Annals of Agric. Sci., Moshtohor **ISSN 1110-0419**
Vol. 52(2) (2014), 261–272 **http://annagricmoshj.com**

Impact of foliar spraying with iron and magnesium on growth, yield, chemical constituents and storability of broccoli

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Abstract

This study were carried out during the winter season of 2012/2013 and 2013/2014 at the Agriculture Research Farm, El-Kassasien Hort. Res. Station, Ismalia Governorate, Egypt, in sandy texture soil and the laboratory of the vegetable handling department, to study the effect of foliar spray with iron (Fe) and magnesium (Mg) i.e. Fe at 50 and 100 ppm, Mg at 0.5 and 1.0 %, Fe at 50 ppm + Mg at 0.5 %, Fe at 50 ppm + Mg at 1.0 %, Fe at 100 ppm + Mg at 0.5 % and Fe at 100 ppm + Mg at 1.0 % as well as the Control on growth, yield, chemical constituents, and storability of broccoli Sakura F_1 hybrid (*Brassica oleracea* var. *italica*), grown under sandy soil conditions using drip irrigation system. Spraying broccoli plants with Fe at 100ppm plus Mg at 0.5% or 1.0% significantly increased all the studied vegetative growth traits compared with other tested treatments with non significant differences between them. Significant increases in the yield and its components and chemical constituents of broccoli florets [Fe (ppm), Mg (ppm), nitrogen and protein %] were recorded by foliar application of Fe at 100ppm plus Mg at 0.5% or 1.0% with non significant differences between them. Regarding quality parameters of broccoli florets during storage at 5°C and 90-95% RH for 15 days, results showed that visual appearance, ascorbic acid content and external color of broccoli florets were decreased as the storage period increased. Broccoli florets obtained from plants treated with Fe at 100ppm plus Mg at 0.5% or 1.0% exhibited acceptable appearance, fresh green color florets and higher ascorbic acid (vit. C.) content during storage as compared with the control or other treatments.

Key words: broccoli, magnesium, iron, yield, chemical constituents, storage.

Introduction

Broccoli (*Brassica oleracea* var. *italica*) is a vegetable with high nutritional value and sometimes referred to as the crown jewel of nutrition due to its low caloric content, high dietary fiber and ascorbic acid levels and wide range of anticarcinogenic and antioxidant compounds (King and Morris, 1994a, and Schouten *et al*., 2009). In Egypt, broccoli is one of the promising vegetable crops for exportation. Broccoli florets produced in high quality especially in the winter season, where the agricultural products exportation to European markets was increase. Broccoli still grown in a very limited scattered areas and the total cultivated area is not exactly known (Tolba, 2005). Recently slight increased attentions towards extending the devoted cultivated areas and increasing the production of some untraditional vegetable crops including broccoli, through the pathway of nutrition for local consumption and early exportation, have been directed (Gad and Abd El-Moez 2011).

Harvested broccoli consists of hundred of immature floral buds and thick fleshy flower branchlets attached to the central plant stem, which is collectively named the head. Harvesting broccoli florets causes a series of stresses to broccoli including wounding, separation from nutrient and hormone source, and dehydration. So, harvested broccoli becomes unable to maintain metabolic homeostasis and senescence rapidly. (Huber, 1987, King and Morris, 1994a, b; Rushing, 1990; Tian *et al.*, 1994). Broccoli shelf life is mainly determined by external appearance and surface color. Techniques utilized to maintain commercial and nutritional quality of broccoli florets usually imply postharvest treatments (Hasperue *et al*., 2011). However, very little attention has been given to preharvest factors, which could affect post harvest life.

Magnesium (Mg) is an essential nutrient for plant growth and plays an important role in many plant physiological processes such as photosynthesis (Mg is the central element of the chlorophyll molecule), sugar synthesis, starch translocation, formation of plant oils and fats, control of nutrient uptake, increase iron utilization and aid nitrogen fixation in legume nodules. It also works as an enzyme activator, a constituent of many enzymes and a carrier of phosphorus in the plant (Mengel and Kirkby 1987, Marschner 1995, Allison *et al.*, 2001).

Several studies have been dealing with the role of Mg on vegetable crops, Mg as a foliar application significantly enhanced fresh weight, plant height, total and marketable curds yield and chemical composition of cauliflower leaves and curds (Ahmed *et al.*, 2011). Foliar spray with Mg at 0.5 or 1.0(g/ ℓ) led to a significant increase in plant growth parameters, total yield and potassium % as well as Magnesium % content in snow pea pods (Darwesh and Atress 2011). Spraying snap bean plants with Mg at 0.2% significantly increased number of branches per plant, N, P and K total uptake by plant, number

of pods per plant and total yield per feddan (Mohammed *et al.,* 2009).

