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Research Article

Enhancement of growth and productivity of cucumber (*Cucumis sativus*) through foliar application of calcium and magnesium

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Abstract

Cucumber (*Cucumis sativus)* is the important vegetable crop in Pakistan. Macronutrients deficiency severely affected growth and yield of cucumber. Therefore the experiment was designed to evaluate response of cucumber (*Cucumis sativus*) to calcium (Ca) and magnesium (Mg) levels in the year of 2014. The experiment was laid out in Randomized Complete Bock Design (RCBD) having sixteen treatment combinations, replicated three times. Foliar application of Calcium @ (0, 10, 15, 20 mM) and Magnesium @ (0, 30, 40, 50, mM) were applied to the plants. Application of calcium and magnesium significantly affected all the growth parameters. Less number of days (39) to first flowering, number of days (49) to fruit initiation, highest vine length (74.66 cm), number of branches plant^{-1} (6.05), number of pickings plot^{-1} (8), fruit length (15.02 cm), fruit diameter (4.00), number of fruits plant^{-1} (9.27) and yield (8.03) tons ha^{-1} was observed with foliar application of 10 mM calcium. Whereas less number of days (37) to first flowering, number of days (48) to fruit initiation, maximum vine length (72.66 cm), number of branches plant^{-1} (5.87), number of pickings plot^{-1} (7.83), fruit length (15.04 cm), fruit diameter (4.43 cm) number of fruit plant^{-1} (9.04), and yield (10.79) tons ha^{-1} was observed with foliar application of 30 mM magnesium. While In case of interaction, number of days (31) to first flowering, days to fruit initiation (45), fruit length (17.27 cm), fruit diameter (5.93 cm), number pickings^{-1} (9), and yield tons ha^{-1}(12.70) were produced by interaction between Ca x Mg at the rate of 10mM and 30 mM respectively. Hence foliar application of calcium @ 10 mM and magnesium @ 30 mM is recommended for the better growth and yield of cucumber at Peshawar.

Keywords: *Cucumis sativus*; Calcium Magnesium dose; Foliar application; Growth and yield

Introduction

Cucumber (*Cucumis sativus* L.) belongs to the cucurbitaceae family. It is an important summer vegetable crop which is grown in the home gardens as well as in fields and in tunnel farming. Cucumber is probably indigenous to Asia and has been cultivated for about 3000 years. It was a well-known

vegetable crop of France in the ninth century and become popular in England in 1327. In spite of its high nutritive value, cucumber is consumed as salad in Pakistan and other countries due to its cold affect in hot summers. Smallest immature fruit of cucumber (about 3-15 cm length) are favored for sweet pickles [1]. Cucumber is an annual herb with furry leaves and tendrils and it is most of the pollination in cucumber for the development of usable fruit is achieved through insects, especially through honey bees either wild or domesticated [2].

The cucumber is very sensitive to frost by causing serious injuries in the fruit [3]. Tunnel farming is the useful method in production of cucumber in all over the Pakistan. Picking starts from (Aug-Sep) after the planting days of 60-65. Hand picking of cucumber were practiced in field and in tunnel farming [2]. Optimum temperature required for the growth of cucumber is 20˚C - 32˚C. Cucumber has ability to grow on the variety of soils. Cucumbers are fairly tolerant to strongly acidic soils but the best result is associated with soil pH of 5.5 - 6.8 [3]. Cucumber is the fast growing crop. For the maximum yield of cucumber, it requires 100-150:80:60 kg of N:P:K. Half dose of nitrogen and full dose of potassium and phosphorus is applied to the soil before sowing while half dose of nitrogen is applied at flowering stage. Weekly irrigation is enough for the cucumber. Frequently irrigation in the field causes the spread of fungal disease. Downy mildew, bacterial wilt, anthracnose, root knot, angular leaf spot, mosaic and scab are vicious diseases of cucumber [2].

