EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENTS, MAGNESIUM AND WRAPPING FILMS ON YIELD, QUALITY AND STORABILITY OF GREEN BEAN PODS

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ABSTRACT

This study was carried out under plastic house conditions during autumn seasons of 2012/2013 and 2013/2014 at the Agricultural Experiment and Researches Station, Faculty of Agriculture, Cairo University on Morelado cv. to study the effect of foliar spraying by Iron at 100 *ppm*+ Manganese at 100 *ppm* + Zinc at 50 *ppm* or Magnesium at 0.5% concentrations on productivity ,quality and storability of snap bean during storage at 6 °C and 95 % RH. Results showed that green bean plants sprayed with Iron at 100 *ppm*+ Manganese at 100 *ppm* + Zinc at 50 *ppm* were, significantly, the highest in all vegetative growth parameters compared with other treatments. Foliar application with Iron at 100 *ppm*+ Manganese at 100 *ppm* + Zinc at 50 *ppm* or magnesium at 0.5% increase leaves chlorophyll content without significant differences between them. Foliar application with Iron at 100 *ppm*+ Manganese at 100 *ppm* + Zinc at 50 *ppm* or magnesium at 0.5% , significantly increased the total yield and its components with significant differences between them and also improved the pods quality. Results showed that with prolonging the storage period at 6 °C and 90 – 95% RH ,weight loss% of pods increased, but general appearance, total chlorophyll and ascorbic acid content were reduced. Green bean pods from plants sprayed with Iron at 100 *ppm*+ Manganese at 100 *ppm* + Zinc at 50 *ppm* gave less weight loss % and high values of chlorophyll and ascorbic acid contents , also maintained good appearance for 16 days storage at 6 ºC + 95 % RH .

Concerning the effect of packaging material, snap bean pods packed in polypropylene or stretch reduced the weight loss percentage as compared with unpacked pods during storage in the two seasons, however, polypropylene film was the most effective treatment in reducing the loss in pods weight compared with those packed in stretch film. Snap bean stored in polypropylene film was perceived to have the highest intensities of freshness, greenness and crispness, while unpacked control was perceived to have low intensities of these attributes. The highest total chlorophyll content was obtained from pods packaged in polypropylene film followed by those packed in stretch film with significant differences between them. However, the lowest ones was obtained from unpacked pods during

storage. Snap bean pods packed in polypropylene or stretch film were significantly higher in ascorbic acid with no significant differences between them than unpacked pods during storage.

INTRODUCTION

Green bean (*Phaseolus vulgaris* L.) is one of the most important leguminous crops in Egypt for exportation and local consumption. Macronutrients are just as important in plant nutrition as micronutrients. Plants grown on macro or micronutrients deficit soil or soil with problems in supplying plants can exhibit similar reduction in plant growth and yield. Attempts have bean made to assess the importance of micronutrients (Mn, Fe and Zn) and macronutrients such as Mg for snap bean plants to enhance nitrogen fixation and regulate soil pH to induce microorganisms activation in rizosphere around plant root to attain maximum photosynthesis capacity, water and minerals uptake and dry matter accumulation which greatly affect snap bean plant growth and productivity.

Magnesium is the central atom of the chlorophyll molecule and play an important nonspecific role in the process of phosphate transfer. It also acts as an activator certain enzymic reactions **(Delvin and Witham, 1986).** The Mg application enhanced snap bean growth, yield and quality as reported by **Wang-Hong and Bao,(1999), Mohammed *et al*.(2009), Olivira *et al*.(2000), Swiereczewska and Sztuder (2001) and Ibrahim *et al*. (2010).**

Zinc is a component of variety of enzymes such as dehydrogenase, proteinase, peptidase and phosphoryllases(metabolism of carbohydrate, protein and phosphate). Zinc is known to simulate plant resistance to dry and hot weather and also to bacterial and fungal diseases**(Kabata and Pendias,1992, Srivasta and Gupta,1996)**. Spraying snap bean with Zn at 50 *ppm* increased pod yield and pod length **(El-Sayed, 1991a)**.

Iron is a factor for approximately 140 enzymes that catalyze unique biochemical reactions (**Brittenhan,1994**). Iron is critical for chlorophyll formation and photosynthesis and is important in the enzyme systems and respiration of plants **(Havlin *et al*.,1999).**

Spraying plants with Fe gave the highest values of growth characters and green pod yield of pea (**Mansour *et al*., 2012**). Increased total chlorophyll as well as yield and its components for broad bean **(El- Tantawy and Nawar,2013)** increased plant height, pod length and yield per plant for broad bean (**El-Tantawy and Mahmoud, 2013**) and increased fresh weight of leaves and number of leaves/ plant as well as plant height in snap bean (**El-Sayed, 1991a**).

Manganese is involved in evolution of Co_2 in photosynthesis (Hill reaction). It is a component of several enzyme systems. It has also a function in chloroplast as a part of transport system (**Srivasta and Gupta, 1996**). Spraying snap bean plants with Mn increased green pods yield and fresh weight of pod

(**El- Sayed, 1991a**), increased pod length, pod diameter and average pod fresh weight (**Mohamed and Kandeel, 1994**) and increased number of green pods / plant (**El- Bassiony *et al*., 2010**).