Iron (Fe) is a factor for approximately 140enzymes that catalyze unique biochemical reactions (Brittenham, 1994). Iron is critical for chlorophyll formation and photosynthesis and is important in the enzyme systems and respiration of plants (Havlin *et al.,* 1999). Lashkari *et al.,* 2007 reported that leaf area and marketable yield of cauliflower were found significantly highest with combined foliar spray of zinc and iron at 0.5% concentration each. Spraying pea plants with Fe at 100ppm gave the highest values of growth characters, green pods yield per feddan and P content in seeds (Mansour *et al.,* 2012). Spraying broad bean plants with Fe at 500ppm increased plant height, pod length and yield per plant (El-Tantawy and Mahmoud 2013), foliar spraying of broad plants with Fe at500 ppm significantly increased chlorophyll a, b and total chlorophyll as well as yield and its components (El-Tantawy and Nawar 2013) . Kazemi, (2014) found that spraying strawberry plants with Fe at 1000mg/ ℓ improved weight of primary and secondary fruits.

The objective of this work was to study the effect of iron and magnesium on the productivity and shelf life of broccoli florets.

Materials and Methods

The field experiment:

This field experiment was carried out during the winter season of 2012/2013 and 2013/2014 at the Agriculture Research Farm, El-Kassasien Hort. Res. Station, Ismalia Governorate, Egypt, to study the effect of foliar spray with iron and magnesium on growth, yield and chemical constituents of broccoli. The physical and chemical properties of the experimental soil field are presented in Table 1 according to Chapman and Pratt (1982).

Table 1. Physical properties and chemical analysis of the experimental soil (average two seasons).

Soil parameter	Values
Physical properties (%)	
Sand	84.8
Silt	8.5
Clay	6.7
Texture	sandy
Chemical properties	
Organic matter (%)	0.29
PH	7.8
Available N (ppm)	21.4
Available P (ppm)	4.9
Available K (ppm)	119.3
Calcium carbonate (%)	3.97
Mg (ppm)	9.4
Fe (ppm)	3.9

Soil sample was taken from 25 cm soil surface.

Seeds of broccoli Sakura F_1 hybrid (*Brassica oleracea* var. *italica*) Tokita seed Co., LTD. Saitama, Japan.were sown at the nursery on 20th and 24th of September in 2012 and 2013 seasons, respectively. Seedlings were transplanted on 30th and 4th of October and November in 2012 and 2013 seasons, respectively, in the permanent field on one side of dripper lines at 40cm between plants. One dripper line ($4.2m^2$) was used to measure vegetative growth traits and the other two dripper lines ($8.4m^2$) were used for estimating yield and its components. One dripper line was left between each two experimental units without spraying as a guard row to avoid the overlapping of spraying solutions. The plot area was 12.6 m^2 every plot consisted of 3 rows 6m in length and 70 cm in width with about 48 plants in every plot. The foliar application treatments i.e. Iron (Fe) at 50 and 100 ppm, Magnesium (Mg) at 0.5and 1.0%, Fe at 50 ppm + Mg at 0.5%, Fe at 50 ppm + Mg at 1.0%, Fe at 100 ppm + Mg at 0.5% and Fe at 100 ppm + Mg at 1.0% as well as the Control (sprayed with tap water), were sprayed three times during the growth period of broccoli plants at 45, 60 and 75 days after transplanting. Each experimental unit received 2 ℓ of solution for each level and using spreading agent (super film 1ml/ ℓ) in all treatments. The untreated plants (check) were sprayed with tap water with spreading agent. The source of Iron was ferrous sulphate ($FeSO_4$), while the source of Magnesium was Magnesium sulphate ($MgSO_4$) and they obtained from El-Gomhouria Co. for trading medicines, chemicals and medical appliances, Sharkia Governorate, Zagazig, Egypt. The normal agriculture practices of broccoli under drip irrigation system were followed according to the recommendations of Ministry of Agriculture. The treatments were distributed in a randomized complete block design with three replications.

The data were recorded as follow:

Morphological characters: A random sample of three plants from each experimental unit was taken at harvesting time (100days from transplanting) to investigate growth parameters *i.e*., plant height (cm), number of leaves/plant, total fresh weight (leaves + stem)/plant (g).

