EFFECT OF ADDITION METHODS OF MAGNESIUM AND CALCIUM FOLIAR APPLICATION ON PRODUCTIVITY AND QUALITY OF POTATO CROP IN WINTER PLANTATION

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ABSTRACT

Two field experiments were carried out during the two successive winter seasons of 2015/2016 and 2016/2017 in the privet farm at Vegetables Farm at meet Faris village Dekarns, Dakhlia Governorate to study the effect of magnesium as application methods, and calcium rates as foliar application and the interaction between them on growth, yield and quality of potato cv. Spunta under clay soil conditions using furrow irrigation system .

Fertilized potato plants with $MgSO_4$ at 20 kg /fed. (SA) combined with 4% calcium chloride (FA) gave the highest values of plant height, number of leaves, leaf area/ plant and dry weight /shoot, N, P and K contents in leaves after 70 days form planting , number of tubers/plant, yield / plant and total yield/fed., dry matter, starch contents in both seasons without any significant differences with the interaction between $MgSO_4$ at 4 % (FA) and $CaCl_2$ at 2 or 4 % (FA) concerning the number of tubers/ plant in both seasons. While the interaction between $MgSO_4$ at 4 % (FA) and $CaCl_2$ at 4 % gave the highest values of Ca and Mg in tuber without any significant differences with $MgSO_4$ at 20 kg /fed. (SA) and $CaCl_2$ at 4 % (FA) in both seasons.

In this regard, the increases in total yield/fed. were about 41.99 and 42.22 % for the interaction between $MgSO_4$ at 20 kg /fed. (SA) and $CaCl_2$ at 4 % (FA), followed by 34.19 and 33.52 % for the interaction between $MgSO_4$ at 4 % (FA) and $CaCl_2$ at 2 % (FA) than untreated plants in the 1st and 2nd seasons, respectively.

Key words: Potato, magnesium , calcium , plant growth, yield and quality

INTRODUCTION

In Egypt, potato (*Solanum tuberosum* L.), in general , is enlisted as one of the major and most important vegetable crops as promising crop for both local consumption and exportation to the European markets and some Arabian countries and for manufacturing.

Magnesium nutrition is one of major factors that affect growth, yield and quality of potato. Its ions (Mg^{2+}) have a specific role in the activation of enzymes involved in respiration, photosynthesis and the synthesis of DNA and RNA. Magnesium is also a part of the ring structure of the chlorophyll molecule. Studies indicated that 15 to 30% of the total magnesium in plants was associated with the chlorophyll molecule. Deficiency of magnesium will seriously affect of plant growth and development, being related directly to photosynthesis (**Marschner, 1995**).

Several investigators indicated that soil application or spraying plants with magnesium enhanced plant growth, stimulated dry matter accumulation and increased yield and quality as well as chemical composition (**Allison *et al.* (2001 Radwan and Tawfik 2004**., **Awad and El-Ghamry., 2007 El-Sayed *et al.*, 2007**

and Talukder *et al.*, 2009) on potato. Other effect on some vegetable crops, **Saad and El-Kholy (2000)** on faba been , **Bardisi** (**2004)** on snap bean, **Thalooth *et al.* (2006)** on mungbean**, Ahmed *et al*. (2011)** on Cauliflower and **El-Morsy *et al*. (2011)** on garlic**,** and **Howladar *et al.* (2014)** on pea.