Calcium is a major component of cell walls having 60-70% of its total tissue [4]. It helps in maintaining cell wall integrity and membrane permeability. Calcium is the basic component of many enzymes [5]. Calcium is considered as important mineral elements that regulates fruit quality and enhances its post-harvest life through decrease the physiological disorders like water core, bitter pit and internal breakdown. As a versatile signaling ion of calcium (Ca^{2+}) act at multiple sites in diverse networks of signaling cascades. It serves as a major regulatory ion in Horticultural crops. These pathways receive signals from a wide array of biotic and abiotic sources, and cause changes in gene expression [6]. Ca^{2+} as an essential plant nutrient actively participates in cell wall structure, cellular signaling responses, and membrane function [7, 8]. Calcium deficiency causes a decline in the growth, reduce leaf size, yield, and in extreme situation it also causes the necrosis of young leaves [9].

Magnesium is a prime constituent of chlorophyll molecule. It can act as an enzyme activator in various types of energy transfer reactions. Lack of Mg may seriously affect the photo assimilate production and supply to other parts of plant [9, 10]. Keeping in view the economic importance of the cucumber and benefits of calcium and magnesium on its growth, yield and post-harvest life.

Materials and method

This study was carried at Horticulture Research Farm, The University of Agriculture Peshawar, during the year 2014. Sowing of cucumber seeds were done manually in each treatments plot. Basal dose of NPK (35-60-60) kg ha^{-1} were applied to all treatments plot by soil dressing method. Net system was used for standing of in field crops. Other cultural practices were also performed in the research plot. The experiment was laid out on Randomized Complete Block Design (RCBD) with two factors factorial arrangement. Total treatments were sixteen (16), each was replicated three times. Calcium @ (0, 10, 15, 20 mM) and Magnesium @ (0, 30, 40, 50, mM) with foliar application applied to the plants. Foliar application of calcium in the form of Calcium Chloride ($CaCl_2$ containing 53 % Ca) and magnesium in the form of

Magnesium Sulphate ($MgSo_4$ containing 43 % Mg) were applied in 1 split after 34 days sowing (at 3 to 4 leaves stage) to all the treatment plots. Growth parameters studied during experiment were Following parameters were studied during the research vine length (cm), number of branches plant^{-1},days to first flowering, days to fruit initiation, number of pickings plot^{-1}, fruit length (cm), fruit diameter cm, number of fruits plot^{-1}, Yield tons ha^{-1}.

$$\text{Yield tons ha}^{-1} = \frac{\text{Plot yield (kg)}}{\text{Plot area (m}^2\text{)}} \times 10000 \text{ m}^2$$

Soil analysis

Before fertilizer application soil samples were taken randomly from the experimental plot area, for appropriate soil analysis with the help auger at two depths i.e. 0-15 and 15-30 cm.

Electrical Conductivity was determined by the method suggested by **[11]**. Soil pH was determined by using protocol described by **[12]**. Organic matter in soil was determined by the modified method of Walkyley-Black as described by **[13]**.

$$\text{Organic matter (\%)} = \frac{(\text{meq } K_2Cr_2O_7\text{-meq } Feso_4)\text{x meq of C}}{\text{Weight of dry sample x (0.75)}}$$

Where 0.75 is derived from the assumption that only 75% of organic matter is oxidized in this method and Meq of C is 0.003.Soil texture was determined by Hydrometer Method **[14]**. The Ca^{2+} + Mg^{2+} concentration in paste extract were determined according to the method described by **[15]**.

Soil properties	Units	Values
pH	-	7.98
EC	dSm^{-1}	0.24
OM	%	0.68
Sand	%	21.98
Silt	%	54.42
Clay	%	23.60
Texture	-	Silt loam
Ca+Mg	meq/L	9.7

Statistical procedure

Data was analyzed statistically using computer software statistix-8.0 to know the significant difference among various parameters. LSD was applied at 5 % level of probability.