Yield and its components: At harvesting time, first week of January, (100 days from transplanting) broccoli florets were picked weekly through the harvesting period till the end of season for estimation of yield parameters: diameter of main floret (cm), length of main floret (cm), average weight of florets (g) and yield of broccoli florets (ton/fed.).

Photosynthetic pigments: Chlorophyll reading was measured at harvest stage in fresh leaves by using Minolta chlorophyll meter SPAD-501as SPAD units.

Chemical constituents of florets: Previously taken sample of florets at harvest were oven dried and ground and wet digested with sulphuric acid and perchloric acid (3:1). Total nitrogen was determined according to the methods described by Bremner and Mulvaney (1982). Total Mg was estimated Flame-photometrically using Ienway Flame-photometer model Corning 400 according to Peterburgski; 1968. Total Fe was estimated using atomic absorption spectrophotometer (A Perkin-Elmer, Model 2380.usa) according to the methods of Chapman and Pratt (1982).

Total crude protein %: It was calculated by multiplying total nitrogen × 6.25.

Statistical analysis: All obtained data were subjected to the proper statistical analysis using the MSTAT statistical software and the treatments means were compared by using the LSD at 0.05 level of probability as described by Snedecor and Cochran (1980) and the differences among treatments were compared using Duncan's multiple range test (Duncan, 1958).

The storage experiment:

This experiment was conducted at the laboratory of the vegetable handling department to study the effect of spraying iron and magnesium at different rates and its combinations on maintaining quality of broccoli florets during storage. In this experiment, fresh broccoli florets which obtained from the previous field experiment were transported to the laboratory within two hours of harvest and kept overnight at 5°C and 90-95% relative humidity (RH). The following morning, the uniform and marketable florets were used from the all previous field treatments, packed in polypropylene bags 31x36cm with thickness of 30 micron sealed hermetically. Three florets of broccoli were taken and placed in carton box at the dimensions of 43x33X12cm as one replicate; and stored at 5°C and 95% RH for 15 days. The sample for each treatment was taken at random in three replications and arranged in a complete randomized design. Samples were evaluated for the changes in the quality parameters at 5, 10 and 15 days during storage.

The obtained data were recorded as follows:

1- **Weight loss percentage:** It was calculated from the difference between initial and final weight and expressed as o percentage of the initial fresh weight.
2- **Visual appearance:** It was determined using score system of 9= excellent, 7= good, 5= fair, 3= poor and 1= unmarktable. This scale depends on the morphological defects, such as wilted florets, color change of florets.
3- **Hue angle:** was measuring with (Minolta CR200, Japan) six times per head at harvest time and during the periods of storage.
4- **Ascorbic acid content (as indicator for vit. C.):** It was determined (as fresh samples of florets) by titration method using 2, 6 dicloro phenol indophenol as dicribed in Ranganna (1979).

Results and Discussion

The field experiment

Morphological characters

Data presented in Table 2 show clearly the effect of foliar spray with magnesium and iron on plant height, number of leaves and total fresh weight per plant of broccoli. It is obvious that, spraying broccoli plants with either Mg or Fe and the combination between them at different tested concentrations had a beneficial effect on all studied vegetative growth parameters compared to the control treatment. In this respect, foliar spray of broccoli plants with Fe at 100ppm plus Mg at 0.5% or Fe at 100ppm plus Mg at 1.0% significantly increased all the studied vegetative growth traits compared with other treatments with non significant differences between them except number of leaves per plant during the first season.

As for chlorophyll reading (SPAD) in leaves, the same data in Table 2 show clearly that there were significant differences among foliar spray treatments and the control treatment in total chlorophyll content in broccoli leaves during the first season of growth. On the other hand, no significant effects were recorded among the control and plants sprayed with Fe at 50 or 100ppm and magnesium at 0.5 % in the second season of growth.

In this connection, the highest values of chlorophyll reading were recorded as a result of spraying broccoli plants with Fe at 100ppm plus Mg at 1.0% (81.89 and 79.90 SPAD) in the 1st and 2nd seasons, respectively, followed by Fe at 100ppm plus Mg at 0.5% and Fe at 50ppm plus Mg at 1.0% with non significant differences among them. On the other hand, the control plants recorded the lowest values of chlorophyll reading in leaves (71.40 and 71.14 SPAD) in the first and second seasons, respectively.