Adequate calcium is a critical aspect of the mineral nutrition of potatoes. Calcium is involved in both the structure and function of all plant cell walls and membranes. Inadequate supplies of calcium caused growth abnormalities like internal brown spot and hollow heart. Adequate calcium nutrition can also, improve skin color red potatoes. Abundant tissue calcium also, can increase resistance to soft rot during storage and may prove the performance of seed potatoes (**Waterer, 2005**). Calcium influence cellular pH and also, act as a regulatory ion in the source sink translocation of Carbohydrates through its effects in cells and cell walls. Calcium is needed for cell wall strengthening and provides protection against biotic and abiotic stresses (**Aranda-Peres *et al*., 2009**)

Several researchers showed that treated potato plants with calcium increased plant growth , yield and tuber quality (**Al-Hamzawi, 2010** on cucumber; **Abdur and Ihsan-ul, 2012; Rab and Haq, 2012; Ilyas*, et al.* , 2014; Kazemi, 2014** on tomato**, Hamdi *et al*., 2015 Helal and AbdElhady, 2015** on potato**, Abou El Hassan and Husein 2016** on tomato, **Seifu and Deneke 2017** on potato**).**

In this regard**, Ilyas, *et al.* (2014)** showed that sprayed tomato plants with Ca at 6% and Mg at 4 % significant increase in plant height, number of branches plant , number of flower/cluster , number of fruits cluster , number of fruits plant , weight fruit and yield ha.

Thus, this work aimed to study the effect of magnesium as different application methods and foliar spray with calcium rates on plant growth, yield, leaf chemical composition and tuber quality of potato grown under clay soil conditions.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive winter seasons of 2015/2016 and 2016/2017 in the privet farm at Vegetables Farm at meet Faris village Dekarns, Dakhlia Governorate to study the effect of magnesium as application methods and calcium rates as foliar application and the interaction between them on growth, yield and quality of potato cv. Spunta under clay soil conditions using farrow irrigation system .

The physical and chemical analyses of the experimental soil are presented in Tables 1.

Table 1: The physical and chemical properties of the experimental soil

Soil properties	1st season	2nd season
Physical properties		
Sand (%)	25.66	25.23
Silt (%)	25.50	25.98
Clay (%)	48.71	48.96
O.M (%)	1.91	2.02
Chemical properties		
pH	7.60	7.30
Total N (%)	0.15	0.15

This experiment included 9 treatments, which were the combinations between two methods application of magnesium, beside control treatment and two rates of calcium as foliar spray, beside control treatment as follows:

a. Magnesium application methods; without, 20 kg/fed. as soil application and foliar application **at** 4 % in the form of magnesium sulphate ($MgSO_4$. $7H_2O$) .

b. Calcium rates: Without , foliar spray at 2% and 4% in the form of Calcium chloride ($CaCl_2$)

These treatments were arranged in a split plot design with three replicates. The magnesium application methods were randomly arranged in the main plots and calcium rates were randomly distributed in the sub plots.

The plots area was 21 m^2 it contained three ridges with 10 meter length and 70 cm in width. One ridge was used to measure plant growth traits and the other two ridges were used to measure yield and its components traits.

Tuber seed of potato cultivar (Spunta) was sown on the 10th and 12th of October in the 1st and 2nd seasons, respectively at 20 cm apart.

All experimental units, received 120 kg N and 80 kg P_2O_5 fed as ammonium sulfate (20.6 % N) and triple superphosphate (37 % P_2O_5), respectively. One third of N and all P_2O_5 were added at soil preparation time with FYM at the rate of 40 m^3/feddan. The rest of nitrogen (two thirds) was applied in three equal split applications after 30 days from planting and 15 days intervals.

Magnesium sulphate at 20 kg /fed. was added as soil application after 30 days from planting with the 1st irrigation , while magnesium as foliar spray and calcium rates were added twice at 45 and 55 days after planting in both seasons.

Other recommended agricultural practices for commercial potato production were followed.

Data recorded

1.Growth parameters

A random sample of five plants was taken from every plot at 70 days after planting, in both seasons of study, for measuring the growth characters of potato plants expressed as follows:

1. Plant height (cm),
2. Number of leaves plant,
3. Leaf area plant (cm^2)
5. Dry weight of shoots plant (gm).

2. Nitrogen, phosphorus and potassium contents

Samples of dry matter of leaves after 70 days from planting, were finely ground and wet digested for N,P and K determination. Total Nitrogen, phosphorus and potassium were determined according to the methods described by **Bremner and Mulvaney (1982), Olsen** and **Sommers (1982)** and **Jackson (1970)**, respectively.