Results and discussion

The results and discussion of the recorded data regarding response of Cucumber to calcium and magnesium levels are briefly explained as;

Days to first flowering

The analysis of variance showed that calcium and magnesium has significant effect on the flowering of cucumber. Mean values showed that, the less number of days (39.08) to first flowering was recorded with foliar application of calcium @ 10 mM. While the more number of days (44.15) to first flowering was recorded at 20 mM followed by (42.75) days at calcium application @ 15 mM. The mean values of magnesium showed that the less number of days (37.17) to first flowering was recorded in the foliar application of magnesium @ 30 mM. While the more number of days (45.67) to first flowering was noticed with the foliar application of 50 mM followed by (44.50) days with 40 mM (Table 1). **[16]** Reported that, macronutrient has beneficial effect on the growth and yield of chilies, while optimum dose of these macronutrients have significant effect on days to flowering. **[17]** Stated that calcium chloride maintained higher total chlorophyll content therefore it might affect days to flowering of cucumber plant.

Table 1. Effect of foliar application of calcium and magnesium on the growth and productivity of cucumber (*Cucumis sativus)*

Calcium levels (mM)	Days to first flowering	Days to fruit initiation	Number of branches plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Number of fruit plant^{-1}	Number of pickings plot^{-1}	Vine length (cm)	Yield tons ha^{-1}
0	42 c	50 c	5.10 b	14.12 b	3.50 b	7.44 b	6.51 b	64.66 b	6.76 b
10	39 d	49 c	6.05 a	15.03 a	4.00 a	9.27 a	7.67 a	74.66 a	8.03 a
15	43 b	53 a	4.80 b	14.10 b	3.45 b	7.03 b	6.50 b	64.58 b	6.81 b
20	44 a	54 a	4.78 b	13.81 b	3.30 b	6.94 b	6.34 b	62.33 b	6.44 b
LSD	**1.1896**	**0.8424**	**0.6452**	**0.8056**	**0.2567**	**1.0875**	**0.4739**	**6.775**	**0.6016**
Magnesium levels (mM)									
0	40 b	49 c	5.15 b	14.25 b	3.56 b	7.76 b	6.59 b	65.75 b	6.97 b
30	37 c	48 d	5.87 a	15.04 a	4.43 a	9.04 a	7.83 a	72.66 a	10.70 a
40	45 a	54 b	4.95 b	14.19 b	3.24 c	7.27 bc	6.50 b	65.33 b	5.64 c
50	46 a	55 a	4.77 b	13.58 b	3.02 c	6.61 c	6.09 b	62.50 b	4.73 d
LSD	**1.1896**	**0.8424**	**0.6452**	**0.8056**	**0.2567**	**1.0875**	**0.4739**	**6.775**	**0.6016**
N x C	**Figure 1**	**Figure 2**	**NS**	**Figure 3**	**Figure 4**	**NS**	**Figure 5**	**NS**	**Figure 6**