Concerning storage period, **Mohammed *et al.* (2009)**found that general appearance and dry matter content of snap bean pods decreased with increasing storage period, whereas weight loss, decay and off odor increased with increasing storage period. In addition, spraying snap bean plant with Mg reduced weight loss, decay and off odor of pos and gave the highest dry matter content as compared with untreated control during cold storage. Also, **Soliman (2004)** found that foliar spraying of sweet fennel plants with Mg had positive effects on reducing the incidence of weight loss and decay percentage during storage. Therefore, the objective of this work was to study the effect of foliar application with iron, manganese and zinc and magnesium on productivity and shelf life of snap bean.

MATERIALS & METHODS

1) Plastic house experiment

This experiment was carried out under plastic house conditions during autumn seasons of 2012/2013 and 2013/2014 at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University. Seeds of Morelado cultivar (an ascent cv.) were sown on 16 th and 18 th September of 2012 and 2013 seasons, respectively. The plastic house was 60 m long and 9 m wide (540 m^2) and divided into five beds, each was 1 m wide and 60 m long. The experiment occupied three beds. Seeds were sown in hills on the two sides of each bed with 50 cm apart, plants were thinned leaving one plant / hill.

The foliar application treatments were Iron (Fe)at 100 *ppm* + Manganese (Mn) at 100 *ppm* + Zinc (Zn) at 50 *ppm*, and Magnesium (Mg) at 0.5% as well as the control (sprayed with tab water), and were sprayed three times during the growth period of bean plants at 30 ,45 and 60 days after sowing. Each experimental unit received 2 l of solution for each treatment using spreading agent (super film) in all treatments.

The previous treatments were arranged in a complete randomized block design with three replicates. The area of each plot was 20 m^2 with 80 plants. Each replicate considered as one plot. Drip irrigation system and agricultural practices were followed as recommended.

The sources of Fe, Mn, Zn and Mg were iron sulphate ($FeSo_4$), Zinc sulphate ($ZnSo_4$), manganese sulphate ($Mn\ So_4$) and magnesium sulphate ($MgSo_4$), respectively. The physical and chemical properties of the loamy soil under study (Table 1) were determined at the soil and water research institute, ARC.

Table 1: Physical and chemical analysis of the experimental soil in 2013 and 2014 seasons.

Season	Clay %	Silt %	Fin sand %	Course fine %	Texture	PH	EC	Mineral nutrients (mg / kg) soil		
								N	P	K
2013	25.4	10.0	15.8	10.2	Loamy clay	8.2	3.5	30.2	21.2	301.2
2014	37.2	11.0	17.9	9.8	Loamy clay	8.0	3.7	28.1	18.7	320.4
	Cations (Mequvelant / l)				Anions (Mequvelant / l)					
	Mg^{+2}	Na^{+2}	Ca^{+2}	K +	HCO^{-3}	C^{-1}			So_4^{-2}	
2013	6.8	31.0	13.1	1.9	2.42	30.1			25.2	
2014	7.1	33.4	15.2	2.1	2.71	34.5			24.1	

Data were recorded as follows:

1. Vegetative growth

A representative sample of 6 plants was chosen at random, 60 days after sowing (flowering stage), from each experimental plot for measuring plant growth parameters , i.e. plant height , number of leaves per plant, plant fresh weight and plant dry weight (dried at 65 °C for 72 hours using the standard methods as illustrated by **A.O.A.C (1990)**. Chlorophyll reading of the sixth mature leaf was measured in SPAD unit, where SPAD = 10 mg chlorophyll /g fresh weight using digital chlorophyll meter (Model Minolta Chlorophyll meter SPAD- 502).

2. Yield and its components:

At harvest stage (75 days from seeds sowing), green pods were collected along the harvesting season (60 days) and the following data were recorded: number of pods / plant, average pod weight and total yield kg / plot.

3. Pod quality:

A random sample of 30 pods from each replicate was taken at harvest and the following characters were measured: pod length , pod thickness, total chlorophyll and ascorbic acid content.

2) Storage experiment

Snap bean pods which obtained from the previous experiment were harvested in the proper stage of marketing on 22th and 25th of November in the first and second seasons respectively then immediately transported to the Laboratory of Handling of Vegetable Crops Department at Giza. Pods uniform in length, diameter color and free from blemishes were selected for storage experiment and placed in polystyrene trays and each had 200 g of snap bean pods and served represented as one replicate and over wrapped with polypropylene (40µm thickness) or stretch film 0.9 µm beside unwrapped as a control. Twelve replicates were prepared for each packaging material and the control and then stored at 6 °C and 95 % RH for 16 days. Samples were taken randomly in 3 replicate and the samples were examined immediately after harvest and at four days intervals in a complete randomized design with three replications, for the following properties.

1. Weight loss percentage was estimated according to the following equation:
Weight loss % = initial weight of fruits-weight of fruits at sampling date /initial weight of fruits *100
2. General appearance was determined according to the following score : 9= excellent , 7 = good,5 = fair , 3= poor , 1 = unusable . This scale depends on morphological defects such as shriveling (wilting), color change of pod surface for physiological defects.
3. Total chlorophyll: total chlorophyll was determined according to **A.O.A.C.(1990)**.
4. Ascorbic acid: was determined according to **A.O.A.C.(1990).**

All data were subjected to statistical analysis according to the method described by **Snedcor and Cochran (1980).**

RESULTS AND DISCUSSION

1. Vegetative growth

Data in Table 2 showed that spraying snap bean plant with either Fe at 100 *ppm* +Mn at 100 *ppm* and Zn at 50 *ppm* or Mg at 0.5% had a beneficial effect on all studied vegetative growth parameters (plant height, number of leaves/plant, plant fresh weight and dry weight of plant compared to the control treatment. In this respect, foliar spray with Fe at 100 *ppm* +Mn at 100 *ppm* and Zn at 50 *ppm* was the most favorable treatment for enhancing growth characters significantly. On the other hand, the lowest values in this respect were recorded in the control.

