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Effect of Foliar Application of Secondary and Micronutrients on Vegetable Crops

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ABSTRACT: Vegetables are most important in healthy human life as compare to the other crops, they are rich source of nutrients, vitamins (C, A, B1, B6, B9, E), minerals, dietary fiber and phytochemicals. Consumption of less than 200 g of vegetables per person per day in many countries today is common and this low amount, often in conjunction with poverty and poor medical services, is associated with unacceptable levels of mortality and malnutrition in preschool children and other vulnerable groups. Potato (*Solanum tuberosum* L.) is originally a native of South America. It is popularly known as 'The king of vegetables' has emerged as the fourth most important food crops in India after rice, wheat and maize. It is providing higher dry matter production per unit area and time as compared to other field crops. Potato is the single most popular vegetable-tuber crop grown in more than 150 countries of the world. Nutrient deficiencies in a crop arising at the critical stages of their growth which adversely affects the yield and quality of produce. Foliar fertilization is a widely used method to supplement soil application for improving the yield and quality of field crops. Foliar nutrition was found to be six, four and twenty times more beneficial than soil application for N, B and Zn respectively. The practice of foliar fertilization has the advantages of low cost and a quick plant response, and it is particularly important when soil problems occur and root growth is inadequate. Foliar application of secondary and micronutrients had a marked influence on growth and yield parameters with the spray of macro and micronutrients (Mg, S, Zn and B).

Keywords: Foliar application, Potato, Micro and Macro nutrients.

INTRODUCTION

Vegetables are vital to human health and rich source of nutrients, vitamins (C, A, B1, B6, B9 and E),minerals, dietary fiber and phytochemicals. According to World Health Organization, lower intake of vegetables is one of the main risk factors for mortality. In world, 200 countries are growing 392 kinds of vegetables. Asia is the largest vegetable producing continent contributing almost 3/4 of the world's production, mostly in China, which produces over half of the world's vegetables. In many countries, consumption of less than 200 g of vegetables per person on daily basis is common and this low amount, often in conjunction with poverty and poor medical services, is associated with unacceptable levels of mortality and malnutrition in preschool children and other vulnerable groups. The International Agency for Research on Cancer (IARC) estimated that the preventable percentage of cancer was due to such diets ranges from 5-12% for all cancers, and 20-30% for upper gastro-intestinal tract cancers. Some phytochemicals present in the vegetables acts as strong antioxidants and are thought to reduce the risk of chronic disease by protecting against free-radical damage with the modification of metabolic activation and detoxification of carcinogens, or even influencing processes that alter the course of tumor cells (Wargovich, 2000; Southon, 2000).

Nutrient deficiencies arising at the critical stages of crop growth adversely affect the yield and quality of produce. In such situations, foliar nutrition can quickly correct nutrient inadequacies. Availability of nutrients through soil application is subjected to various edaphic factors but through foliar application can quickly penetrate into leaf cells and directly reaches to the cell cytoplasm. Foliar feeding is the most efficient method of application of water-soluble fertilizers. Fertilizer application on leaves of growing plants at suitable concentrations is termed as foliar fertilization. Foliar nutrition was found to be six, four and twenty times more beneficial for the nutrients such as N, B and Zn respectively as compared to soil application. The practice of foliar fertilization has gain of minimal cost and a quick plant response, and it is particularly more crucial when soil problems occur and root growth is inadequate. Plants are able to absorb essential elements through their leaves. The leaf is the principal seat of several metabolic activities in higher plants, and the mineral elements which are both structural and functional in nature, reaches to the leaf to participate in the acquisition and fixing up of the atmospheric carbon.

Cuticle is the first route for the uptake of water and water-soluble salts into plants. Absorption of ions is governed by kind of charge and ion radius. Accumulation of ions takes place against a concentration gradient by leaves. It was also reported that, ion uptake by leaves is completed in three stages. In the first stage, particles penetrate into the cuticle and cell wall by active or passive diffusion. Diffused particles are adsorbed to the surface of plasma membrane and adsorbed particles are taken up by the cytoplasm by the way of active diffusion in the second and third stage respectively. Nutrients can also enter the plants through stomata, other specialized epidermal cells and leaf hairs. Absorption is hasten through the stomata but the net quantity is greater for epidermis.