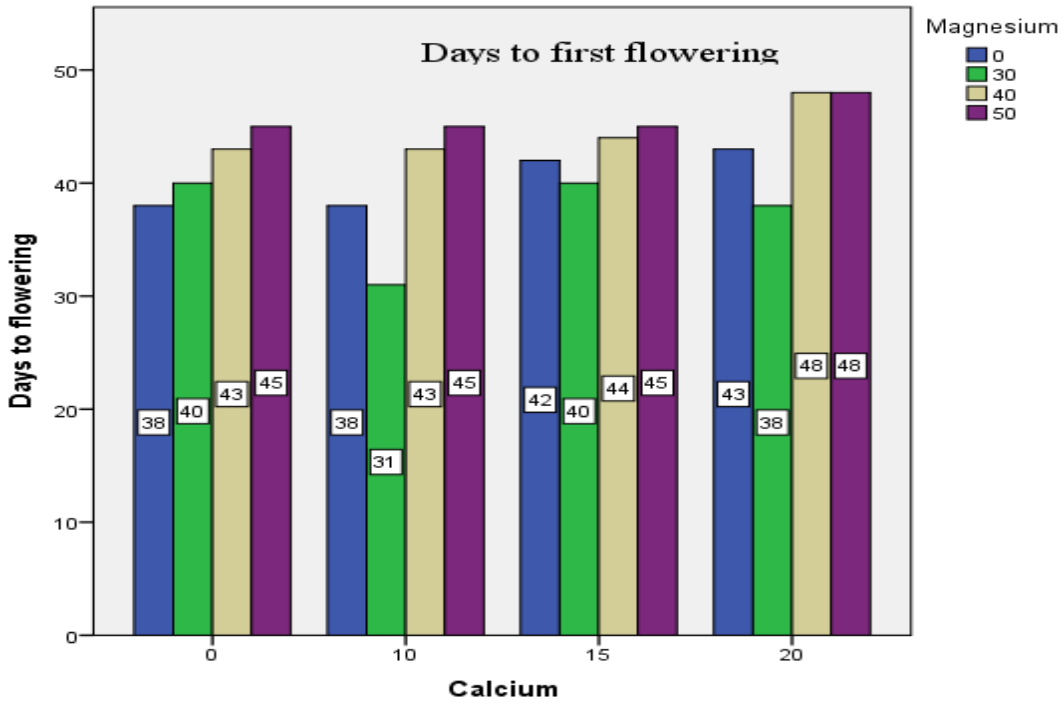

Figure 1. Days to first flowering

Days to fruit initiation

Fruit initiation is significantly affected by the application of calcium and magnesium. Mean values of calcium indicated that, less number of days (49.42) to fruit initiation was counted in 10 mM. While, more number of days (53.58) to fruit initiation was recorded in 20 mM calcium application followed by (52.75) in 15 mM. In case of magnesium application, less number (47.50) of days to fruit initiation was counted in 30 mM. While more number (55.42) of days to fruit initiation were taken in 50 mM magnesium application, followed by (54.17) 40 mM (Table 1). [18] Analyzed the effect of calcium on various parts of the plant such as fruit, leaves and whole plants by using different techniques.

