observed for the non-marketable yield (non-desirable characteristic) as the ATP treatments gave the lowest values (0.2 ton/fed) in the two seasons and the control treatment gave the highest values (0.7 and 0.6 ton/fed) in the first and second seasons, respectively.

Table 8: Effect of different treatments on fibers and carbohydrates of snap bean planted in two planting dates in two successive seasons of 2009/2010 and 2010/2011

	Fibers content (%)as dry weight						Carbohydrates content (%) as dry weight					
	2009/2010			2010/2011			2009/2010			2010/2011		
Treatments	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)
Control	17.2	16.3	16.7	16.7	15.0	15.9	16.5	15.0	15.7	15.0	14.2	14.6
Yeast (4 g/L)	11.2	10.5	10.8	10.8	10.3	10.5	18.9	16.3	17.6	16.6	15.5	16.0
Yeast (8 g/L)	12.4	12.2	12.3	12.1	12.0	12.0	180	15.4	16.7	15.8	14.8	15.3
Yeast (12 g/L)	13.1	13.0	13.0	12.9	12.8	12.8	18.3	16.0	17.1	16.3	15.3	15.8
KCL (20mM)	15.3	14.8	15.0	14.9	14.8	14.8	16.7	15.0	15.8	15.0	14.5	14.7
KCL (30mM)	14.6	14.3	14.4	14.4	14.3	14.4	16.9	15.2	16.0	15.3	14.8	15.0
KCL (40mM)	14.0	13.9	13.9	13.9	13.5	13.7	17.4	15.5	16.4	15.7	14.9	15.3
ATP (60 ppm)	14.3	13.9	14.1	14.1	13.9	14.0	17.8	16.2	17.0	16.4	15.4	15.9
ATP (120 ppm)	13.0	12.6	12.8	12.4	12.2	12.3	17.4	15.8	16.6	15.9	14.9	15.4
ATP (180 ppm)	10.1	9.8	9.9	9.8	9.7	9.7	19.2	16.5	17.8	16.8	15.6	16.2
SA (0.5 mM)	12.6	12.5	12.5	12.4	12.4	12.4	17.9	15.3	16.6	15.6	15.2	15.4
SA (1.0 mM)	13.5	13.1	13.3	13.2	13.3	13.2	18.1	16.2	17.1	16.3	15.4	15.8
SA (2.0 mM)	15.8	15.4	15.6	15	14.9	14.9	14.3	12.7	13.5	13.5	10.2	11.8
Mean of planting dates (A)	14.3	13.8		13.9	13.4		17.3	15.4		15.6	14.6	
L.S.D. at 0.05 for: A	0.13			NS			0.13			0.05		
: B	0.11			0.46			0.17			0.04		
:AB	0.12			0.64			0.30			0.08		

Table 9: Effect of different treatments on nitrogen (N) and protein content in green pods (%) and of snap bean planted in two planting dates in two successive seasons of 2009/2010 and 2010/2011

	Nitrogen (N) content (%) as dry weight						Protein content in green pods (%)					
	2009/2010			2010/2011			2009/2010			2010/2011		
Treatments	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)
Control	2.1	2.3	2.2	2.2	1.8	2.0	3.3	2.6	3.0	3.0	2.4	2.7
Yeast (4 g/L)	3.2	3.4	3.3	3.1	2.6	2.8	4.4	3.6	4.0	4.2	3.5	3.9
Yeast (8 g/L)	2.9	3.1	3.0	2.9	1.9	2.4	3.7	2.9	3.3	3.6	2.8	3.2
Yeast (12 g/L)	2.8	3.5	3.0	3.2	1.8	2.5	4.1	3.4	3.7	4.0	3.3	3.6
KCL (20mM)	2.2	2.3	2.2	2.2	1.9	2.0	3.4	2.8	3.1	3.2	2.7	2.9
KCL (30mM)	2.5	2.6	2.5	2.5	2.1	2.3	3.5	2.9	3.2	3.4	2.9	3.2
KCL (40mM)	2.7	2.8	2.7	2.7	2.1	2.4	3.7	3.2	3.4	3.5	3.2	3.4
ATP (60 ppm)	2.4	3.9	3.1	2.5	2.0	2.2	4.3	3.5	3.9	3.8	3.4	3.6
ATP (120 ppm)	2.6	2.9	2.7	2.8	2.2	2.5	3.8	3.2	3.5	3.5	3.2	3.3
ATP (180 ppm)	3.2	3.4	3.3	3.3	3.0	3.1	5.3	4.4	4.8	5.1	4.5	4.8
SA (0.5 mM)	2.3	2.6	2.4	2.5	2.1	2.3	4.0	3.5	3.7	3.4	3.0	3.2
SA (1.0 mM)	2.7	3.0	2.8	2.9	2.5	2.7	4.3	3.8	4.0	4.0	3.4	3.7
SA (2.0 mM)	1.5	1.9	1.7	1.6	1.3	1.4	2.4	2.1	2.2	2.2	1.8	2.0
Mean of planting dates (A)	2.8	2.4		2.5	2.0		3.7	3.1		3.5	2.9	
L.S.D. at 0.05 for: A	0.03			0.03			0.09			0.08		
: B	0.04			0.04			0.10			0.09		
:AB	0.08			0.05			0.13			0.17		

