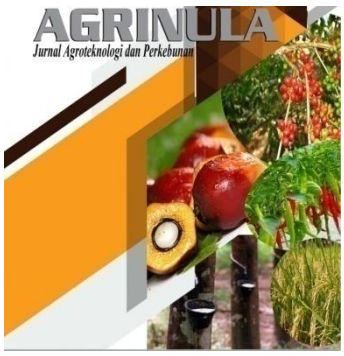

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INFLUENCE OF FOLIAR APPLICATION OF MAGNESIUM ON HORTICULTURAL CROPS: A REVIEW

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ABSTRACT

- **Introduction**: Magnesium is very important nutrient and performs a significant part in development and formation of many sink organs like roots and seeds. Furthermore, its fertilization significantly affects yield and numerous physiological mechanisms in different horticulture crop species. Moreover, its deficiency caused germination and reduction in horticulture crop stand. Nevertheless, its adequate concentration by foliar application plays important role in biochemical and physiological processes of plants like proteins synthesis, metabolism of carbohydrates, enzymes activation and energy transferring. Worldwide, many of our horticulture crops are facing low yield and quality problem due to fertilizer application at inadequate rate. The current review focuses on the impact of foliar applied Mg on some important cultivated horticultural crops

(sugar beet, tomato, banana, potato, spinach, cauliflower, cassava, garlic, green case, potus, cucumber and grapes).

- **Review results**: Our extensive review has demonstrated that magnesium is very important factor limiting horticulture crop production but its negative impacts can be reduced by foliar application of magnesium. Foliar application of Mg can be recommended for correcting deficiencies because foliar sprays have no long term residual effect and every time fresh applications must be given to each crop. Moreover, amount depends on the nutrient status of crop and soil.

Keywords: deficiency; foliar application; horticulture crops; magnesium; physiological mechanisms

INTRODUCTION

Food, fiber and fuel are provided by agriculture sector that are the main necessities of a man (Adnan, 2020). Agriculture productions are facing a major challenge to fulfill the requirements of ever growing population (Adnan et al., 2020a), and many poor countries are facing problem of malnutrition (Saeed et al., 2020). Magnesium plays importantfunctionin many physiological functions of plants. Itperforms vital function in the formation and development of seeds and roots i.e. sink organs of plants (Ceylan et al., 2016). The deficiency of Mg mostly occurs where highly acidic weathered soils are present (Wang et al., 2019). Moreover, it has also been reported that the Mg concentrations in the cereals crops shows a clear decline in last 60 years. It is most possibly due to Mg dilution associated with increases in the grain yield as well as due to imbalanced fertilization without knowing crop demand for Mg (Guo et al., 2016). Its fertilization fundamentally influences the crop yield and numerous physiological cycles in different crop species, just as Mg agronomic efficiencies, under various soil conditions remain the main inquiry to be tended to publically on the grounds that its lack in plants caused lower measures of starch and decrease the germination and seedling formation when looked at Mg satisfactory plants (Wang et al., 2019). Nowadys, many advanced countries are chaning their policies of agriculture to reduce or ban chemical products (Adnan & Anjum, 2021). The applications of fertilizers can be done to crops by soil and foliar yet foliar application is simple and affordable and environment friendly. (Toor et al., 2020; Adnan et al., 2020b; Bilal et al., 2020; Wasaya et al., 2019). Foliar applied Mg plays an importanct function in physiological and biochemical cycle of plants (Adnan et al., 2020c) for example, compounds initiation for proteins synthesis, Metabolism of starches and energy transfer just as magnesium likewise proceeds as an impetus in oxidation and reduction reaction inside the tissues of plant along with magnesium enhances the resistance against dry spell in plant (Thalooth et al., 1990). The current review focuses on the impact of foliar appliedMg on some important cultivated horticultural crops (sugar beet, tomato, banana, potato, spinach, cauliflower, cassava, garlic, green case, potus, cucumber and grapes).

REVIEW RESULTS

Sugar Beet (*Beta vulgaris* L. ssp. *vulgaris*)

Kristek, (2000) evaluated the role of Epsom salt on sugar beet. Foliar application of Epsom salt was applied as 5% w/v solution, 400 litre ha^{-1} two times application in ten-day interim of June. The results depicted that great differences in sucrose, yields, Amino-N, Potassium and Sodium status of sugar beet werenoted among years and among three tested areas in all three years of testing and results also recorded that foliar application of Epsom salt increased sucrose concentration by 0.25, 0.20 and 0.26% at growing periods 1995, 1996 and 1997, respectively. The sugar production was increased in amount of 0.40 ton ha^{-1} in the third year testing and also enhanced the root quality but decreased Amino-N content in the 2nd year.