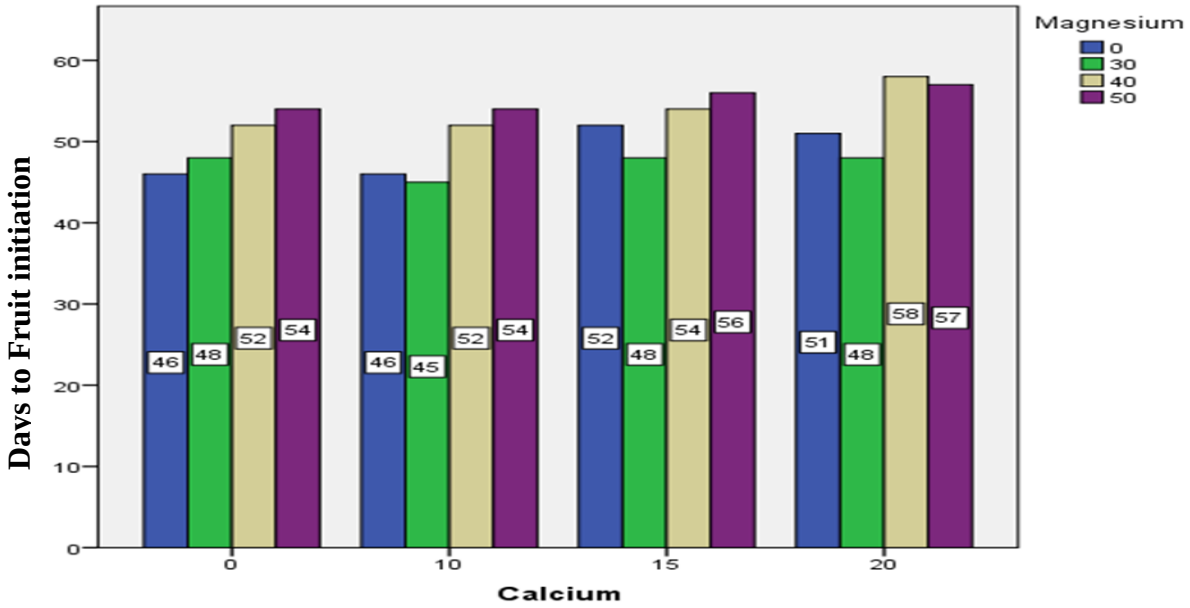

Figure 2. Days to fruit initiation

Number of branches plant^{-1}

Numbers of branches significantly affected with the calcium and magnesium treatment. Mean values of Table showed that the maximum number (6.05) of branches plant^{-1} was recorded in plants treated with the foliar application of calcium at the rate of 10 mM. While the minimum (4.78) number of branches plant^{-1} was recorded with the foliar application of calcium 20 mM. The mean values of magnesium shows that the maximum number (5.87) of branches plant^{-1} was counted with foliar application of magnesium 30 mM. Concentration 50mM showed minimum number (4.77) of branches plant^{-1}(Table 1). The foliar application of calcium significantly enhanced the number of branches plant^{-1}. These Results are in line with the agreement of **[19]**, who stated that number of branches Plant^{-1} improved with the application of calcium. Similar results are found by **[20]**, who reported that foliar application of magnesium increased the growth of the plant and new cells took place due to which number of branches plant^{-1} was increased.

Fruit length (cm)

Fruit length of cucumber the analysis of variance Table showed that foliar application of calcium and magnesium was significantly affected fruit length while their interaction was also found significant. Mean values of calcium indicated that the maximum fruit length (15.02 cm) was counted with foliar application of 10 mM followed by (14.12 cm) in 0 mM while the minimum fruit length (13.81 cm) was counted in 20 mM. In case of magnesium application the maximum fruit length (15.04 cm) was counted with 30 mM Followed by (14.25 cm) in 0 mM respectively. While the minimum fruit length (13.58 cm) was counted in 50 mM. In case of interactive effect, more increase in fruit length (17.27 cm) was recorded by the combine application of calcium 10 mM and magnesium 30 mM respectively (Table 1). The fruit length of cucumber was significantly enhanced by the application of calcium and Magnesium. **[21]** Stated that the cucumber length can be promoted by the combined application of calcium.