Previous results revealed that vegetative growth parameters and chlorophyll reading of broccoli 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 (Allison *et al.*, 2001). Many investigators reported that magnesium application caused increases in plant growth (Ahmed *et al.*, 2011 on cauliflower, Darwesh and Atress 2011 on snow pea and Mohammed *et al.*, 2009 on snap bean). Meanwhile, the promotive effect of iron on growth parameters and chlorophyll reading of broccoli plants may be attributed to that iron is necessary for the biosynthesis of chlorophyll and

cytochrome, besides the function of iron in the metabolism of chloroplast RNA, leading to increase in the biosynthesis materials (produced and accumulated), consequently, the growth was enhanced (Marschner, 1995). Similar findings with iron foliar application were obtained by Lashkari *et al.,* (2007) on cauliflower, Mansour *et al.,* (2012) on pea and El-Tantawy and Nawar (2013) on broad bean.

Yield and its components

The results listed in Table 3 indicate the effect of foliar spray with magnesium and iron on yield and its components of broccoli plants expressed as diameter, length, weight and total yield of main floret per feddan. Such results reveal that, there were significant differences due to the tested treatments in both seasons of study on all studied parameters of yield and its components compared to the control treatment. In this connection, foliar application with iron at 100ppm plus magnesium at 1.0% significantly increased all studied yield and its components parameters followed by iron at 100ppm plus magnesium at 0.5% and iron at 50ppm plus magnesium at 1.0% with non significant differences among them. The enhancing effect of magnesium on yield and its components may be attributed to its aids in the formation of many compounds, such as sugars, proteins, its regulates the uptake of other plant nutrients, especially phosphorus and it is involved in the translocation and metabolism of carbohydrates (Kiss, 1989). These results are in harmony with those obtained by Mohammed *et al.,* (2009) on snap bean, Ahmed *et al.,* (2011) on cauliflower, Darwesh and Atress (2011) on snow pea.

Meanwhile, the enhancing effect of iron on yield and its components may be due to the increasing in photosynthetic pigments (Table3). Other investigators recorded a similar trend such as Lashkari *et al.,* (2007) on cauliflower, Mansour *et al.,* (2012) on pea, El-Tantawy and Nawar (2013) on broad bean and Kazemi, (2014) on strawberry.

Chemical constituents of broccoli florets

Data presented in Table 4 show the effect of foliar spray with magnesium and iron in single form or in a mixture at tested concentrations on chemical constituents of broccoli florets. Such results revealed that there were significant differences due to the tested treatments in both seasons of study on all studied chemical constituents i.e., total nitrogen, iron, magnesium and total crude protein percentage compared to the control treatment except dry matter

Percentage which did not significantly affected by foliar spray with both elements in the two seasons.

In this concern, the highest values of magnesium (ppm), iron (ppm) and nitrogen as well as curd protein percentages were recorded as a result of spraying broccoli plants with Fe at 100ppm plus Mg at 1.0% followed by Fe at 100ppm plus Mg at 0.5% with non significant differences between them. On the other side, control plants recorded the lowest values in this respect.

The enhancing effect of magnesium on chemical constituents of broccoli florets may be attributed to that magnesium regulates the uptake of other nutrients, especially phosphorus (Allison *et al.,* 2001). These results are in harmony with those obtained by Mohammed *et al.,* (2009) on snap bean, Ahmed *et al.,* (2011) on cauliflower, Darwesh and Atress (2011) on snow pea. Similar findings with iron foliar application were obtained by Mansour *et al.,* (2012) on pea.

The storage experiment

Weight loss percentage

The effect of foliar spraying with magnesium and iron on weight loss percentage of broccoli florets stored at 5C°and 95% RH for 15 days was summarized in Table 5. Generally, all broccoli florets obtained from plants treated with iron or magnesium and its combinations effectively reduced the weight loss percentage without any significant differences among them (except florets sprayed with Fe at 50ppm in the first season). Such results may be due to the beneficial effects of iron (Lashkari *et al.,* 2007, Mansour *et al.,* 2012 El-Tantawy and Nawar 2013) and magnesium (Kiss, 1989, Mohammed *et al.,* 2009, Ahmed *et al.,* 2011, Darwesh and Atress, 2011) on vegetative growth and chemical compositions of broccoli which in turn maintained the metabolic homeostasis after harvest and reduce dehydration of broccoli florets. On the contrary, broccoli florets obtained from non- sprayed plants (control) recorded the highest significant weight loss percentage in both seasons. With respect to storage period, the same table show an increment in weight loss percentages as the storage period extended. This result may be attributed to the loss of water by transpiration or dry mater by respiration.

The interaction between treatments and storage period was significant in both seasons.