Effect of foliar application of Magnesium on vegetable crops:

Growth parameters. Ahmed *et al.* (2011) conducted an experiment on cauliflower cv. Amshiry with different concentrations of molybdenum and magnesium on vegetative growth, chemical content and curd yield. Plants were treated with 15, 30 and 45 µg/l of Mo and 0.50, 0.75 per cent of Mg at 20, 40, 60 and 80 days after transplanting. They reported that the foliar application with 0.50 and 0.75 per cent of Mg had significantly increased the growth parameters. Saad *et al.* (2014) concluded that the soil inoculation with phosphorien containing phosphate-dissolving bacteria (PDB) and/or foliar application of magnesium at the rates of 0, 0.5 and 1mM on growth, green pod and seed yields, and chemical constituents of *Pisum sativum* L. had significantly increased growth and canopy dry weight plant^{-1}.

Yield and quality attributes. Ikbal and Naif (2014) investigated the effect of foliar application of magnesium salts ($MgSO_4.7H_2O$, Mg $(NO_3)_2$. $6H_2O$ and $MgCl_2$. $6H_2O$) on growth, yield components and some inorganic minerals on leaves of garliclocal variety. The concentration of Mg were used was constant (1.97 g per l Mg. which comes from 2 per cent $MgSO_4.7H_2O$). The results revealed that vegetative growth of garlic was affected significantly by magnesium salts. The results showed that spraying plants with Mg $(NO_3)_2$ and $MgSO_4$had improved the yield traits. Saad *et al.* (2014) reported that the soil inoculation with phosphorien containing phosphate-dissolving bacteria (PDB) and/or magnesium foliar application at the rates of 0, 0.5 and 1mM had significantly improved the number of green pods, seed yield and soluble sugars. Ahmed *et al.* (2011) observed that the plants (cv. Amshiry) were sprayed with 15, 30 and 45 µg per l of Mo and 0.50, 0.75 per cent of Mg at 20, 40, 60 and 80 days after transplanting and the results showed that the foliar spray of Mg with 0.50 and 0.75 per cent significantly increased yield parameters in cauliflower. Talukder *et al.* (2009) revealed that higher tuber yield was obtained (32.33, 31.63, and 28.03 t/ha during three successive years) with 10 kg/ha of Mg that was statistically identical to the yields obtained with 15 and 20 kg/ha of Mg and tuber yield tended to decrease with increasing rate of Mg beyond 10 kg/ ha. Average tuber yield of potato was increased by 18 and 31 per cent from 5 and 10 kg/ ha of Mg, respectively, over untreated control. Magnesium at the rate of 10 kg/ha increased mean tuber yield by 31 % over magnesium (control).

Effect of foliar application of sulphur on vegetable crops:

Growth parameters. Dehigaspitiya *et al.* (2016) conducted an experiment with the foliar application of sulphur in different concentrations on some selected growth parameters of okra plants. Pot experiment was conducted with six treatments (2g per l, 4g per l, 6g per l, 8g per l and 10g per l sulphur solutions). Results showed that the highest significant values were recorded for the characters such as number of leaves (26), leaf length (21cm) and leaf width (24 cm) with the foliar application of sulphur (10g per l). Application of sulphur solutions on plants were directly proportional to the selected physiological features in okra. Sujatha *et al.* (2016) observed the effect of SO_2 (0, 10, 20, 30, 40, 50, 100 and 250ppm) on different parameters of pigeon pea (*Cajanus cajan* L.) Mill sp. cv. PDM1, a C_3 plant and amaranth (*Amaranthus paniculatus* L. a local cultivar), a C_4 plant and concluded that the foliar application of aqueous SO_2 interferes with several components of plant growth. Comparatively, the root growth was more affected than the shoot growth in amaranth. The fresh and dry weights of the whole plant and its parts decreased more in amaranth than in pigeon pea.