3. Yield and its components

At harvest; i.e., at 105 days after planting for Spunta cultivar, tubers from each plot were weighed and counted, and the following parameters were calculated :

1.Number of tubers plant.
2.Tuber yield per plant (gm).
4.Total yield (ton/*fed*).
5.Relative yield (%).

4. Tuber Quality

4.1. ***Dry matter (%)*** : One hundred grams of the grated mixture were dried at 105 ^{0}C till constant weight and DM (%) was calculated.

4.2. Starch content (%): It was determined according to the method reported by **A.O.A.C. (2000).**

4.3. **Total Ca;** It was determined according to the method described by **Cheng and Bray (1953)**.

4.4. Mg; It was determined according to the method described by **Katz and Navone (1964**) .

Statistical Analysis: Recorded data were subjected to the statistical analysis of variance according to **Snedecor** and **Cochran (1980**) and means separation were done according to **Duncan (1955).**

RESULTS AND DISCUSSION

1. Plant growth

a. Effect of magnesium

Data presented in Tables 2 and 3 show that plant height, number of leaves , leaf area/ plant and dry weight /shoot were significantly increased with treated potato with 20 kg /fed. Magnesium sulphate ($MgSO_4$) as soil application (SA), followed by when applied $MgSO_4$ at 4% to plants as foliar application (FA), while control treatment recorded the lowest values of plant height, number of leaves, leaf area plants and shoot dry weight plant in both seasons. The increases in dry weight of shoot/ plant were about 27.35 and 39.69% for $MgSO_4$ (SA) and 9.55 and 22 % for $MgSO_4$ (FA) than untreated plants in the 1st and 2nd seasons, respectively.

These increases in growth parameters may be attributed to the effect of Mg on some physical functions such as carbohydrates synthesis and active many enzymes which in turn affect plant growth (**Marschner, 1995**).

These results are agreement with those reported by **Radwan and Tawfik (2004)** and **Awad and El-Ghamry.(200**7) on potato.

b. Effect of calcium

Data in Tables 2 and 3 indicate that foliar spray of calcium chloride ($CaCl_2$) from control to 2% and furtherly to 4% progressively and significantly increased plant height, number of leaves, leaf area and shoot dry weight in the both season. The increases in dry weight of shoot/ plant were about 42.31 and 50.73 % for $CaCl_2$ at 4% (FA) and 20.57 and 22.72 for $CaCl_2$ at 2 % (FA) application than unsprayed plants in the 1st and 2nd seasons, respectively.

Calcium application increased vegetative growth of potato by activating enzymes for cell mitosis, division and elongation and thus height plant **Jones, 1999**.

Results are harmony with those reported with **Al-Hamzawi, 2010** on cucumber**, Kazemi (2014)** on tomato, **Helal and AbdElhady (2015)** on potato and **Youssef *et al*. (2017)** on lettuce**.**

c. Effect of interaction between magnesium and calcium

Data in the same Tables 4 and 5 showed that soil application of magnisum sulfate at 20 Kg fed combined with the foliar application calcium chloride at 4 % (FA) significantly had the maximum values of plant height, number of leaves , leaf area and shoot dry weight, in both season. The increases in shoot dry weight were about 86.85 and 120.15 % for the interaction between soil application $MgSO_4$ at 20 kg /fed. And foliar application of $CaCl_2$ at 4 %, followed by 50.65 and 76.13 % for the interaction between soil application $MgSO_4$ at 20 kg/fed. And foliar appliation $CaCl_2$ at 2 % than untreated plants in the 1st and 2nd seasons, respectively.

Magnesium and calcium are the vital nutrients for plant growth and have important role in photosynthesis, enzymes activation and carbohydrate metabolism (**Bergmann 1992**).