Hue angle

Broccoli florets consists of an immature floral buds enclosed within chlorophyll-containing sepals, the chlorophyll degradation within these sepals that results in the rapid yellowing of the florets during storage. Ethylene appears to have an important role in regulating the yellowing of sepals after harvest, since chlorophyll loss is associated with the increase in floret ethylene synthesis (Tian *et al*., 1994; Pogson *et al*., 1995).

Changes in hue angle values of broccoli florets are good indicator of senescence. As shown in Table 5 non-sprayed broccoli florets (control) exhibited detectable decrease in hue angle values as compared with the other treatments. Spraying broccoli plants with iron and magnesium or its combinations gave

different statistical effects in hue angle of broccoli florets. Spraying broccoli plants by Fe at 100 ppm plus 0.5 or 1.0% Mg maintained dark green color of broccoli florets (higher values of hue angle) without significant differences between them in both seasons, followed by florets that treated with Fe at 50 ppm + 0.5 or 1.0% Mg during the first season. On the other side, no significant effect was occurred among broccoli florets obtained from plants sprayed with Fe at 50 ppm + Mg at 1.0 % and Fe at 100 ppm + 0.5 or 1.0% Mg in the second season. Generally, it could be concluded that spraying broccoli with Fe at 100 ppm + 0.5 or 1.0% Mg significantly maintained broccoli florets with dark green color and delayed broccoli senescence.

Concerning storage period it is obvious from the given data that the hue angle values of broccoli florets gradually decreased as the storage period extended indicating that broccoli florets turned to slight yellow as the storage period prolonged.

The interaction between the sprayed treatments and storage period was significant in both seasons.

Visual appearance

Broccoli is highly perishable vegetable with an accelerated senescence which leads to tissue deterioration and loss of nutritional and commercial quality (Page *et al*., 2001). Higher increase in the weight loss percentage and the higher decrease in hue angle values of broccoli florets were expressed as senescence.

Results tabulated in Table 6 reveal that broccoli florets obtained from plants sprayed with Fe at 100ppm+ 0.5 or 1.0% Mg displayed attractive appearance (high visual appearance score) for 15 days storage at 5C°and 95% RH without significant differences among them, followed by florets sprayed with Fe at 50ppm+0.5 or 1.0%Mg which displayed good appearance without significant effect among them in the two seasons. Such results due to the useful rule of iron and magnesium in reducing weight loss percentage and maintaining broccoli florets with green color during storage. Regarding storage period, it is clear that visual appearance score of broccoli florets gradually decreased as the storage period increased. In general broccoli florets become less acceptable to consume after 15 days from storage at 5C°and 95% RH for 15 days. The interaction between the used treatments and storage period was significant in the two seasons.

Ascorbic acid content

Changes in ascorbic acid contents are presented in Table 6. It may be pointed out that ascorbic acid content in broccoli florets is positively affected by the combinations between the high level of iron and the both level of magnesium as compared to the other treatments.

Treating broccoli plants with Fe at 100ppm plus Mg at 0.5 or 1.0 % Mg significantly maintained higher ascorbic acid content in broccoli florets during storage as compared with other treatments.

On the other hand, non treated florets (control), and florets treated with the two levels of Fe solely maintained lower ascorbic acid content in both seasons. Moreover, no significant effect was noticed between non treated florets (control) or florets treated with the two Fe levels in the first season. Regarding storage period, it is obvious from the obtained results that ascorbic acid content was dramatically decreased in all tested treatments as the storage period increased. The greatest decrease in ascorbic acid content was noticed at the end of the storage (15 days) in both seasons. The interaction between tested treatments and storage period was significant in both seasons.

Conclusion

From the previous results of this investigation, it could be concluded that spraying broccoli plants with Fe at 100ppm plus Mg at 1.0% or 0.5% significantly enhanced vegetative growth characters, florets chemical constituents of Fe (ppm), Mg (ppm), N and protein percentages, and yield and its components with non significant differences between them. Furthermore, broccoli florets obtained from plants treated with the previous combinations between iron and magnesium exhibited acceptable appearance, fresh green color and higher ascorbic acid content during storage as compared with the control or other treatments during storage at 5C° and 90-95% RH.