As for chlorophyll reading (SPAD) in leaves, data in Table2 showed clearly that there were significant differences among foliar spray treatments and the control in total chlorophyll content in snap bean leaves during the two seasons. In this respect , the highest values of chlorophyll readings were recorded as a result of spraying snap bean plants with Mg at 0.5% (73.12 and 81.24 SPAD) in the 1 st and 2 nd seasons, respectively, followed by Fe at 100 *ppm* , Mn at 100 *ppm* and Zn at 50 *ppm* with non significant differences between them. On the other hand, the control plants recorded the lowest chlorophyll reading in leaves (68.48 and 75.23 SPAD) in the first and second seasons respectively.

Previous results revealed that vegetative growth parameters and chlorophyll reading of snap bean plants were increased due to the beneficial effects of magnesium on plant growth which may be attributed to its role as the central atom of the chlorophyll molecule and plays an important non specific role in the process of phosphate transfer and the role of Mg as an activator for certain enzymic reactions **(Allison et al., 2001)**. Many investigators reported that magnesium application caused increases in plant growth (**Darwesh and Atress, 2011)** on pea and **Mohamed *et al*. (2009) and Ibrahim *et al.*(2010)** on snap bean).

Table 2: Effect of foliar spraying with some micro elements on vegetative growth and chlorophyll reading (SPAD) of snap bean plants during 2012 / 2013 , 2013 / 2014 seasons.

Treatment	Plant Hight (cm)	No. of leaves/ plant	Plant fresh weight (g)	Plant dry weight	Chlorophyll reading (SPAD)
2012 / 2013					
Fe+ Zn+ Mn	211.52	16.34	150.26	24.65	72.50
Mg	200.45	14.83	138.41	21.72	73.12
Cont.	191.81	13.12	110.6	18.23	68.48
LSD at 0.05 level	3.11	1.14	5.36	1.42	0.70
2013 / 2014					
Fe+ Zn+ Mn	201.62	18.72	142.6	22.42	80.74
Mg	196.06	17.13	132.12	20.31	81.24
Cont.	189.35	14.57	117.46	17.1	75.23
LSD at 0.05 level	3.41	1.23	4.72	1.31	0.56

The promotive effect of iron on growth parameters and chlorophyll readings of snap bean plants, in this study, may be attributed to that iron is necessary for biosynthesis of chlorophyll and cytochrome, besides the function of iron in the metabolism of chloroplast RNA, leading to increase in the biosynthesis and materials (produced and accumulated), consequently, the growth was enhanced **(Marchner, 1995)**. Similar findings with iron foliar application were obtained by **Mansour *et al*. (2012)** on pea and **El-Tantawy and Nawar (2013)** on broad bean. Also higher number of leaves means higher interception of light and higher photosynthesis, photosynthesis is also affected by the presence of Fe and Mn(**Kirkby and Rrombeld, 2004)**. Also, **Abd- El-Lateaf *et al*. (1998)** revealed that foliar application of either Fe or Zn gave the tallest plant and increased the pods / plant and the number of branches on mung bean plant.

Concerning the effect of Zinc, **El-Tohamy and El-Greadlg (2007)** found that foliar application of snap bean plant with zinc significantly improved vegetative growth and gave higher total chlorophyll content in leaves.

Also, **Nadergoli *et al*. (2011) and Teixeira *et al*. (2004)** found that zinc and manganese activate some of enzyme systems and have an important role in cell division and cell lengthening. These two factors lead to the increase of stem height of common bean.

Yield and its components

Data in Table 3 indicated that there were significant differences due to the tested treatments in both seasons on all studied parameters of yield and its components,i.e., (number of pods/ plant, pod weight and total yield compared to the control treatment. In this connection, foliar spray with (Fe at 100 *ppm* +Mn at 100 *ppm* and Zn at 50 *ppm* significantly increased all studied yield and its components parameters followed by magnesium treatment with significant differences between them.

The enhancing effect of Mg on yield and its components, such as sugars, proteins , its regulates the uptake of other plant nutrients, especially phosphorus and it is involved in the results are in harmony with those obtained by **Darwesh and Atress (2011), Ibrahim *et al*.(2010)** and **Mohammed *et al*. (2009)** on snap bean. They reported that adding Mg caused increasing in vegetative growth, pod yield as well as gave best quality of green bean pods. Meanwhile, the enhancing effect of iron on yield and its components may be due to the increasing in photosynthetic pigments. Other investigators recorded a similar trend such as **Mansour *et al*. (2012)** on pea and **El-Tantawy and Nawar (2013)** on broad bean.

For the effect of Zn, **Karaman *et al*.(1999)** showed that dry matter production increased with foliar spray of bean plants with Zn.

Applications of micronutrients especially zinc and manganese has a positive effect on formation of stamens and pollens and we can attribute the increase of number of pods per plant to this property of micronutrients. As we know, snap bean is a self pollinated plant, so naturally as the activity of stamens increases, the flowers well fertile well and more number of pods will be produced on the plant **(Nadergoli *et al*., 2011).**

Table 3 : Effect of foliar spraying with some micro elements on yield and its components of snap bean plants during 2012 –2013 , 2013 - 2014 seasons.