These results are harmony with those reported with **Rani *et al*. (2016**) on potato. They showed that combined spray of calcium and magnesium (0.4% Ca + 0.2% Mg) had significant influence on imperative vegetative growth.

3. Plant chemical contents.

a. Effect of magnesium:

Data in Table (6) show that, soil or foliar application of $MgSO_4$ at 20 Kg fed or 4% recorded significantly higher values of leaf N,P and K contents than control. However, the difference between soil and foliar application on leaf N,P and K content was not significant.

Results are harmony with those reported with **El-Sayed *et al.* (2007) and Talukder *et al.* (2009)** on potato **and El-Morsy *et al*. (2011)** on garlic

b. Effect of calcium

Spraying potato plants with $CaCl_2$ at 4 % recorded significantly the maximum values of N, P and K in leaves, followed by sprayed plants with 2 % and finallythe control in both seasons.

The present findings are in agreement with the results obtained by **Seifu, and Deneke (2017)** on potato**.**

c. Effect of interaction between magnesium and calcium

Foliar application $MgSO_4$ at 4% combined with foliar application of $CaCl_2$ at 4% significantly recorded maximum leaf N content in both seasons and the same effect of leaf P and K content in the 1st seasons. However, soil application of $MgSo_4$ combined with foliar application $CaCl_2$ at 4% attained significantly maximum leaf P and K content in 2nd season.

Yield and Its Components

a. Effect of magnesium

Data in Table 8 show that number of tubers plant, yield plant and total tuber yield fed^{-1} significantly increased with treated potato plants grown in clay soil with $MgSO_4$ at 20 kg /fed. (SA) without any significant differences with Mg at 4 % (FA) respecting number of tubers plant in both seasons and total yield fed. in the 1st season.

The increases in total yield /fed. were about 18.64 and 18.50% for $MgSO_4$ (SA) and 14.77 and 13.76 % for Mg (FA) than untreated plants in the 1st and 2nd seasons, respectively.

The positive effect of Mg in improving total yield and its components may be attributed to the important role of Mg in increasing the activity of plant metabolism, which reflected on tuber yield and enhance tuber quality. In addition, the beneficial effect of Mg as a foliar fertilizer on the yield and its components may be due to the fact that Mg plays an important role in formation of the organic compound such as carbohydrates, lipids and etc…which translocate to the reproductive organs and consequently increasing the yield and its components (**Marschner, 1995**). The present findings are in accordance with the results obtained by **Radwan and Tawfik (2004)** , **Awad and El-Ghamry (2007) , El-Sayed *et al.* (2007) , Talukder *et al.* (2009)** on potato and **El-Morsy *et al.* (2011)** on garlic**.**

b. Effect of calcium

Spraying potato plants with $CaCl_2$ at 4% had significant effect on number of tubers /plant, yield /plant and total yield/ fed. in both seasons, without any significant differences with $CaCl_2$ at 2 % regarding number of tubers/plant in the 1st seasons (Table 8).

The increases in total yield/fed. were about 19.80 and 21.71 % for $CaCl_2$ at 4% (FA) and 6.30 and 11.79 for $CaCl_2$ at 2 % (FA) than unsprayed plants in the 1st and 2nd seasons, respectively.

These results are in agreement with those **Hamdi *et al*.(2015), Helal and AbdElhady (2015)** on potato**, Abou El Hassan and Husein (2016)**on tomato and **Seifu, and Deneke (2017)** on potato.

c. Effect of interaction between magnesium and calcium

Data in Table 9 showed that the interaction between magnesium and calcium had significant effect on yield and its components in both seasons.

Fertilized potato plants with $MgSO_4$ at 20 kg /fed. (SA) combined with foliar 4% calcium chloride (FA) gave the highest values of number and weight of tubers/plant, yield / plant and total tuber yield/fed. in both seasons, with no

significant differences with the interaction between foliar $MgSO_4$ at 4 % and $CaCl_2$ at 2 or 4 % (FA) concerning the number of tubers/ plant in both seasons.