Table 2. Effect of foliar spraying with iron and magnesium on morphological characters and chlorophyll reading (SPAD) of broccoli plants during 2012/2013 and 2013/2014 seasons

Treatments	Morphological characters/plant							
	Plant height (cm)		No. of leaves		Fresh weight/ plant (g)		chlorophyll reading in leaves (SPAD unit)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	46.0d	41.0d	14.3c	13.3c	1020c	735d	71.40d	71.14c
Fe 50ppm	47.3cd	44.3cd	16.3b	14.3bc	1060bc	768cd	76.00cd	71.66c
Fe 100ppm	49.7b-d	45.0b-d	16.7b	14.3bc	1118a-c	1118ab	76.80a-c	72.83bc
Mg 0.5%	50.0bc	45.0b-d	16.3b	15.3a-c	1157a-c	995bc	76.70bc	76.07a-c
Mg 1.0%	51.0a-c	45.3b-d	17.3ab	16.3ab	1332ab	1073ab	79.60a-c	78.86ab
Fe 50ppm + Mg 0.5%	46.0d	46.7a-c	16.3b	14.0c	1277a-c	1140ab	80.22a-c	79.33ab
Fe 50ppm + Mg 1.0%	49.7b-d	49.0ab	16.3b	14.7bc	1402a	1177ab	81.38ab	79.62a
Fe 100ppm + Mg 0.5%	51.3ab	49.0ab	16.3b	15.3a-c	1407a	1210ab	81.60ab	79.37ab
Fe 100ppm + Mg 1.0%	54.3a	50.3a	18.7a	17.0a	1418a	1290a	81.89a	79.90a

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 3. Effect of foliar spraying with iron and magnesium on yield and its components of broccoli plants during 2012/2013 and 2013/2014 seasons

Treatments	Yield and its components of main florets							
	Diameter (cm)		Length (cm)		Weight (g)		Yield (ton/fed)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	20.3c	17.7c	14.7bc	11.3f	415.0d	271.7d	4.980d	3.260d
Fe 50ppm	21.7bc	19.7b	13.3c	11.7ef	420.0cd	278.3cd	5.040cd	3.340cd
Fe 100ppm	23.0b	21.0ab	16.7a	15.7a	455.0b-d	315.0b-d	5.460b-d	3.780b-d
Mg 0.5%	23.7b	22.3a	15.7ab	14.7ab	465.0b-d	371.7a-c	5.580b-d	4.460a-c
Mg 1.0%	26.3a	22.7a	16.3ab	12.7de	523.3a-d	400.0ab	6.280a-d	4.800ab
Fe 50ppm + Mg 0.5%	26.3a	21.7a	16.3ab	13.0cd	531.7a-c	381.7ab	6.380a-c	4.580ab
Fe 50ppm + Mg 1.0%	27.7a	22.7a	17.3a	12.3d-f	545.0ab	390.0ab	6.540ab	4.680ab
Fe 100ppm + Mg 0.5%	27.7a	22.7a	15.7ab	14.0bc	566.7ab	415.0a	6.800ab	4.980a
Fe 100ppm + Mg 1.0%	28.3a	23.0a	16.7a	13.3cd	583.3a	428.3a	7.000a	5.140a

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 4. Effect of foliar spraying with iron and magnesium on chemical constituents of broccoli plants during 2011/2012 and 2012/2013 seasons

Treatments	Chemical constituents of florets									
	Dry matter %		Magnesium (ppm)		Iron (ppm)		N%		Total crude protein%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	11.75a	10.22a	639d	643c	28.7e	29.7c	1.72c	1.79b	10.75c	11.19b
Fe 50ppm	11.98a	10.30a	642d	678c	34.0de	33.7bc	1.96a-c	2.04ab	12.25a-c	12.75ab
Fe 100ppm	11.82a	10.35a	647d	680c	47.7ab	49.3a	2.26a-c	2.25ab	14.13a-c	14.06ab
Mg 0.5%	11.95a	10.44a	795c	792b	30.3de	30.0c	1.83bc	1.89ab	11.44bc	11.81ab
Mg 1.0%	11.82a	11.16a	895ab	833b	31.7de	33.3bc	1.86bc	2.01ab	11.63bc	12.56ab
Fe 50ppm + Mg 0.5%	11.52a	10.74a	820bc	812b	37.7cd	36.7bc	2.15a-c	2.19ab	13.44a-c	13.69ab
Fe 50ppm + Mg 1.0%	11.10a	10.74a	837bc	835b	42.3bc	40.7b	2.39a-c	2.28ab	14.94a-c	14.25ab
Fe 100ppm + Mg 0.5%	11.84a	10.79a	974a	961a	49.7a	50.3a	2.78ab	2.67ab	17.38ab	16.69ab
Fe 100ppm + Mg 1.0%	12.55a	10.96a	983a	979a	51.0a	52.3a	2.92a	2.89a	18.25a	18.06a