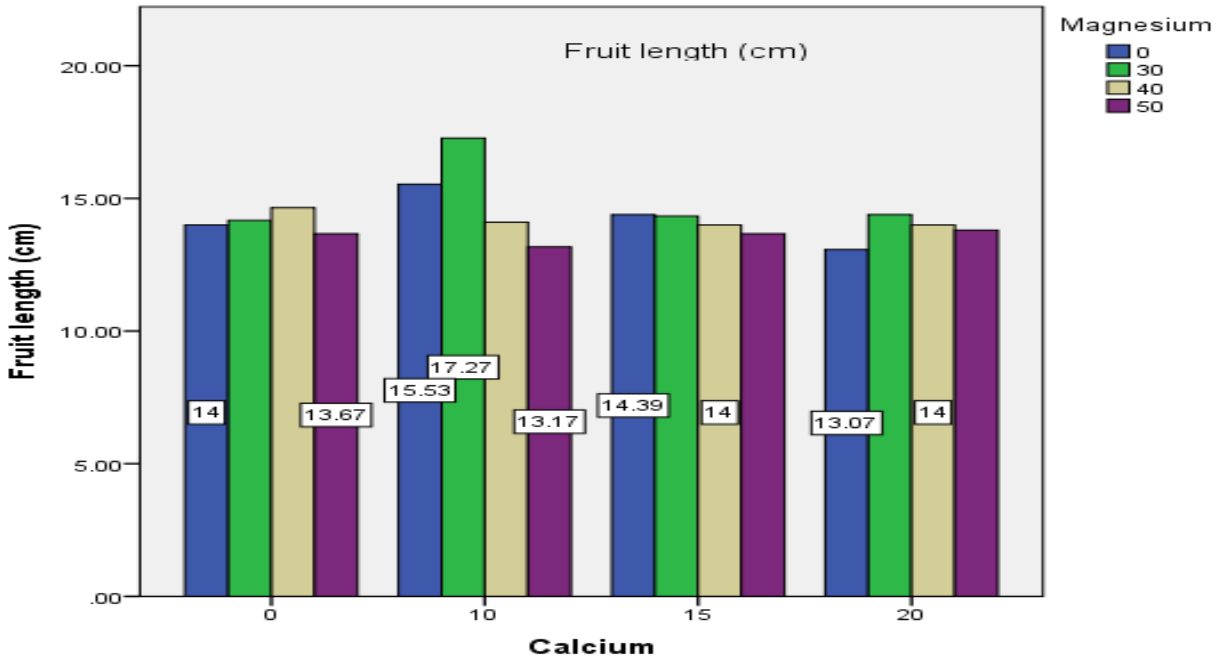

Figure 3. Fruit length (cm)

Fruit diameter (cm)

Calcium and magnesium application showed the significant increase in the size of fruit diameter 10 mM concentration of calcium showed significant improvement in the fruit diameter followed by (3.50 cm). In case of magnesium application the maximum fruit diameter (4.43 cm) was counted with 30 mM followed by (3.56 cm. While the minimum fruit diameter (3.02 cm) was counted in 50 mM (Table 1). [22] Who observed that application of calcium can significantly increase the reproductive growth yield.

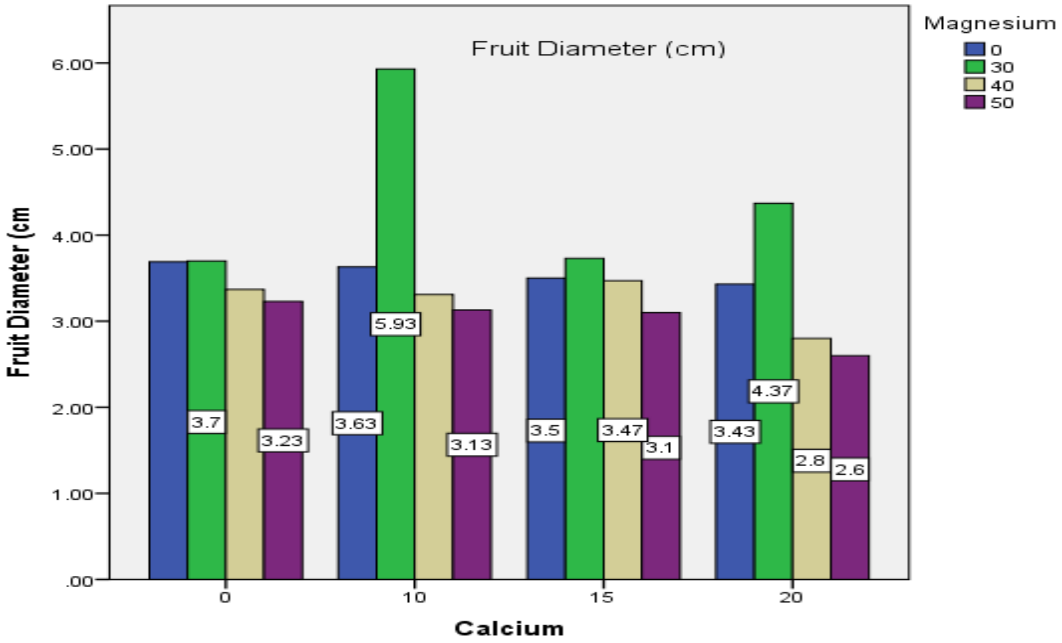

Figure 4. Fruit diameter (cm)

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Number of fruit plant^{-1}

Mean values of calcium indicated that the maximum number of fruits plant^{-1} (9.27) was counted with foliar application of 10 mM followed by (7.44) in 0 mM and the minimum number of fruit plant^{-1} (6.94) was counted in 20 mM magnesium application the maximum number of fruit plants^{-1} (9.04) was counted with 30 mM followed by (7.76) in 0 mM respectively. While the minimum number of fruits plant^{-1} was counted (6.61) was counted in 50mM (Table 1). **[23, 24]** stated that the number of fruits plant^{-1} increased significantly with increasing calcium chloride application 0.3% in tomato plant.