Chemical Composition of Plants and Green Pods

Fibers and Carbohydrates Content (As a Percentage of t he Dry Weight): High fibers content values (as a non-desirable characteristic) were obtained from the non-treated plants (16.7 and 15.9%) in the first and second season, respectively followed by the SA treatments (15.6% at the 2.0mM concentration). On the other hand, the lowest values were obtained from plants treated with the ATP treatment at the 180 ppm concentration (9.9 and 9.7%) in the first and second season, respectively (Table 8). In regards to the carbohydrates content, both ATP and yeast treatments in the used low and high concentrations gave higher values of carbohydrates content (17.8 and 17.6% in the first season and 16.2 and 16.0 % in the second season, respectively) comparing to the control treatment which gave 15.7 and 14.6% in the first and second seasons, respectively. The lowest values of carbohydrates content was obtained by treating the snap bean plants with SA at 2.0 mM (13.5 and 11.8% in the first and second seasons, respectively) as shown in Table 8.

Minerals (As Percentages of the Dry Weight) and Protein (In Green Pods) Contents: Generally, all minerals content and also the protein content values were significantly higher in the first planting date than that of the second planting date (Tables 9 and 10). Also, the treatments and their concentrations showed significant effects of the treated snap bean plants. In the first season, the ATP (at 120 ppm) and yeast (at 4.0 g/L) gave the

Table 10: Effect of different treatments on phosphorus (P) and potassium (K) content in green pods (%) and of snap bean planted in two planting dates in two successive seasons of 2009/2010 and 2010/2011

	Phosphorus (P) content (%)as dry weight						Potassium (K) content (%)as dry weight					
	2009/2010			2010/2011			2009/2010			2010/2011		
Treatments	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)	1st date	2nd date	Mean of treatments (B)
Control	0.32	0.22	0.27	0.25	0.18	0.21	1.81	2.11	1.96	1.90	1.65	1.77
Yeast (4 g/L)	0.48	0.37	0.42	0.39	0.29	0.34	2.52	2.64	2.58	1.53	2.22	2.37
Yeast (8 g/L)	0.37	0.28	0.32	0.31	0.23	0.27	2.29	2.49	2.39	2.41	1.93	2.17
Yeast (12 g/L)	0.43	0.32	0.37	0.35	0.26	0.30	2.19	2.40	2.29	2.34	1.80	2.07
KCL (20mM)	0.35	0.26	0.30	0.30	0.22	0.26	2.06	2.30	2.18	2.22	1.81	2.01
KCL (30mM)	0.39	0.30	0.34	0.32	0.26	0.29	2.28	2.44	2.36	2.35	1.99	2.17
KCL (40mM)	0.42	0.35	0.38	0.36	0.30	0.33	2.40	2.51	2.45	2.44	2.15	2.29
ATP (60 ppm)	0.36	0.27	0.31	0.28	0.21	0.24	2.19	2.38	2.28	2.25	1.92	2.08
ATP (120 ppm)	0.42	0.31	0.36	0.32	0.25	0.28	2.36	2.52	2.44	2.38	2.15	2.26
ATP (180 ppm)	0.51	0.37	0.44	0.40	0.30	0.35	2.54	2.63	2.58	2.53	2.30	2.41
SA (0.5 mM)	0.36	0.27	0.31	0.29	0.23	0.26	2.00	2.28	2.14	2.20	1.83	2.01
SA (1.0 mM)	0.42	0.32	0.37	0.34	0.27	0.30	2.20	2.43	2.31	2.30	2.00	2.15
SA (2.0 mM)	0.26	0.18	0.22	0.20	0.14	0.17	1.53	2.22	1.87	1.58	1.30	1.44
Mean of planting dates (A)	0.37	0.28		0.30	0.23		2.35	2.11		2.19	1.87	
L.S.D. at 0.05 for: A	0.03			0.03			0.15			0.33		
: B	0.04			0.04			0.14			0.10		
:AB	0.05			0.05			0.18			NS		