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 foliar spraying with iron and magnesium on weight loss % and hue angle of broccoli florets during storage at 5° and 90-95 RH% for 15 days in 2012-2013and 2013-2014 seasons

Treatments (T)	2012-2013					2013-2014				
	Storage period (days)					Storage period (days)				
	0	5	10	15	Mean	0	5	10	15	Mean
				Weight loss (%)						
Control	-	0.14	0.17	0.19	0.16	-	0.18	0.19	0.25	0.20
Fe 50ppm	-	0.11	0.13	0.18	0.14	-	0.13	0.14	0.21	0.16
Fe 100ppm	-	0.11	0.11	0.18	0.13	-	0.12	0.14	0.21	0.15
Mg 0.5%	-	0.07	0.11	0.19	0.13	-	0.09	0.13	0.20	0.14
Mg 1.0%	-	0.07	0.12	0.19	0.13	-	0.09	0.12	0.21	0.14
Fe 50ppm + Mg 0.5%	-	0.06	0.11	0.21	0.13	-	0.05	0.14	0.23	0.14
Fe 50ppm + Mg 1.0%	-	0.05	0.12	0.21	0.13	-	0.06	0.13	0.22	0.14
Fe 100ppm + Mg 0.5%	-	0.04	0.12	0.20	0.12	-	0.06	0.13	0.22	0.13
Fe 100ppm + Mg 1.0%	-	0.04	0.12	0.19	0.12	-	0.06	0.12	0.21	0.13
Mean	-	0.78	0.12	0.19	-	-	0.09	0.13	0.21	-
LSD at 0.05%		T = 0.02	S = 0.01	T X S = 0.05			T = 0.02	S = 0.01	TX S = 0.05	
				hue angle						
Control	117.28	117.09	116.53	115.30	116.55	117.82	117.49	116.07	115.17	116.64
Fe 50ppm	119.47	117.29	116.48	115.05	117.07	118.66	118.39	115.62	115.42	117.02
Fe 100ppm	119.19	117.19	116.48	115.72	117.15	119.50	117.49	116.00	115.73	117.18
Mg 0.5%	119.99	117.46	117.17	115.60	117.55	119.01	118.21	116.44	116.22	117.47
Mg 1.0%	120.49	119.65	117.24	116.85	118.56	119.76	119.09	117.22	115.44	117.87
Fe 50ppm + Mg 0.5%	120.22	119.56	119.32	117.83	119.23	119.24	118.01	117.46	116.64	117.83
Fe 50ppm + Mg 1.0%	120.00	119.80	119.11	118.51	119.35	119.93	118.74	117.77	117.63	118.52
Fe 100ppm + Mg 0.5%	122.30	120.80	119.10	118.39	120.15	119.59	119.53	118.10	116.72	118.49
Fe 100ppm + Mg 1.0%	122.27	120.33	119.81	118.63	120.26	120.22	119.60	118.80	118.04	119.16
Mean	120.13	118.80	117.91	116.87	-	119.30	118.50	117.05	116.33	-
LSD at 0.05%		T = 0.73	S = 0.48	T X S = 1.46			T = 0.73	S = 0.49	TX S = 1.47	

S= Storage period

Table 6. Effect of foliar spraying with magnesium and iron on visual appearance, and ascorbic acid content (mg/100g FW) of broccoli florets during storage at 5° and 90-95 RH% for 15 days in 2012-2013and 2013-2014 seasons