Yield and quality attributes. Babaleshwar *et al.* (2017) studied the effect of sulphur on productivity of garlic. Plant height (43.71 cm), no. of leaves per plant (7.25), bulb diameter (36.27 mm), no. of cloves/ bulb (21.75), 10 cloves weight (10.23 g) and average bulb weight (11.75 gm) increased significantly with the application of 60 kg of S per ha (T_5) and marketable yield (5.19 t per ha), total yield (5.79 t per ha). Khalid *et al.* (2017) studied on sulphur foliar fertilization on reproductive growth and development of canola. The results revealed that sulphur foliar spray at the rate of 2 per cent as aqueous solution of ammonium sulphate (AS), significantly improved number of pods per plant, productive pods per plant, grains per pod, pod length (cm), 1000 grains weight (g) and grains oil content (per cent). Mani *et al.* (2014) was reported that small size tuber yield (per cent) was the maximum under control followed by 15, 30, 60 and 45 kg per ha in descending order along with this medium and large size tuber yield (per cent) was maximum under 45 kg per ha followed by 60, 30 and 15 kg per ha sulphur application but small size of tuber yield not affected by S application.

Effect of foliar application of zinc on vegetable crops:

Growth parameters. Acharya *et al.* (2015) conducted experimental studies on effect of zinc and boron application on seedling transplanting of multiplier onion CO 5 at different levels of zinc and boron both foliar and basal application. Results reveled among the treatments foliar application of 0.5 per cent zinc sulphate significantly increased growth, fresh leaf weight and total dry matter production compared to control. Kazemi (2013) conducted experiment on foliar application of zinc (50 and 100 mg per l) and iron (100

and 200 mg per l) and their combination on vegetative, reproductive growth, fruit quality and yield of tomato plants. Zn (100 mg per l) and Fe (200 mg per l) and their combination significantly promoted vegetative and reproductive growth. Foliar application of Zn (100 mg per l) + Fe (200 mg per l) resulted in the maximum plant height (124.14 cm), branches per plant (8.36).Ahmed *et al.* (2011) were report that response of potato to foliar application of yeast and zinc on vegetative growth, yield was studied with 0, 1, 2, 3, 4 and 5 g per l each yeast and zinc spray with four zinc treatments (0, 100, 200 and 300ppm). Results showed that the increase of zinc concentration up to 300ppm significantly increased the vegetative growth characters like plant height, stem and number of leaves per plant, leaf area per plant, fresh and dry weight of whole plant. Bharad *et al.* (2007) were conducted experiments on net house grown capsicum under Akola conditions with foliar applications of zinc and iron at three levels (Z_0 - 0.0 per cent $ZnSO_4$, Z_1 - 0.25 per cent $ZnSO_4$, Z_2 - 0.50 per cent $ZnSO_4$) and (F_0 - 0.0 per cent $FeSO_4$, F_1 - 0.15 per cent $FeSO_4$, F_2 - 0.30 per cent $FeSO_4$) were significantly improved the various growth attributes. Compared to different treatments, $ZnSO_4$ at 0.50 per cent resulted in maximum growth.