highest values of N content in the dried snap bean plants (3.3 %) with a double fold than that of the SA (2.0 mM) which gave 1.7% comparing to the control treatment (2.2%) with significant differences with all the other treatments. In the second growing season, the treatments behaved the same trend as the first season but with little lower values for each treatment (Table 9).

Protein content was determined in the green pods of snap bean plants and values were higher in the first planting date than in the second one as shown in Table 9. Furthermore, both ATP (at 180 ppm) and yeast (at 4.0 g/L) treatments gave the highest values of protein content (4.8 and 4.0%) in the first season and (4.8 and 3.9%) in the second season, respectively. On the other hand the SA (at 2.0mM) gave the lowest values of protein content (2.2 and 2.0%) in the first and second seasons, respectively comparing to the control treatment which gave 3.0 and 2.7%, in the first and second seasons, respectively (Table 9).

The same behavior of treatments effect on P and K contents was observed in non-treated or treated snap bean plants. Data shown in Table (10) showed that both ATP (at 180 ppm) and yeast (at 4.0 g/L) treatments gave the highest values of P and K (0.44 and 0.42 %) in the first season and (0.35 and 0.34%) in the second season, respectively for P content and (2.58 and 2.85) in the first season and (2.41 and 2.37 %) in the second season, respectively for K content. On the contrary, the SA treatment (at 2.0mM) gave the lowest values of P and K (0.22 and 1.87 %) in the first season and (0.17 and 1.44 %) in the second season, respectively comparing to the control treatments which gave (0.27 and 1.96%) in the first season and (0.21 and 1.77%) in the second season for P and K contents, respectively (Table 10).

DISCUSSION

These results showed that spraying the snap bean plants with yeast in different concentrations enhanced plant growth and most of the studied characteristics. Yeasts have been reported to be a rich source of phytohormones (especially cytokinins), vitamins, enzymes, amino acids and minerals [10-12]. Moreover, it has stimulatory effects on cell division and cell enlargement, protein and nucleic acid synthesis and chlorophyll formation [14, 15]. It participates in a beneficial role during stress due to its cytokinins content [10]. Improving growth and productivity of vegetable crops by application of active yeast extract were recorded by prior studies on beans [11, 31]; eggplant [32, 33]; tomatoes [34, 35] and peas [36, 37]. Likewise, such enhancement effect of active yeast extract on growth and fruiting of horticultural plants was recorded on vines [34, 38-40] as well as by Atawia and El-Desouky [41] and Hegab *et al*. [42] on citrus.

Nassar *et al*. [43] studied the influence of different levels from active yeast extract on vegetative growth, anatomy and productivity of kidney bean plants and their results revealed that foliar application with active yeast extract at the relatively low used concentration of 25 ml/L showed non significant effects on all studied morphological characters of vegetative growth, yield of

green pods/plant, seed yield per plant and its related characters as well as on seed quality of Kidney bean cv 'Giza 6' in both studied seasons. On the other hand, foliar application with the relatively median used concentration of 50 ml (Active Yeast Extract) AYE/L as well as with the relatively high used concentrations of 100 and 150 ml AYE/L induced significant promotive effects on all investigated morphological characters (plant height, number of branches/plant, number of leaves/plant, total leaf area/plant and shoot dry weight/plant), yield of green pods/plant, number of pods/plant, number of seeds/plant, seed yield/plant and the percentage of crude protein in seeds in both studied seasons and the maximum promotion was detected at 100 ml AYE/L.