The increases in total yield/fed. were about 41.99 and 42.22 % for the interaction between $MgSO_4$ at 20 kg /fed. (SA) and $CaCl_2$ at 4 % (FA), followed by 34.19 and 33.52 % for the interaction between $MgSO_4$ at 4 % (FA) and $CaCl_2$ at 4% (FA) than untreated plants in the 1st and 2nd seasons, respectively.

Both Ca and Mg are involved in various cellular functions such as activation of enzymes, photosynthesis and carbohydrate metabolism, therefore there deficiency may cause poor tuber growth and yield (**Davis *et al.*, 2003**).

Obtained results contradicted with those reported by **Ilyas, *et al.* (2014).** They found that sprayed tomato plants with Ca at 6% and Mg at 4 % showed significant increase number of flower/cluster, number of fruits cluster , number of fruits plant , weight of fruit (gm) and yield/ha .

3.2. Tuber quality

a. Effect of magnesium

It is clear from the data in Table 10 that fertilization potato plants with 20 kg $MgSO_4$ /fed. as (SA) significantly increased dry matter , starch contents, Ca and Mg in tuber at harvesting time in both season without any significant differences with Mg as (FA) at 4 % concerning Ca and Mg in both seasons.

The increases in dry matter content in tuber was about 9.61 and 14.49% for $MgSO_4$ at 20 kg /fed. (SA) and 3.96 and 5.23 % for $MgSO_4$ at 4 % (FA) than untreated plants in the 1st and 2nd seasons, respectively. Also, The increases in starch content in tuber was about 8.53 and 5.63% for $MgSO_4$ at 20 kg /fed (SA) and 4.22 and 2.49 % for $MgSO_4$ at 4 % (FA) than untreated plants in the 1st and 2nd seasons, respectively.

However, the increases in Mg contents in tuber was about 11.01 and 13.26% for $MgSO_4$ (SA) and 12.52 and 13.56 % for $MgSO_4$ (FA) than untreated plants in the 1st and 2nd seasons, respectively.

b. Effect of calcium

Spraying potato plants with calcium chloride had significant effect on dry matter, starch contents, Ca and Mg in tuber at harvesting time compared to unsprayed plants in both seasons (Table 10). The highest values of dry matter, starch contents, Ca and Mg in tuber were obtained with the plants sprayed with $CaCl_2$ at 4 %, followed by sprayed with $CaCl_2$ at 2 % in both seasons.

The increases in dry matter content in tuber was about 5.77 and 8.89% for $CaCl_2$ at 2 % (FA) and 15.03 and 16.56 % for $CaCl_2$ at 4 % (FA) than untreated plants in the 1st and 2nd seasons, respectively. Also, The increases in starch content in tuber was about 10.28 and 3.41% for $CaCl_2$ at 2 % (FA) and 15.77 and 10.23 % for $CaCl_2$ at 4 % (FA) than untreated plants in the 1st and 2nd seasons, respectively.

Moreover ,the increases in Ca contents in tuber was about 13.65 and 14.54% for $CaCl_2$ at 2 % (FA) and 43.39 and 34.94 % for CaCl2 at 4 % (FA) than untreated plants in the 1st and 2nd seasons, respectively.

These results agreement with those reported by **Buczkowska *et al*. (2016)** on sweet pepper. They found that spraying sweet pepper plant with different sources

of Ca significantly increased dry matter content, TSS, Vitamin C than unsprayed plants.

c. Effect of interaction between magnesium and calcium

Data in Table 11 show that the interaction between $MgSO_4$ and $CaCl_2$ had significant effect on dry matter, starch contents, Ca and Mg in tuber at harvesting time in both seasons.

The highest values of dry matter, starch contents were obtained with the interaction between $MgSO_4$ at 20 kg /fed (SA) and $CaCl_2$ at 4 % (FA) in both seasons. While the interaction between $MgSO_4$ at 4 % (FA) and $CaCl_2$ at 4 % gave the highest values of Ca and Mg in tuber without any significant differences with Mg at 20 kg /fed (SA) and $CaCl_2$ at 4 % (FA) in both seasons.