Treatment	No of pods/ plant	Pod weight (gm)	Total yield(kg / m2)
2012 / 2013			
Fe+ Zn+ Mn	71.8	7.04	21.25
Mg	70.1	6.82	19.18
Cont.	66.4	6.43	16.12
LSD at 0.05 level	0.34	0.11	0.98
2013 / 2014			
Fe+ Zn+ Mn	74.4	7.27	20.53
Mg	70.2	6.90	19.40
Cont.	62.3	0.18	17.01
LSD at 0.05 level	1.11	0.23	0.74

Pod quality

Data in Table 4 showed that spraying snap bean plant with either Fe at 100*ppm* + Mn at 100*ppm* and Zn at 50 *ppm* or Mg at 0.5% increased their pod quality expressed as average pod length and ascorbic acid and chlorophyll contents with significant differences between them. In this respect, foliar spray with Fe at 100 *ppm* + Mn at 100*ppm* + Zn at 50 *ppm* was the most effective treatment for improving pod quality. These results were true in the two seasons. On the other hand, the lowest record of this character was resulted by untreated control. However, concerning pod thickness, there were no significant differences between treatments and the control in the two seasons.

The improvement of growth of bean plants in response to foliar application of Fe, Mn, Zn and Mg may result in improving quality of snap bean pods such as length and ascorbic acid and chlorophyll contents of pods (**El-**

Tohamy and El- Gready (2007) for zinc **Ibrahim *et al.* (2010)** for Mg, (**Abd-El-Lateaf *et al*., 1998**) for Fe and Zinc, **Mohamoud *et al*., (2009)** for Mn and **(Nadergoli *et al*., 2011**) for zinc and manganese.

Table 4: effect of foliar spraying with some micro elements on pod quality during 2012 - 2013 , 2013 - 2014 seasons.

Treatment	Pod length (cm)	Pod thickness (cm)	Ascorbic acid (mg/100/gFW)	Total chlorophyll(mg/100g)
2012 / 2013				
Fe+ Zn+ Mn	13.95	0.80	23.40	110.30
Mg	13.02	0.79	22.30	107.70
Cont.	12.70	0.78	19.10	102.40
LSD at 0.05 level	0.11	NS	0.92	1.24
2013 / 2014				
Fe+ Zn+ Mn	13.20	0.84	27.32	121.32
Mg	12.80	0.81	23.71	112.74
Cont.	11.60	0.77	21.40	100.32
LSD at 0.05 level	0.13	NS	1.07	1.72

Storage experiment

Weight loss percentage

Data in Table 5 showed that weight loss percentage of snap bean pods was increased considerably and consistently with the prolongation of storage period during the two seasons. These results agree with those obtained by **Mohammed *et al.* (2009)**. The loss in weight may be attributed to respiration and other senescence related metabolic processes during storage (**Wills *et al*., 1989**).

Concerning the effect of foliar spray with micro elements, data showed that snap bean pods obtained from plants treated with (Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm*) or Mg at 0.5% showed reduction in the weight loss percentage during storage in comparison with untreated control. However, snap bean pods obtained from plants treated with Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* suppressed the loss in weight than those obtained from Mg treatment during storage in the two seasons these results agree with those obtained by **Mohammed *et al.* (2009)** on snap bean and **Atrees and Mohamed (2014)** on broccoli. Such results may be due to the beneficial effect of iron and zinc (**Lashkeri *et al*., 2007, Mansour *et al*.,2012)** and magnesium **(Kiss, 1989,Mohammed *et al*., 2009, Ahmed *et al* (2011)., Darwesh and Atrees, 2011)** on vegetative growth and chemical composition of snap bean pods which in turn maintained the metabolic homeostasis after harvest and reduce dehydration of pods. On the contrary, snap bean pods obtained from the control recorded the highest significant weight loss percentage in both seasons.

Concerning the effect of packaging material, snap bean pods packed in polypropylene or stretch reduced the weight loss percentage as compared with unpacked pods during storage in the two seasons, however, polypropylene film was the most effective treatment in reducing the loss in pods weight compared with those packed in stretch film.

The interaction between treatments and packaging materials had significant effect on weight loss percentage. The lowest value was recorded by the interaction between (Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm*) treatment and polypropylene film, while the highest value was recorded by the interaction between control treatment and unpacked pods.

The interaction between pre harvest treatments and storage period was significant in the two seasons. However, the lowest value of weight loss percentage was recorded at the end of storage period from Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* treatment.

The interaction between pre harvest treatments, packaging material and storage period was significant in both seasons, however, after 16 days of storage, snap bean pods obtained from plants treated with Fe at 100 *ppm*+ Mn at 100 *ppm* + Zn at 50 *ppm* and packed in polypropylene bags showed the least weight loss percentage. These results were true in the two seasons.

Lowest weight loss from snap bean packed in different packaging material is due to the confinement of moisture around the produce by polypropylene or stretch film. This increases the relative humidity and reduces vapor pressure deficit and transpiration. In addition, packaging creates a modified atmosphere with higher concentration of CO_2 and reduced O_2 around the produce which slows down the metabolic processes and transpiration (**Thompson, 1996**), which diminished the weight loss during storage (**Wang and Qi, 1997**). The highest weight loss observed in unpacked fruits throughout the storage period can be attributed to air movement, which tends to sweep away the unstirred layer of air at equilibrium vapor pressure with the tissues adjacent to the surface of the produce, thus increasing the vapor pressure deficits (**Wills *et al* ., 1998**).