Tomato (*Lycopersicon esculentum* Mill.)

Hao & Papadopoulos, (2003) carried out an experiment in rockwool to test the effect of two levels of calcium 150 mg and 300 mg per litre are combine with four levels of Mg (110, 80, 50 and 20 mg $litre^{-1}$) on tomato (*Lycopersicon esculentum* Mill.). Results revealed that high concentration of Calcium (300 mg per litre) improved the yield of fruit but the low level of calcium (150 mg per litre) decreased russeting of fruit and theblossom occurrence. However high level of calcium decreased firmness of fruit but the leaf photosynthesis and fruit size did not decrease. While the leaf chlorosis shows the symptoms at the level of 20 mg per litre of magnesium at the bottom and mid of the leaves after eight weeks of planting. The 50% of the moderate chlorosis of leaves lost their photosynthetic capacity as well as production of fruit in the delayed period reduced at the magnesium level of 20 mg per litre. The occurrence of blossom end rot enhanced with increasing magnesium level in the premature stage of growth at low level of Calcium while the occurrence of blasoom end rot at high level of Calcium were not affected by magnesium level. However, the firmness of fruit enhanced with enhancing magnesium level with low Calcium. The high levels of calcium and magnesium influenced the firmness of fruit in late period but at the level of magnesium 80 mg per litre in firmness of fruit, the magnesium level was more than 50 mg per litre. While in the mid period russeting of fruit was influenced by treatments, being at the smallest amount of Calcium/Magnesium 300/50 mg per litre. However, the optimal level of Calcium/Magnesium in the fall greenhouse for tomato yield is projected to 300/50-80 mg per litre and magnesium level started from 50 mg per litre and slowly enhanced to 80 mg per litre towards the last period and also to develop the growth of plant improve the firmness of fruit.

Banana (*Musa* L.)

Mostafa et al., (2007) investigated the influence of foliar Mg application in the form of sulphate and chelate with or without magnesium sulphate on vegetative stage, leaf chlorophyll, mineral, yield and fruit quality of banana plants cultivated under clay loam soil conditions. Results showed that Mg application have positive impact on

growth parameters, yield and fruit quality with the application of 100 g Mg at chelate form 2% $MgSO_4$ foliar application.

Potato (*Solanum tuberosum* L.)

El-Zohiri & Asfour, (2009) laid out two field experiments at the experimental farm during two successive fall seasons 2005/2006 and 2006/2007 to tested the effects of potassium, magnesium and calcium and their combination on yield, yield components, chemical constituents and storage ability of potato tuber cv valor. Results showed that foliar appllied potassium sulphate combined with calcium nitrate or with magnesium gave significant effects on number of tubers weight of tubers, yield and yield components. However, maximum number of tuber, weight of tubers per plant, total and relative enhance in yield were obtained by foliar application of potassium sulphate and magnesium sulphate and results also indicated that best number of days for sprouting were recorded in the foliar Mg sulpate application. weight loss percentage after 90, 60 and 30 days after storage were significantly enhanced with the application of Mg sulphate alone whereas application of potassium nitrate and magnesium sulphate in first season and potassium sulphate and magnesium sulphate in the 2nd season gave the maximum dry matter after 90 days. Horvat et al., (2010) concluded that foliar applications of three salts and control on various parameters such as the content index of chlorophyll, size of tuber and production of potato grown under water scarce situations. The research was conducted out in greenhouse using the cultivar of 'Courage' throughout the three growing periods (2005, 2006, 2007). Foliar application was applied 5 times throughout vegetation period from the beginning of formation of tuber to the phase of full tuberization. The results depicted that there was no major variation in chlorophyll content index of potato leaf prejudiced by foliar application among water scarce situations and optimal irrigate supply. While, production of tuber was considerably decreased by an aggregate of 15% beneath water scarce situations. Moreever, the water scarcity showed in a drastically more number of 0-25 mm tuber sizes, but lesser number of 50-75 mm tuber sizes. Foliar spray of magnesium sulphate carried regarding alike production of tuber underneath situations of water scarce and optimal water provide. While In difference, salts and control treatment obtained extensively higher production of tubers beneath optimal water deliver compared to water scarce situations.

Spinach (*Spinacia oleracea* L.)