Yield and quality attributes. Javanmardi and Rasuli (2017) reported that high tuber yield through increasing the number and weight of quality tubers with Gibberellic acid (GA_3 at 0, 100, 200 and 400 ppm and zinc sulfate (at 0, 500, 1000 and 2000 ppm). Compared to control, a 38 percent increase in total tuber yield resulted from treatment with 200 ppm GA_3 and 1000ppm zinc sulfate. The greatest tuber dry matter content (24.33 g per 100g fresh weight) was obtained from 200ppm GA_3 and 2000ppm of zinc sulfate treatment. The highest starch content (32.56 per cent tuber fresh weight) was obtained from sole application of zinc sulfate at 2000 mg/l. Application of GA_3 at 400 mg per l and zinc sulfate at 2000 mg/l resulted in the highest tuber crude protein content of 8.37 percent tuber dry weight which was over twice as much as that of control treatment. Moinuddin *et al.* (2017) conducted experiment on the response of potato crop to foliar application of macro and micronutrients. Among the different treatments, foliar application of micronutrients mixture i.e. mixture of Zn, B, Fe, Mn along with NPK (19-19-19) produced the highest tuber yield of 22.45 t per ha which was 32.01 per cent higher than control plot yield. Slosar *et al.* (2017) conducted experiment on effect of zinc foliar fertilizer on broccoli cv. Bejo 2914 (F1) with different treatments: (1) untreated control; (2) Zn 0.75 – Zinkuran SC as foliar fertilizer at the rate of 0.75 l per ha (375 g Zn per ha); (3) Zn1.50 – Zinkuran SC as foliar fertilizer at the rate of 1.50 l per ha (750 g Zn per ha), respectively broccoli yield higher by (Zn 0.75) and (Zn 1.50) than control. Fadhly (2016) studied the effect of foliar application of Zinc and Manganese on mean weight of potato tuber, tuber yield per plant and total tuber yield with the treatments *viz*., Control (no Zn or Mn applied), 60ppm Zn, 30ppm Mn and mixture (60ppm Zn + 30ppm Mn). Mixture solution application (Zn + Mn) increased mean weight of potato tuber to 94.03 g per tuber which was 65 per cent higher compared to control, tuber yield per plant to 921.90 g $plant^{-1}$ which was 56 per cent higher compared to control and total tubers yield to 46.10 Mg per ha which was 57 per cent higher compared to control. The interaction effect (sprayed Zn + Mn × application date) was significant. In conclusion, foliar application of Zn + Mn at vegetative growth stage increased mean weight of potato tuber, tuber yield per plant and total tubers yield which were 98.87 gm per tuber, 941.40 g per Plant and 47.07 mg per ha respectively. Geries *et al.* (2016) reported that foliar application with salicylic acid with and without of some micronutrients (Fe, Zn and Mn) on the growth, onion bulbs yield and its quality as well as storability of onion bulbs variety Giza Red by the three foliar application with salicylic acid rates (100, 200 and 300 ppm), whereas foliar application with micronutrients at the same dose, 2 ml per l (spraying with water; spraying with Fe or Zn or Mn and spraying with Fe + Zn + Mn). Results showed that foliar application of onion plants with mixture of Fe, Zn and Mn markedly, after storing for 180 days the lowest values of per cent weight loss was observed under combination of salicylic acid at 200ppm with mixture of Fe, Zn and Mn. Parmar *et al.* (2016) conducted experiment on influence of foliar supplementation of zinc and manganese on yield and quality of potato. Different doses of Zn (0, 5, 10 and 15ppm) and Mn (0, 2, 4 and 6 ppm) were applied as foliar application. Significantly maximum tuber yield per plant (610.43 g), tuber yield per hectare (417.61q), reducing sugar (3.53 percent), non-reducing sugar (4.33 percent), total sugars (7.86 per cent) and protein (2.60 percent) were recorded under the supplementation of Zn with 15ppm and Mn with 6ppm. Acharya *et al.* (2015) conducted experimental studies on effect of zinc and boron application on seedling transplanting multiplier onion CO 5 at different levels of zinc and boron both foliar and basal application. The treatment consists of soil application of zinc sulphate (5 kg per ha and 10 kg per ha), Borax (5 kg per ha and 10 kg per ha), foliar application of zinc sulphate (0.5 per cent foliar spray) and Borax (0.25 per cent foliar spray), zinc sulphate (5 kg soil + 0.5 per cent foliar spray), zinc sulphate (10 kg per ha soil + 0.5 per cent foliar spray), borax (5 kg per ha soil + 0.25 per cent foliar spray), borax (10 ha kg soil + 0.25 per cent foliar spray) and control without micronutrient. Foliar application of 0.5 per cent zinc sulphate significantly increased yield attributes compared to control. Hameda *et al.* (2015) reported that different levels of sulphur application either single or in combination with mixed micronutrients (Fe, Ze and Mn) at 0, 150, 200 and 250 ppm levels as foliar application on plant growth, yield and its components, as well as chemical constituents and storability of bulbs. Results revealed that moisture loss percent of garlic bulbs significantly reduced during storage by sprayed 250 ppm micronutrient mixture. Lopez *et al.* (2014) reported that yield performance of the cultivar "Criolla Colombia" under foliar applications of Zn chelate (0, 1, 2 and 3 kg per ha) and edaphic applications of granulated Zn sulfated (0, 1, 2