Table 5: Effect of foliar application of micro elements , magnesium and packaging materials on weight Loss % of snap bean pods during cold storage in 2012/2013 and 2013/2014 seasons.

Treat.(T)	packaging material(P)	storage period in days (S)											
		2012/2013						2013/2014					
		0 time	4	8	12	16	mean	0 time	4	8	12	16	mean
Fe+ Zn+ Mn	polypropylene	0.00	0.10	0.13	0.18	0.32	0.15	0.00	0.14	0.19	0.23	0.43	0.20
	stretch	0.00	0.26	0.45	0.63	0.95	0.46	0.00	0.34	0.48	0.82	1.03	0.53
	control	0.00	1.93	3.11	5.72	8.25	3.80	0.00	2.11	3.32	5.16	7.62	3.63
mean		0.00	0.76	1.23	2.18	3.17	1.47	0.00	0.86	1.33	2.06	3.03	1.38
Mg	polypropylene	0.00	0.19	0.22	0.32	0.45	0.24	0.00	0.23	0.31	0.42	0.55	0.30
	stretch	0.00	0.30	0.52	0.74	1.23	0.56	0.00	0.34	0.59	0.81	1.36	0.62
	control	0.00	2.14	3.62	5.91	8.62	4.06	0.00	2.17	3.51	5.84	8.72	4.05
mean		0.00	0.88	1.45	2.32	3.43	1.62	0.00	0.91	1.47	2.36	3.54	1.66
Cont.	polypropylene	0.00	0.22	0.30	0.42	0.57	0.30	0.00	0.24	0.33	0.48	0.64	0.34
	stretch	0.00	0.37	0.65	0.86	1.38	0.65	0.00	0.42	0.72	0.81	1.45	0.68
	control	0.00	2.41	3.83	6.26	8.94	4.29	0.00	2.58	3.91	6.41	8.90	4.36
mean		0.00	1.00	1.59	2.51	3.63	1.75	0.00	1.08	1.65	2.57	3.66	1.79
Mean	polypropylene	0.00	0.17	0.22	0.31	0.45	0.23	0.00	0.20	0.28	0.38	0.54	0.28
	stretch	0.00	0.31	0.54	0.74	1.19	0.56	0.00	0.37	0.60	0.81	1.28	0.61
	control	0.00	2.16	3.52	5.96	8.60	4.05	0.00	2.29	3.58	5.80	8.41	4.02
mean		0.00	0.84	1.37	2.28	3.34	1.57	0.00	0.91	1.43	2.25	3.33	1.56
LSD at 0.05 level	T	0.10						0.09					
	P	0.11						0.11					
	S	0.12						0.11					
	T*P	0.12						0.12					
	T*S	0.14						0.17					
	P*S	0.16						0.17					
	T*P*S	0.17						0.20					

General appearance (GA)

Data in Table (6) showed that there was significant reduction in GA with the prolongation of storage period in both seasons. Similar results were reported by **Mohammed *et al.* (2009)**. The decreases in GA during storage of snap bean pods might be due to shriveling with color change and decay (**El- Mogy, 2001**).

All treatments had higher score of GA when compared with the control. However, snap bean pods obtained from plants treated with Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* or Mg at 0.5% had the best GA with significant differences between them. The worst GA recorded for the untreated control. These results were true in the two seasons and agree with those obtained by **Atrees and Mohamed (2014)** on broccoli and **Mohammed *et al.* (2009)** on snap beans. Such results may be due to the useful role of iron, Mn and magnesium in reducing weight loss percentage and maintaining green color during storage **(Atrees and Mohamed, 2014)**.

Table 6: Effect of foliar spraying of micro elements, magnesium and packaging materials on general appearance (score) of snap bean pods during cold storage in 2012/2013 and 2013/2014 seasons.

Treat. (T)	packaging material(P)	storage period in days (S)											
		2012/2013						2013/2014					
		0 time	4	8	12	16	mean	0 time	4	8	12	16	mean
Fe+ Zn+ Mn	polypropylene	9.00	9.00	9.00	9.00	7.67	8.73	9.00	9.00	9.00	8.33	7.00	8.47
	stretch	9.00	9.00	8.33	7.67	6.33	8.07	9.00	9.00	8.33	7.00	6.33	7.93
	control	9.00	9.00	7.67	6.33	5.00	7.40	9.00	9.00	7.00	6.33	5.00	7.27
mean		9.00	9.00	8.33	7.67	6.33	8.07	9.00	9.00	8.11	7.22	6.11	7.89
Mg	polypropylene	9.00	9.00	8.33	7.67	6.33	8.07	9.00	9.00	9.00	7.67	6.33	8.20
	stretch	9.00	9.00	7.67	7.00	5.67	7.67	9.00	9.00	8.33	7.00	5.00	7.67
	control	9.00	9.00	7.00	5.67	4.33	7.00	9.00	9.00	7.67	5.00	4.33	7.00
mean		9.00	9.00	7.67	6.78	5.44	7.58	9.00	9.00	8.33	6.56	5.22	7.62
Cont.	polypropylene	9.00	9.00	7.67	6.33	4.33	7.27	9.00	9.00	7.67	6.33	5.00	7.40
	stretch	9.00	9.00	7.00	6.33	4.80	7.23	9.00	9.00	7.00	6.33	5.67	7.40
	control	9.00	8.33	6.33	4.33	3.00	6.20	9.00	9.00	5.00	3.67	3.00	5.93
mean		9.00	8.78	7.00	5.66	4.04	6.90	9.00	9.00	6.56	5.44	4.56	6.91
mean	polypropylene	9.00	9.00	8.33	7.67	6.11	8.02	9.00	9.00	8.56	7.44	6.11	8.02
	stretch	9.00	9.00	7.67	7.00	5.60	7.65	9.00	9.00	7.89	6.78	5.67	7.67
	control	9.00	8.78	7.00	5.44	4.11	6.87	9.00	9.00	6.56	5.00	4.11	6.73
mean		9.00	8.93	7.67	6.70	5.27	7.51	9.00	9.00	7.67	6.41	5.30	7.47
LSD at 0.05 level	T	0.39						0.31					
	P	0.35						0.32					
	S	0.40						0.34					
	T*P	0.42						0.36					
	T*S	NS						0.40					
	P*S	NS						0.42					
	T*P*S	0.49						0.46					