Borowski & Michalek, (2010) conducted an experiment of pod in a phytotron to findout the impact of foliar applied nutrients on spinach with various Mg salts with and without 0.5% $CO(NH_2)_2$addition was examined. Magnesium was applied three times, $Mg(NO_3)_2$ x $6H_2O$,$MgSO_4$ x $7H_2O$, $C_4H_6O_4Mg$ x $4H_2O$, $MgCl_2$ x $6H_2O$, compared to water as the control treatment. The significant effects indicated that the foliar nutrition of spinach and with inorganic magnesium salts was a well-organized technique for improving the magnesium concentration in plants throughout the growing stage.

However, the application of a organic metalo complex in the form of Mg acetate ($C_4H_6O_4Mg$ x $4H_2O$) at a level of 1.7%, in spite of approximating result on leaf magnesium content, induced phytotoxic effect in the form of necrotic and chlorotic spots on leaves. The inorganic magnesium salts application had a positive result which is more intensive gas exchange of leaf such as transpiration, stomatal conductance, and photosynthesis and an increase in leaf yield. The foliar nutrition of the spinach with Mg salts ensued in an enhanced leaf protein,carotenoids,proline, chlorophyll and nitrates while a reduction in the vitamin C. The urea addition to magnesium salt solutions enhanced the plant gas exchange rates and the leaf content of protein, chlorophyll, carotenoids, nitrates and proline, but it decreased the content of vitamin C, potassium and magnesium.

Cauliflower (*Brassica oleracea* var. botrytis)

Ahmed et al., (2011) studied foliar application of molybdenum and magnesium on the vegetative growth, chemical (%) and curds production of cauliflower. Foliar Mg application was carried out four times 20, 40, 60 and 80 days after transplanting at the level of (15, 30 and 45µg/1 Mo) and magnesium was applied four times 15, 35, 55 and 75 days at the level of (0.25, 0.50 and 0.75% Mg) after transplanting. The data was recorded and results indicated that 30 and 45µ/1 Mo enhanced the vegetative growth, curds production and chemical composition of leaves and curds similarly 0.50 and 0.75% foliar application of Mg improved the fresh weight, plant height, fresh weight of leaves, dry weight of leaves, total production of curds and chemical composition of curds and leaves. Biswas et al., (2013) stated that three magnesium sulphate levels (0, 1.5, 3.0 g/m^2) were applied on paddy crop, flowers and vegetables during February to May in 2013. Results indicated that the level 3.0g/m^2 of $MgSO_4$ enhanced the growth and produced highest production of paddy and also positive effect of qualitative and quantitative yield of sunflower, vegetables, and rose.

Cassava (*Manihot esculenta* Crantz)

Panitnok et al., (2013) observed that the Micro nutrient application is an essential for adding efficiency of cassava cultivar (*Manihot esculenta* Crantz) production. The three cassava cultivars (KU 50, HB 60 and HB 80) were grown in coarse-loamy and sandy loam soil with low organic matter at Research Station of Thailand, to assess the combination effects of zinc, sulphur and Magnesium foliar spray management on production and cassava quality. There were five main plots (T1) non foliar fertilization, (T2) foliar application of Zn+Mg+S @ 10 cc/20 liters of water, 30 cc/20 liters of water and 60 g/20 liters of ton per hector water at 2 and 3 month after planting (2 times/month), (T3) foliar application of Zn+Mg @ 10 cc/20 liters of water and 30 cc/20 liters of water at 2 and 3 month after planting (2 times/month), (T4) foliar application of Zn+S @ 10 cc/20 liters of water and 60 g/20 liters of water at 2 and 3 month after planting (2 times/month) and (T5) foliar application of Mg+S @ 30 cc/20 liters of water and 60 g/20 liters of water at 2 and 3 month after planting (2 times/month) and three

cassava cultivars in sub plots (V1) KU 50, (V2) HB 60 and (V3) HB 80. The results exemplified that the treatment with different rates of zinc, magnesium and sulphur gave difference in fresh stem weight, fresh rhizome weight, fresh root weight and root starch content, but the foliar application with Zn+Mg+S gave the highest on its while KU 50 cultivar gave the better result on fresh stem weight and fresh rhizome weight, HB 60 cultivar inclined to give greater fresh root yield (11.90 t rai^{-1} or 74.38 t ha^{-1}) and fresh root weight (370.10 g/root). However, HB 80 cultivar inclined to give higher root starch content (27.16%) and root number (13.81 root/plant). The maximum fresh root yield (15.77 t rai-1 or 98.56 t ha^{-1}) and fresh root weight (442.45 g/root) was obtained from Zn+Mg treatment sprayed on HB 60 cultivar, however, the HB 80 cultivar with foliar application of Zn+Mg+S gave the highest root starch content of cassava by 29.33%.