Treatments (T)	2012-2013					2013-2014				
	Storage period (days)					Storage period (days)				
	0	5	10	15	Mean	0	5	10	15	Mean
	*Visual appearance score**									
Control	9.00	7.33	5.66	3.00	6.25	9.00	7.00	5.00	3.00	6.00
Fe 50ppm	9.00	8.00	6.00	3.33	6.58	9.00	7.33	5.00	3.00	6.08
Fe 100ppm	9.00	8.00	6.00	3.66	6.66	9.00	7.00	5.00	3.33	6.08
Mg 0.5%	9.00	8.00	6.66	5.00	7.16	9.00	8.00	6.66	4.66	7.08
Mg 1.0%	9.00	8.33	7.00	6.00	7.58	9.00	8.00	7.00	5.00	7.25
Fe 50ppm + Mg 0.5%	9.00	9.00	7.33	7.00	8.08	9.00	9.00	7.00	6.00	7.75
Fe 50ppm + Mg 1.0%	9.00	9.00	7.33	7.00	8.08	9.00	9.00	7.00	6.66	7.91
Fe 100ppm + Mg 0.5%	9.00	9.00	8.66	7.33	8.50	9.00	9.00	8.66	7.00	8.41
Fe 100ppm + Mg 1.0%	9.00	9.00	8.66	7.33	8.50	9.00	9.00	8.66	7.00	8.41
Mean	9.00	8.40	7.03	5.51	-	9.00	8.14	6.66	5.07	-
LSD at 0.05%		T = 0.27	S = 0.18	TX S = 0.54			T = 0.20	S = 0.13	TX S = 0.41	
	Ascorbic acid content (mg/100g FW)									
Control	122.18	112.50	81.50	65.63	95.45	119.45	109.00	81.00	65.63	93.77
Fe 50ppm	122.50	114.45	85.00	69.25	97.80	121.30	111.00	83.50	66.25	95.51
Fe 100ppm	122.56	114.85	85.38	69.42	98.05	121.43	111.10	84.00	66.58	95.78
Mg 0.5%	123.12	115.50	85.82	72.38	99.20	121.50	112.50	85.19	68.76	96.99
Mg 1%	123.45	116.78	86.15	72.86	99.79	121.50	112.50	85.23	69.50	97.18
Fe 50ppm + Mg 0.5%	123.45	117.72	86.55	73.28	100.25	122.33	115.31	88.33	70.25	99.06
Fe 50ppm + Mg 1.0%	123.50	117.83	94.30	74.25	102.47	123.16	115.33	88.90	70.25	99.41
Fe 100ppm + Mg 0.5%	123.72	119.00	100.25	75.00	104.50	123.37	116.16	94.15	72.50	101.54
Fe 100ppm + Mg 1.0%	123.95	119.35	100.41	75.17	104.72	123.41	116.16	94.45	73.20	101.80
Mean	123.16	116.43	89.49	71.91	-	121.94	113.23	87.19	69.21	-
LSD at 0.05%		T = 0.59	S = 0.39	TX S = 1.19			T = 0.38	S = 0.25	TX S = 0.77	

*Score: 9=Excellent, 7=Good, 5=Fair, 3=Poor, 1=Unmarketable.

Annals of Agric. Sci., Moshtohor, Vol. 52 (2) 2014.

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تأثير الرش الورقى بالحديد والماغنسيوم على النمو و المحصول و المكونات الكيماوية والقدرة التخزينية للبروكولى

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أجريت هذه الدراسة فى المزرعة البحثية بمحطة بحوث البساتين بالقصاصين بمحافظة الإسماعلية مصر ومعمل قسم بحوث تداول الخضر وذلك لدراسة تأثير الرش الورقى لنباتات البروكولى الهجين سكيورا الجيل الأول بتركيزات وتراكيب مختلفة من كل من عنصرى الحديد والماغنسيوم (مغ) وهى حديد 50 و100جزء فى المليون و مغ 0,5 و 1,0 % وحديد50 جزء فى المليون + مغ 0,5 % وحديد 50 جزء فى المليون + مغ 1,0 % وحديد 100 جزء فى المليون + مغ 0,5 % وحديد 100 جزء فى المليون + مغ 1,0 % والنامية تحت ظروف الأراضى الرملية ونظام الرى بالتنقيط على بعض الصفات الدالة على معدل النمو الخضرى والمحصول والمكونات الكيماوية والقدرة التخزينية . وقد أوضحت النتائج أن الرش الورقى لنباتات البروكولى بالحديد بتركيز 100 جزء فى المليون + 0,5 أو 1 % مغ أدى إلى حدوث زيادة معنويه فى كل صفات النمو الخضرى التى تم دراستها مقارنة بالمعاملات الأخرى فيما عدا عدد الاوراق / نبات فى الموسم الأول بدون أى فروق معنوية بينهم. وكذلك حدوث زيادة معنوية فى المحصول ومكوناته وزيادة فى تركيز الحديد والماغنسيوم (بالجزءفى المليون) والنسبة المئوية من النيتروجين والبروتين فى نورات البروكولى. كما أوضحت النتائج إنخفاض فى المظهر العام ولون ا لنورات ومحتواها من حمض الأسكوربيك مع زيادة فترة التخزين على درجة 5 مئوي ورطوبه نسبيه من 90–95 % 0 بينما أدى الرش الورقى لنباتات البروكولى التى تم الحصول عليها من النباتات المعاملة بالحديد بتركيز 100 جزء فى المليون + 0,5 أو 1 % مغ الى تقليل نسبة الفقد فى الوزن والمحتوى من حامض الاسكوربيك كما احتفظت نورات البروكولى بمظهر جيد لمدة 15 يوم من التخزين.