and 3 kg per ha). The results revealed that the 3.0 kg per ha edaphic application rendered quadratic yield behavior with a relative increase of 7.9 t per ha(136 per cent) for the first category tuber weight and 9.5 t per ha(68 per cent) for total weight. In turn, the foliar application of the same dose resulted in a 5.8 t per ha(93 per cent) relative increase and a first category tuber total weight increase of 3.8 t per ha(24 per cent). Under the edaphic and foliar Zn applications, the number of tubers underwent 77 per cent and 86 per cent increases, respectively, with respect to the control. Kamil and Saifedin (2014) was reported that foliar application of micronutrients like Zinc, Manganese, Copper and Iron on yield and dry matter percentage of potato increased all plant characteristics relating to yield components and dry matter percentage of potato crop. Application of full micronutrients mixture increased yield to 22.89 tonnes per ha which was 8.74 percent higher compared with control. Kazemi (2013) conducted experiment on foliar application of zinc (50 and 100 mg per l) and iron (100 and 200 mg per l) and their combination on vegetative, reproductive growth, fruit quality and yield of tomato plants. Zn (100 mg per l) and Fe (200 mg per l) and their combination significantly promoted vegetative and reproductive growth. Foliar application of Zn (100 mg per l) + Fe (200 mg per l) resulted in the maximum flowers per cluster (18.14), fruits per cluster (8), fruits per plant (90.14), fruit weight (95.14 g), yield (25.14 t per ha), chlorophyll content (22.14 SPAD), TSS (5.87 °Brix), TA (4 per cent), pH (2.61 per cent), fruit firmness (3.66 kg cm^{-2}) and fruit lycopene content (2.25 mg per 100 g). Hameda *et al.*(2012) were conducted experimental studies on effects of foliar spray with some microelements (Fe, Zn and Mn, 100ppm) at different fertilizer sources (FYM, mineral fertilizer and control) and bio-fertilization with Rhizobium as well as their interactions on yield and yield components and chemical constituents of pea plant (*Pisum sativum* L.) cv. Master-B. Result reveled that foliar application with mixture of micronutrients significantly increased yield components.Mousa (2009) was reported that application of Zn and Mn foliar combination once in every two weeks significantly increased the number and size of marketable tubers and total marketable tubers of three commercially cultivated potato cultivars showed that the highest yield of marketable tubers was recorded for 'Spunta' cultivar when treated with Zn and Mn foliar combination. Bharad *et al.* (2007) were conducted experiments on net house grown capsicum under Akola conditions with foliar applications of zinc and iron at three levels (Z_0 - 0.0 per cent $ZnSO_4$, Z_1 - 0.25 per cent $ZnSO_4$, Z_2 - 0.50 per cent $ZnSO_4$) and (F_0 - 0.0 per cent $FeSO_4$, F_1 - 0.15 per cent $FeSO_4$, F_2 - 0.30 per cent $FeSO_4$) were significantly improved the various yield attributes. Compared to different treatments, $ZnSO_4$ at 0.50 per cent resulted in maximum yield. Lashkari (2007) was reported that growth and yield performance of cauliflower cv. Snowball-16 were studied with different concentrations of Zn (0.0, 0.5 and 1.0 per cent) and Fe (0.0, 0.5 & 1.0 per cent) at 30 and 60 days after transplanting of seedlings. Result shows marketable yield (q per ha) was found significantly highest with combined foliar sprays of zinc and iron each at 0.5 per cent concentration.