Garlic (*Allium sativum* L.)

Al-Barzinji & Naif, (2014) evaluated that foliar application of different magnesium salts ($MgSO_4.7H_2O$, $Mg(NO_3)_2.6H_2O$, $MgCl_2.6H_2O$ and control) on garlic (*Allium sativum* L.). Positive and good vegetative growth of garlic was produced by magnesium salts. Highest number of leaves was produced by $MgCl_2$; highest dry weight of shoots was enhanced by $Mg(NO_3)_2$ but lowest plant height was produced by $MgSO_4$. The foliar application of $MgSO_4$ and $Mg(NO_3)_2$ enhanced the yield components like head diameter, head weight, bulbs production and cloves number per head and also enhanced the production and yield quality of garlic.

Green Pod (*Pisum sativum* L.)

Howladar et al., (2014) stated that the results of soil treatment with phosphorien containing phosphate dissolving bacteria (PDB) and Mg foliar spray at the concentrations of 0, 0.5 and 1 mM on growth, green pod and production, and chemical components of *Pisum sativum* L. cultivated on a sandy calcareous soil were examined. The effects showed that phosphate dissolving bacteria and magnesium considerably enhanced per plant length of shoot, number of branches, total leaf area and canopy dry weight per plant, leaf contents of pigments, soluble sugars, free proline, N, P, K, Mg and Ca and also determined that phosphate dissolving bacteria and magnesium have good effects on *Pisum sativum* L. crop cultivated in sandy calcareous soil and can enhanced the green pod and seed yields.

Potus Plant (*Epipremnum aureum*)

Metwally et al., (2015) laid out an experiment during two growing seasons 2012 and 2013 at the laboratory of National Research Centre, Egypt to determine the effect of potus plants (*Epipremnum aureum*) watered by waste water of attractive fish basins liquefy with tap water (DWOFB) at the levels 100% DWOFB, 75% DWOFB + 25% Tap water and 50% DWOFB + 50% Tap water) and combined with Epsom salt as foliar application level (EFAL) at the level EFAL1 (25 ppm) and EFAL (50 ppm). The results showed that the crop watered with total fish waste (100% fish)

single or combined with magnesium 50 ppm achieved the maximum growth components, the maximum carbohydrate percentage enhanced in photosynthetic pigments. The foliar spray of magnesium 50 ppm had progressive result on growth parameters and drastically enhances in photosynthetic pigments. The crop watered with fish water waste 75% followed by 50% had the second and the third largest average growth parameters and chemical constituents respectively.

Cucumber (*Cucumis sativus* L.)

Azarmi et al., (2015) evaluated that five different Mg concentration levels (0, 1, 2, 3 and 4 mM) in the solution form were applied on cucumber plant in hydroponic culture under low 50% and optimum 100% light intensity. He demonstrated that the concentration of Mg (3 mM) in the form of nutrient solution in hydroponics with the optimum light intensity enhanced the growth and fruit quality of cucumber plant, but decreases the growth and fruit quality with the decreases of light intensity and also reduced the growth and fruit quality with the increased of Mg level (4 mM). Mg concentration of 1 mM enhanced the fruit firmness with the increasing light intensity.

Grapes (*Vitis vinifera*)

Zlamalova et al., (2015) carried out three-year field experiment (2011–2013) to study the effects foliar application of magnesium sulphate and potassium sulphate both separately 3.86 kg Mg per hectare or 12.44 kg K per hectare and in combination 1.93 kg Mg per hectare plus 6.22 kg K per hectare on yield of grapes of cv. Zweigelt and some qualitative parameters of the grapes. The average 3-year results the grape yields were obtained by 11.2% magnesium sulphate, 13.9% potassium suphate and 6.6% magnesium sulphate plus potassium sulphate considerably more than the control. The sugar content of grapes like sum of glucose and fructose was lesser in all the fertilized treatments than in the control. The fertilizer application had no effect on the pH of must (juice) and ranged between 3.02 and 3.25. Results showed that it is obvious that separate foliar applications of magnesium and potassium have a good effect, in exacting in that they enhance grape yield.

CONCLUSION

Our extensive review has demonstrated that magnesium is very important factor limiting horticulture crop production but its negative impacts can be reduced by foliar application of magnesium. Foliar application of Mg can be recommended for correcting deficiencies because foliar sprays have no long term residual effect and every time fresh applications must be applied to each crop. Moreover, amount depends on the nutrient status of crop and soil.

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