Significant differences in appearance were found between the two packaging materials and control on snap bean pods during storage. Snap bean stored in polypropylene film was perceived to have the highest intensities of freshness, greenness and crispness, while unpacked control was perceived to have low intensities of these attributes. These results were true in the two seasons and agree with those obtained by **Jia *et al*. (2009)** and **Mohamed, (2013)** on broccoli.

The interaction between treatments and packaging materials was significant in the two seasons, however, the highest score of general appearance was in pods obtained from plants treated with Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* and packed in polypropylene film. While the interaction between pre harvest treatment and storage period was significant only in the second season.

The interaction among the pre harvest treatments, packaging materials and storage period revealed that snap bean pods obtained from plants treated with Fe at 100*ppm* +Mn at 100 *ppm* and Zn at 50 *ppm* and packaged in poly propylene film did not exhibit any changes in their appearance till 12 th days and gave good appearance after 16 days of storage at 6℃ , while pods which obtained from plants treated with Mg at 0.5% and packed in polypropylene film rated good appearance after 12 days of storage. On the other hand untreated and un packed treatment rated the poorest appearance at the end of storage at 6° C. The previous results were true in the two seasons.

Total chlorophyll

Data in Table 7 showed that total chlorophyll content in snap bean pods was decreased gradually during storage. This decrement could be attributed to gradual increase in of destruction by chlorophyll degrading peroxidase (POD) activity which is transformation chloroplast to chromoplasts **(Charles and Rjb 1991)**. These result agree with those obtained from **Mohammed *et al*.,(2009)** and **Kinyuru *et al*., (2011)**.

Concerning the effect of foliar spray with micro nutrients, data revealed that snap bean pods obtained from plants treated with Fe at 100*ppm* +Mn at 100 *ppm* and Zn at 50 *ppm* or Mg at 0.5 % had the highest total chlorophyll content during storage with significant differences between them. However, the lowest ones were obtained from untreated (control). These results were true in the two seasons and agree with those obtained by **Mohammed *et al*. (2009).**

For the effect of packaging materials, data showed that there were significant differences between packaging materials and the control. The highest total chlorophyll content was obtained from pods packaged in polypropylene film followed by those packed in stretch film with significant differences between them. However, the lowest ones was obtained from unpacked pods during storage. These results were true in the two seasons and agree with those obtained **Kinyru *et al*., (2011)** who found that changes in snap bean pod color at the end of storage preceded more slowly in fruits packed in polypropylene bags, however, the colors of unpacked fruits changed rapidly.

The interaction between pre harvest treatment and packaging materials was significant, however, snap bean pods obtained from plants treated with Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* and then packed in polypropylene film had the highest value of chlorophyll content. The interaction between pre harvest treatments and storage period was significant.

The interaction among pre harvest treatments, packaging materials and storage period was significant. However after 16 days of storage, snap bean pods obtained from plants treated with Fe at 100*ppm* +Mn at 100 *ppm* and Zn at 50 *ppm* and packed in polypropylene film had the highest value of chlorophyll content, while the lowest one was found in those obtained from plants sprayed with distilled water and unpacked at the same period of storage.

Table (7): Effect of foliar spraying of micro elements , magnesium and packaging materials on total chlorophyll content (mg/100g FW) of snap bean pods during cold storage in 2012/2013 and 2013/2014 seasons