ATP (adenosine triphosphate) is an organism's form of energy. The ATP molecule has three phosphates attached to an adenosine molecule. The last phosphate bond holds a lot of energy. When a cell from an organism (in this case, a plant) needs to perform a function, such as active transport of a molecule across the plasma membrane, the last phosphate bond is broken to release the stored energy for the function to be performed. As energy is required for cell division, the ATP is used to perform cell division. If the plant cells contain a large supply of ATP, cell division is able to occur more rapidly and more often. This means that with larger amounts of ATP, the plant is able to grow to a greater height.

Potassium chloride (KCl), known also as muriate of potash (MOP), is the most widely used source of potassium for agricultural crops. Only the cation K^+ in KCl is usually considered as one of the major plant nutrients; the accompanying anion Cl has been generally referred to as undesirable but unavoidable anion. However, Cl is now considered as an essential micronutrient for optimal growth [44]. Moreover, both K and Cl are the main ions involved in the neutralization of charges and as the most important inorganic osmotic active substances in plant cells and tissues [45]. Potassium is required by plants in different amounts (in kg unit) similar to or greater than nitrogen (N) [46]. At all levels in plants, within individual cells, tissues and in long distance transport via the xylem and phloem, K exists as a free ion in solution or as an electrostatically bound cation. Also, potassium takes part in many essential processes: enzyme activation, protein synthesis, photosynthesis, phloem transport, osmoregulation, cation-anion balance, stomatal movement and light-driven nastic movements [47, 48]. Usherwood [49] showed that potassium has been described as the "quality element" for crop production (potassium increases the protein content of plants, the starch content in grains and tubers, vitamin C and the solid soluble contents in fruits, it improves fruit color and flavor, increases the size of fruits and tubers, it reduces the incidence of pests and diseases, enhances storage and shipping quality and extends shelf life.

Potassium chloride enhanced the snap bean plants growth and yield because it is important for the proper growth and viability of plants and partially controls their osmotic and ionic regulation. Furthermore, it is an essential trace element involved in more than 300 biochemical reactions in plants, including carbohydrate and protein synthesis and has a vital role in plant physiology. It is associated with water homeostasis which is a metabolic equilibrium process actively maintained by complex biological mechanisms. On the other hand, low levels of potassium chloride in plants adversely affect photosynthesis at various levels. It also plays a role in carbon dioxide fixation.

Our results showed that using Salicylic acid (SA) as foliar applications affect the plant growth positively when it was used in low concentrations and negatively when the higher concentrations were used. Salicylic acid (SA) is a phenolic derivative, distributed in a wide range of plant species. Presently, there is no direct evidence that may be used to prove the transportability of SA. However, the physical properties of SA suggest that it could be transported, metabolized and/or conjugated in the plants [20, 21]. Moreover, the exogenously applied SA seems to be carried away from the sites of its initial application to different other tissues of the plants to generate response [22].

It is well documented that phenolic compounds exert their influence on physiological and biochemical processes including, photosynthesis, ion uptake, membrane permeability, enzyme activities, flowering, heat production and growth and development of plants. One, such a natural compound is salicylic acid that may function as plant growth regulator [50]. Khan *et al*. [51] reported that the application of salicylic acid (SA), acetylsalicyclic acid (ASA) gentisic acid (GTA) or other analogues of SA, to the leaves of corn and soybean accelerated their leaf area and dry mass production but plant height and root length remained unaffected. Out of the various concentrations of SA used, Fariduddin *et al*. [52] observed maximum increase in dry matter accumulation at a concentration of 5-10M, supplemented to the leaves of the standing plants of *Brassica juncea* but the concentrations above that proved an inhibitory action. Moreover, they added that wheat seedlings raised from the grains soaked in 5-10M of SA possessed more number of leaves and higher fresh and dry mass.

CONCLUSION

The used substances to foliar treat the snap bean plants played a positive role in cold stress tolerance of the plants, promoted plant growth and increased the marketable yield along with improving the chemical composition of snap bean green pods. Furthermore, these substances are recommended to be used by farmers as they are cheap, easy and safe and almost available for all farmers in all countries.

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