Effect of foliar application of boron on vegetable crops:

Growth attributes. Bharati *et al.* (2018) studied foliar application of different micronutrients in view of rising temperature to enhance the productivity of bitter gourd with better quality. It was observed that the foliar application of mixture of all micronutrients with 100 ppm being at par with boric acid with 100 ppm sprayed at 30, 40, 50 DAS resulted in the maximum length of vines (5.58 m). Patel *et al.* (2017) reported that Boron (B) and Molybdenum (Mo) influenced the growth, yield quality of broccoli cv. Pusa KTS 1. Treatments comprising of recommended dose of fertilizers (RDF), Borax at two levels (1.5 and 2.5 per cent), Ammonium molybdate at two levels (1.5 and 2.5 per cent) and control and statistical analysis clearly revealed that T_7 (RDF + Borax (1.5 per cent) + Ammonium molybdate (2.5 per cent) was found as the best combination for the vegetative growth (plant height, stem circumference, plant spreading, number of leaves, length and width of leaves etc). Shnain *et al.* (2017) were studied the effect of zinc and boron on growth of tomato (*Lycopersicon esculentum*. Mill.) CV. Heem Sohna, under protected cultivation. From the results of different treatments the highest plant height (2.93 m), number of leaves per plant (39.33 leaves) with T_6 (B 1.25 g per l). Tantawy *et al.* (2017) reported that effect of foliar application of boron on the growth and production of two potato cultivars namely Spunta and Diamond. At 60 days after planting, plants were fully sprayed with a diluted solution of liquid boron (11.5 per cent B). The dilution rate was 0.5, 1.0 and 2.0cm^3 per l in addition to control treatment (only water). The results showed that plants responded positively and significantly to all application rate of boron. The vegetative parameters (plant height, number of leaves, fresh, dry weights) responded the highest to the concentration of 0.5 cm^3 per l. Dissoky and Kadar (2013) conducted experiments in two different locations to evaluate the effect of boron as a foliar application (0, 30, 60 and 90 mg per l) on some potato cultivars (Spunta and Valor). Results revealed that foliar spray of B-levels at significantly affected potato growth parameters (i.e. plant height, No. of leaves per plant, fresh weight of plant, dry weight of plant and leaf area) and yield. Jafari-Jood *et al.* (2013) conducted studies on the effects of boron and manganese and nitrogen levels on growth (potato). That dual application of boron and manganese resulted in remarkable improvement in agronomic traits of potato. Manna (2013) was experiment conducted with 4 levels of boron (0, 0.1, 0.2 and 0.5 per cent) and 4 levels of zinc (0, 0.1, 0.2 and 0.5 per cent) as foliar application started from 30 days after transplanting sprayed three times on onion cv. Baswant 780. Results revealed that 0.5 percent boron significantly increased the plant height and yield over control. Singh *et al.* (2013) were studied on different fertility levels (F_1: 30-20-2.5, P_2O_5-S-Zn kg per ha and F_2: 60-40-5, P_2O_5-S-Zn kg per ha) and micronutrients on plant growth, nodulation,

production potential of pea. Experiment results signified that combined application of micronutrients enhanced the plant growth, nodulation of crop also increased to a great extent by the combined application of micronutrient (B 0.3 per cent + Co 2 per cent + Mo1per cent kg per ha) under fertility level F_2. Singh and Tiwari (2013) studied the five levels of micronutrient each at two levels of concentration on tomato. The maximum plant height, number of leaves per plant and number of flowers per plant superior with the application of (Boric acid + Zinc sulphate + Copper sulphate with 250 ppm each). Sitapara *et al.* (2011) were studied effect of plant growth regulators (GA_3 and NAA) and micronutrient (boron) on cauliflower (*Brassica oleracea* L.) cv. SNOWBALL-16. Two foliar sprays (15 and 30 DAT) of gibberellic acid with 100ppm and boric acid at 0.2 per cent were found better for growth attributes (*viz.*, plant height, number of leaves, stem length, stem diameter, days taken for marketable curd etc.).