Treat. (T)	packaging material(P)	storage period in days (S)											
		2012/2013						2013/2014					
		0 time	4	8	12	16	mean	0 time	4	8	12	16	mean
Fe+ Zn+ Mn	polypropylene	110.30	108.30	105.40	101.70	98.30	104.80	98.40	96.50	93.40	90.70	87.10	93.22
	stretch	110.30	104.30	100.30	98.20	95.30	101.68	98.40	93.50	90.20	88.10	84.30	90.90
	control	110.30	102.80	95.80	90.60	84.30	96.76	98.40	90.30	87.20	83.40	80.70	88.00
	mean	110.30	105.13	100.50	96.83	92.63	101.08	98.40	93.43	90.27	87.40	84.03	90.71
Mg	polypropylene	107.70	103.40	101.50	97.20	93.70	100.70	96.20	94.30	92.00	88.80	85.70	91.40
	stretch	107.70	98.30	95.30	92.40	88.20	96.38	96.20	91.70	88.30	85.40	83.20	88.96
	control	107.70	97.70	91.20	86.30	81.10	92.80	96.20	91.30	85.10	80.20	77.40	86.04
	mean	107.70	99.80	96.00	91.97	87.67	96.63	96.20	92.43	88.47	84.80	82.10	88.80
Cont.	polypropylene	102.40	96.10	89.30	83.70	78.40	89.98	92.50	88.30	84.10	81.20	78.40	84.90
	stretch	102.40	94.20	85.10	80.30	73.10	87.02	92.50	88.20	83.40	78.50	76.20	83.76
	control	102.40	92.40	82.40	76.40	70.30	84.78	92.50	85.10	81.20	76.40	71.50	81.34
	mean	102.40	94.23	85.60	80.13	73.93	87.26	92.50	87.20	82.90	78.70	75.37	83.33
mean	polypropylene	106.80	102.60	98.73	94.20	90.13	98.49	95.70	93.03	89.83	86.90	83.73	89.84
	stretch	106.80	98.93	93.57	90.30	85.53	95.03	95.70	91.13	87.30	84.00	81.23	87.87
	control	106.80	97.63	89.80	84.43	78.57	91.45	95.70	88.90	84.50	80.00	76.53	85.13
	mean	106.80	99.72	94.03	89.64	84.74	94.99	95.70	91.02	87.21	83.63	80.50	87.61
LSD at 0.05 level	T	1.74						1.31					
	P	1.87						1.37					
	S	1.91						1.42					
	T*P	2.11						1.65					
	T*S	2.13						1.82					
	P*S	2.50						1.98					
	T*P*S	2.55						2.06					

Ascorbic acid:

Data in Table 8 showed that ascorbic acid content of snap bean pods was decreased by the prolongation of storage period. These results are true in the two seasons and agree with those obtained by **Kinyru *et al.*, (2011)** this reduction might be due to the higher rate of sugar loss through respiration than water loss through transpiration **(Wills et al., 1998)**.

Concerning the effect of foliar spray with micro nutrients, data revealed that there were significant differences between treatments in their ascorbic acid content during storage, however, snap bean pods obtained from plants treated with Fe at 100*ppm* +Mn at 100*ppm* and Zn at 50 *ppm* or Mg at 0.5% were higher in fruit ascorbic acid with significant differences between them compared with untreated (control). These results were true in the two seasons.

Regarding the effect of packaging materials, data in the same Table 8 indicated that snap bean pods packed in polypropylene or stretch film were significantly higher in ascorbic acid with no significant differences between them than unpacked pods during storage. These results were true in the two seasons and agree with those of **Kinyuru *et al.*,(2012)** who found ,in snap bean, that pods packed in different packing materials prevent ascorbic acid content degradation caused by low O_2 concentration in this way, ascorbic acid changes in plastic material treated were suppressed.

The interaction between pre harvest treatments and packaging materials was significant, however, snap bean pods obtained from plants treated with Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* and then packed in polypropylene film or stretch film had the highest values of ascorbic acid content, while, the lowest one was obtained from pre harvest control and unpacked pods.

The interaction between pre harvest treatments and storage period was non significant in the two seasons.

For the interaction among pre harvest treatments, packaging materials and storage period, data in Table7 revealed that snap bean pods obtained from plant treated with Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* and packed in polypropylene film or stretch were the best in maintaining ascorbic acid content at the end of storage period (16 days of storage).

Table 8: Effect of foliar spraying of micro elements , magnesium and packaging materials on ascorbic acid content (mg/100g FW)of snap bean pods during cold storage in 2012/2013 and 2013/2014 seasons.

Treat. (T)	packaging material(P)	storage period in days (S)											
		2012/2013						2013/2014					
		0 time	4	8	12	16	mean	0 time	4	8	12	16	mean
Fe+ Zn+ Mn	polypropylene	23.40	22.60	22.10	21.50	19.31	21.78	20.50	19.72	18.14	18.82	17.23	18.88
	stretch	23.40	22.49	22.00	21.32	19.11	21.66	20.50	19.61	18.24	18.63	17.10	18.82
	control	23.40	22.20	21.86	21.04	17.51	21.20	20.50	19.02	17.64	16.13	15.92	17.84
mean		23.40	22.43	21.99	21.29	18.64	21.55	20.50	19.45	18.01	17.86	16.75	18.51
Mg	polypropylene	22.30	21.50	20.94	20.13	17.24	20.42	19.10	18.03	17.00	16.14	15.60	17.17
	stretch	22.30	21.35	20.82	20.00	17.09	20.31	19.10	17.92	16.91	15.90	15.10	16.99
	control	22.30	21.06	20.12	19.07	15.13	19.54	19.10	16.24	14.92	13.51	11.64	15.08
mean		22.30	21.30	20.63	19.73	16.49	20.09	19.10	17.40	16.28	15.18	14.11	16.41
Cont.	polypropylene	19.10	18.06	17.12	16.10	13.36	16.75	17.70	16.60	14.90	13.52	12.31	15.01
	stretch	19.10	17.93	16.92	15.83	13.20	16.60	17.70	16.50	14.83	13.23	12.17	14.89
	control	19.10	16.23	14.82	13.50	1.13	12.96	17.70	16.04	14.12	12.93	11.02	14.36
mean		19.10	17.41	16.29	15.14	9.23	15.43	17.70	16.38	14.62	13.23	11.83	14.75
mean	polypropylene	21.60	20.72	20.05	19.24	16.64	19.65	19.10	18.12	16.68	16.16	15.05	17.02
	stretch	21.60	20.59	19.91	19.05	16.47	19.52	19.10	18.01	16.66	15.92	14.79	16.90
	control	21.60	19.83	18.93	17.87	11.26	17.90	19.10	17.10	15.56	14.19	12.86	15.76
mean		22.43	21.37	20.75	19.91	16.64	20.22	19.57	18.20	16.86	16.16	15.03	17.16
LSD at 0.05 level	T	0.24						0.23					
	P	0.24						0.24					
	S	0.26						0.28					
	T*P	0.28						0.29					
	T*S	NS						NS					
	P*S	NS						NS					
	T*P*S	0.92						0.36					