Number of pickings plot^{-1}

Mean values of calcium indicated that the maximum number of pickings plot^{-1} (7.67) was counted with foliar application of 10 mM. In case of magnesium application the maximum number of pickings plot^{-1} (7.83) was counted with 30 mM followed by (6.59) in 0 mM respectively. While the minimum numbers of pickings (6.09) were counted in 50 mM. In case of interactive effect more number (9.00) of pickings plot^{-1} was recorded by the foliar application of calcium and magnesium at the rate of 10 mM and 30 mM respectively (Table 1).Our results also found supportive evidence from the study of **[19]** who reported that foliar application of calcium and magnesium remarkable increased number of pickings plot^{-1}. **[20]** Reported that application of magnesium proliferate the formation of new cells inside plant meristematic tissues which in turn increase number of picking plot^{-1}.

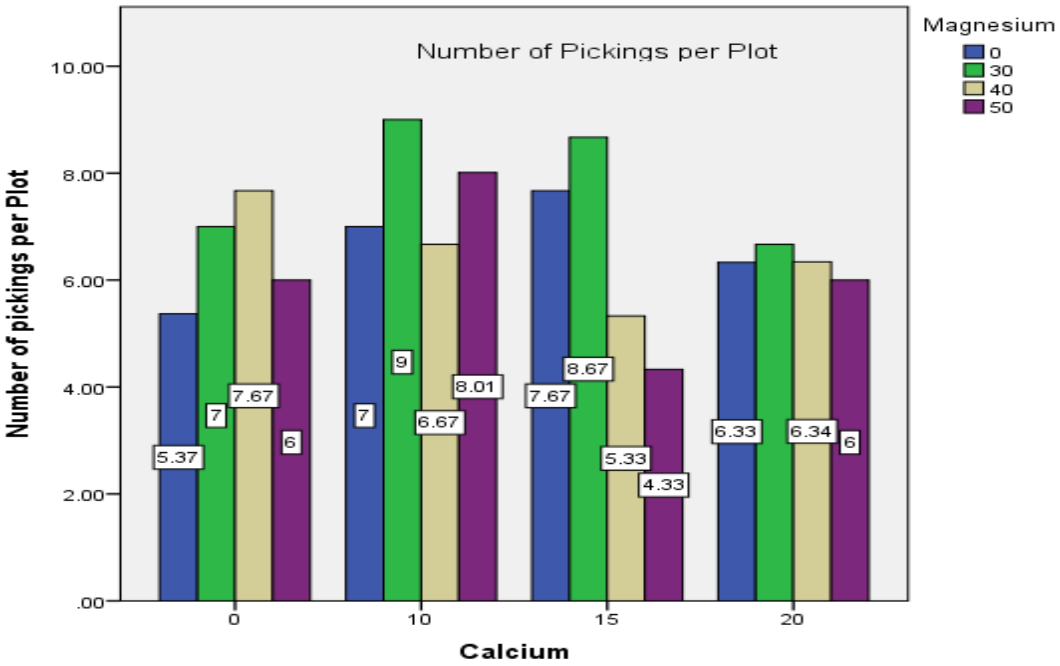

Figure 5. Number of pickings per plot

Vine length (cm)

The mean Table showed that the maximum vine length (74.66 cm) was recorded with 10 mM foliar application of calcium. While the minimum vine length (62.33 cm) was recorded with foliar application of 20 mM of calcium. Magnesium showed the maximum vine length (72.66 cm) was recorded with foliar application of 30 mM. While the minimum vine length (62.50 cm) was observed with foliar application of magnesium 50 Mm (Table 1).Calcium plays an important role in growth and development of plant due to which the vine length was increased. It helps in structure of cell wall and cell membrane to improve the quality of a

plant. This result is confirmation with [25] who observed that application of calcium at the rate of 0.3% significantly increased plant height. These results are in agreement with [22] who reported that the application of calcium can significantly increase the vegetative growth of a plant. [20] Also reported that the length of a plant increased with magnesium application.