The increases in dry matter content in tuber was about (25.02 and 33.97%) and in starch content (28.91 and 19.12%) , in Mg content (53.16 and 46.32 %) and in Ca content (51.13 and 49.14 %) due to the interaction between $MgSO_4$ at 20 kg /fed (SA) and $CaCl_2$ at 4 % (FA) than the untreated plants with any Mg and Ca in the 1st and 2nd seasons, respectively .

Finally, it could be concluded that, soil application fertilized potato plants with $MgSO_4$ at 20 kg /fed. combined with foliar application 4% calcium chloride gave the highest values of plant growth, yield and its as well as bulb quality.

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تأثير طرق اضافة المغنسيوم والرش بالكالسيوم على انتاجية وجوده محصول البطاطس فى العروه الشتويه

حمادة ماهر بدير المتولى ، فوزى يحيى عمر منصور

معهد بحوث البساتين – مركز البحوث الزراعية- مصر

اجريت تجربتان حقليتان خلال موسمى شتاء ٢٠١٥/٢٠١٦ ، ٢٠١٦/٢٠١٧ بمزرعة خضر خاصة بقرية ميت فارس – دكرنس - محافظة الدقهلية وذلك لدراسة طرق اضافة المغنسيوم والرش بمعدلات من الكالسيوم والتفاعل بينهم على النمو ، المحصول وجوده الدرنات للبطاطس صنف سبونتا تحت ظروف الارض الطينية واستحدام الرى بالغمر.

وقد أوضحت النتائج أن التفاعل بين معاملة نباتات البطاطس بسلفات المغنسيوم كاضافة أرضية بمعدل ٢٠ كجم /فدان والرش بكلوريد الكالسيوم بتركيز ٤ % قد أدى للحصول على أعلى القيم لكل من ارتفاع النبات ، عدد الأوراق/ نبات ، المساحة الورقية ، الوزن الجاف للعرش / نبات ، محتوى العرش من النيتروجين والفوسفور والبوتاسيوم بعد ٧٠ يوم من الزراعة ، عدد الدرنات / نبات ، محصول النبات ، المحصول الكلى للفدان ، النسبه المئويه لمحتوى الدرنات من المادة الجافة والنشا وبدون فروق معنوية بين معامله التفاعل بين الرش باستخدام سلفات المغنسيوم بتركيز ٤ % مع الرش بكلوريد الكالسيوم بتركيز ٢ او ٤ % بخصوص عدد الدرنات / نبات فى كلا الموسمين. بينما سجلت معاملة التفاعل بين الرش باستخدام سلفات المغنسيوم بتركيز ٤ % مع الرش بكلوريد الكالسيوم بتركيز ٤ % أعلى القيم لمحتوى الدرنات من الكالسيوم والمغنسيوم وبدون فروق معنوية بين ٢٠ كجم سلفات مغنسيوم / فدان والرش بكلوريد الكالسيوم بمعدل ٤ % فى كلا الموسمين.

وفى هذا السياق ، كانت الزيادة فى المحصول الكلى قد تراوحت بين ٤١.٩٩ ، ٤٢.٢٢ % بالسبة لمعاملة التفاعل بين معاملة نباتات البطاطس بسلفات المغنسيوم بمعدل ٢٠ كجم / فدان اضافة أرضية والرش بكلوريد الكالسيوم بمعدل ٤ % ، يليها ٣٤.١٩ ، ٣٣.٥٢ % بالنسبة لمعاملة التفاعل بين رش نباتات البطاطس بسلفات المغنسيوم بمعدل ٤ % مع الرش بكلوريد الكالسيوم بمعدل ٤ % عن النباتات الغير معاملة فى الموسم الاول والثانى على التوالى.