CONCLUSION

From the previous results it could be concluded that spraying snap bean plants with Fe at 100 *ppm* + Mn at 100 *ppm* and Zn at 50 *ppm* improved vegetative growth, yield and its components and pod quality. Snap bean pods obtained from this treatment and packed in polypropylene film maintained pod quality during storage for 16 days at 6℃ and 95% relative humidity.

Concerning the effect of packaging material, polypropylene film was the most effective treatment in reducing the loss in pods weight, gave the best appearence, maintained the highest total chlorophyll content and ascorbic acid compared with unpacked pods during storage.

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تأثير الرش بالعناصر الصغرى والماغنسيوم والمغلفات على المحصول والجودة والقدرة التخزينية لقرون الفاصوليا الخضراء.

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قسم بحوث تداول الخضر – معهد بحوث البساتين – مركز البحوث الزراعية**

اجريت هذه الدراسة تحت ظروف الصوب البلاستيكية خلال موسم الخريف لعامى ٢٠١٢ / ٢٠١٣ ، ٢٠١٣ /٢٠١٤ ، بمحطة التجارب الزراعية بكلية الزراعة – جامعة القاهرة على الصنف موريلادو بهدف دراسة تأثير الرش الورقى بالحديد(١٠٠ جزء فى المليون) + المنجنيز (١٠٠ جزء فى المليون) + زنك (٥٠ جزء فى المليون) والماغنسيوم بتركيز ٥. % بالاضافة الى المعاملة الكنترول على الانتاجية والجودة والقدرة التخزينية لقرون الفاصوليا الخضراء والمخزنة على ٦ °م ورطوبة نسبية ٩٥%.

اظهرت النتائج المتحصل عليها مايلى:

* وقد اوضحت النتائج ان الرش الورقى لنباتات الفاصوليا ب (الحديد + المنجنيز+ الزنك) قد ادى حدوث زيادة معنوية فى كل صفات النمو الخضرى مقارنة بالمعاملات الاخرى
* ادى رش النباتات بالماغنسيوم ٥. % و(الحديد + المنجنيز + الزنك) الى زيادة محتوى ا لاوراق من الكلوروفيل بدون وجود فرق معنوى بينهم.
* كما ادت المعاملة ب (الحديد+ المنجنيز + الزنك) والماغنسيوم الى زيادة معنوية فى كمية المحصول ومكوناته مع عدم وجود فرق معنوى بينهم كما ادت تلك المعاملات الى تحسين جوده القرون
* كما اوضحت النتائج الى ان زيادة نسبة الفقد فى الوزن وانخفاض المظهر العام والكلوروفيل وفيتامين ج لقرون الفاصوليا الخضراء مع زيادة فترة التخزين على درجة حرارة ٦ م ورطوبة نسبية ٩٠ – ٩٥ %
* قرون الفاصوليا الخضراء التى تم الحصول عليها من النباتات التى تم رشها ب (الحديد + المنجنيز + الزنك) اعطت اقل فقد وزن واعلى قيمة من الكلوروفيل وحمض الاسكوربيك ، كما احتفظت القرون بمظهر جيد لمدة ١٦ يوم من التخزين على درجة ٦ م ورطوبة نسبية ٩٠ – ٩٥ %
* قرون الفاصوليا التى تم تعبئتها فى البولى بروبلين او الاسترتش كانت اقل نسبة مئوية لفقد الوزن مقارنة بالقرون التى لم تغلف (الكنترول) ، وكانت اكثر المعاملات فاعلية فى تقليل النسبة المئوية لفقد الوزن وجدت مع تغليف القرون بالبولى بروبلين مقارنة بالقرونالتى تم تغليفها فى الاسترتش فيلم .
* قرون الفاصوليا التى تمت تعبئتها فى البولى بروبلين كانت الاكثر احتفاظ بالمظهر الطازج والاخضرار والقرمشة مقارنة بالكنترول.
* اعلى محتوى من الكلوروفيل الكلى وجد عند تعبئة قرون الفاصوليا فى البولى بروبلين يلى ذلك معاملة الاسترتش فيلم مع وجود فرق معنوى بينهم وكان اقلهم محتوى من الكلوروفيل مع معاملة الكنترول.
* اعلى محتوى من حمض الاسكوربيك وجد عند تعبئة قرون الفاصوليا فى البولى بروبلين والاسترتش بدون وجود فرق معنوى بينهم مقارنة بالكنترول.