Fruit yield (kg ha^{-1})

Significant result showed by the foliar application of Ca and Mg. The maximum cucumber yield (8.03) tons ha^{-1} was recorded in plants treated with 10 mM of calcium, while the minimum cucumber yield (6.44) tons ha^{-1} was noted when plant treated 20 mM of calcium. In case of magnesium the maximum cucumber yield tons ha^{-1} (10.70) was recorded with foliar application of 30 mM, followed by cucumber yield (6.97) tons ha^{-1} in plants treated with 0 mM, while the minimum cucumber yield tons ha^{-1} (4.73) was observed with foliar application of magnesium 50 mM. In case of interactive effect maximum yield of cucumber fruit (12.70) was recorded by the foliar application of calcium and magnesium at the rate of 10 mM and 30 mM respectively. The results were in agreement with that of [21] observed that application of Calcium can significantly increase the reproductive growth and yield. The results are supported by the finding of [9] reported that Calcium sprays increased fruit yield and reproductive growth of tomato. These results are in line with the findings of [26].

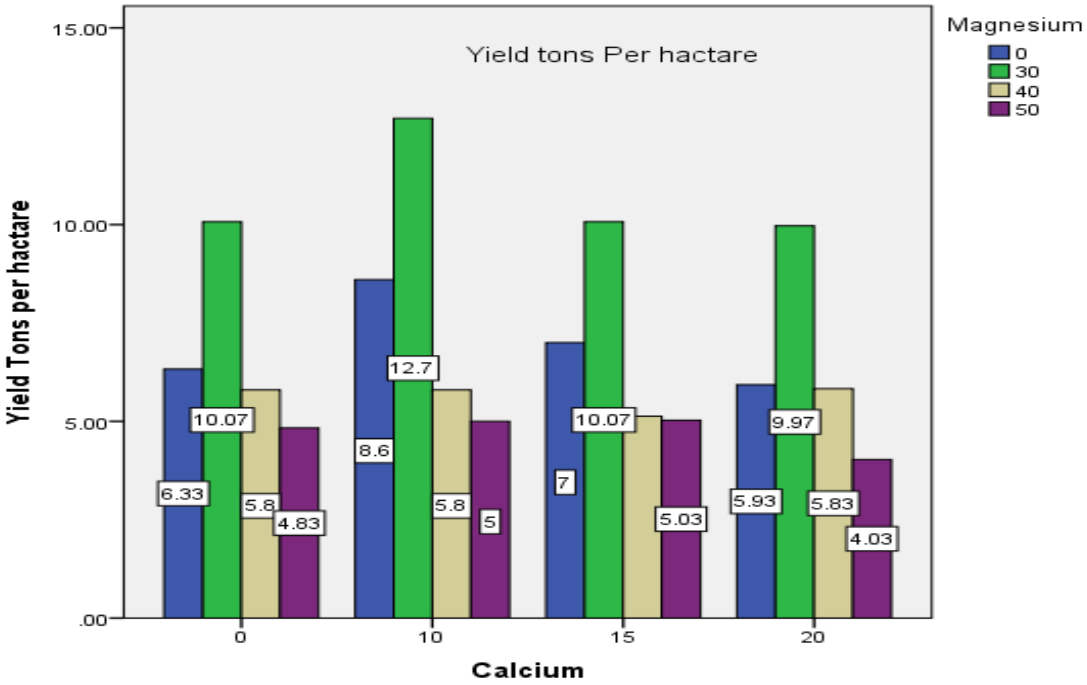

Figure 6. Yield tons per hectare

Conclusion

This experiment revealed that calcium and magnesium had significant effect on the growth and yield of the cucumber plant it was observed that the foliar application of calcium at the rate of 10 mM and magnesium at the rate of 30 mM showed maximum yield and growth of the plant.

Authors' contributions

Conceived and designed the experiments: S Siddique, G Ayub & N Ahmad, Performed the Experiments: Z Nawaz, A Khan & S Siddique, Analyzed the Data: Z Nawaz & FS Khan Contributed reagents/ materials/ analysis tools: A Khan & K Rauf, Wrote the paper: S Siddique.

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