Yield and quality attributes. Awalin *et al.* (2017) conducted an experiment to evaluate the response of bell pepper through foliar feeding of micronutrients and shoot pruning. The experiment consisted of two levels of shoot pruning *viz*., P_0: no shoot pruning & P_1: shoot pruning and six levels of foliar applications of micronutrients as: M_0: control (water); M_1: boron (B) with 100ppm as H_3BO_3; M_2: zinc (Zn) with 100 ppm as $ZnSO_4$; M_3: copper (Cu) with 100ppm as $CuSO_4$: M_4: manganese (Mn) with 100 ppm as $MnSO_4$ and M_5: mixed micronutrients with 100ppm each (B, Zn, Cu and Mn). The greatest number of marketable fruits per plant (9.57), maximum fruit setting (40.53 per cent) and highest yield (29.98 t/ha) were elicited with mixed micronutrients @ 100ppm. However, application of shoot pruning along with mixed micronutrients (100ppm) produced the highest yield (30.43 t per ha) as compared to other treatments. Patel *et al.* (2017) reported that the application of Boron (B) and Molybdenum (Mo) influenced the growth, yield, quality of broccoli cv. Pusa KTS 1. Treatments comprising of recommended dose of fertilizers (RDF), Borax at two levels (1.5 and 2.5 per cent), Ammonium molybdate at two levels (1.5 and 2.5%) and control and statistical analysis clearly revealed that T_7 (RDF + Borax (1.5 per cent) + Ammonium molybdate (2.5 per cent) was found as the best combination for the attributes such as curd weight, yield. Dixit *et al.* (2017) conducted an experiment on the effect of calcium and some micro nutrients with different concentration levels (foliar application) on quality attributes of tomato cv 'Arka Rakshak'. The data clearly showed that the treatment (T_5) exhibited more shelf life (16.63 days), maximum TSS (5.25 per cent), reducing sugars (1.68 per cent), non-reducing sugars (2.00 per cent), and total sugar (3.63 per cent). Shnain *et al.* (2017) studied the effect of zinc and boron on growth of tomato (*Lycopersicon esculentum*. Mill.) cv. Heem Sohna, under protected conditions. Result shown that highest shelf life (26.33 days), TSS (°Brix) (5.67), Vitamin C (32.57 mg per 100 g) were recorded in T_6 (B 1.25 g per l).Sultana *et al.* (2017) were conducted experiment on effect of boron on the yield and quality of bitter gourd was studied with the application of recommended NPK, 0.5, 0.75, 1.0 and 1.25 kg boron per ha along with recommended NPK and control. The results showed that boron had a significant effect on bitter gourd fruit yield (14.1 t per ha) was obtained when boron with 1.25 kg per ha was applied. Singh *et al.* (2017) studied the efficacy of various levels of boron and molybdenum on growth, yield and quality of cauliflower (*Brassica oleracea* L. var. *botrytis*). The treatments comprised of foliar application of boron with 100ppm and molybdenum with 50ppm alone and in combination and two levels of borax with 10 and 20 kg per ha and sodium molybdate with 1 and 2 kg per ha alone and in combination and control treatment (NPK with 120: 60: 60 kg per ha). There were quadratic responses of curd yield were recorded with the application of boron with 100 ppm. Banerjee *et al.* (2015) were studied the performance of different forms of boron on yield of cauliflower (*Brassica oleracea* var. botrytis L.) through reducing hollow stem disorder under West Bengal conditions. This study indicated that the hollow stem of cauliflower can effectively be managed by both the application of farm yard manure at 7.5 t per ha as basal and either application of Boric acid with 0.3 per cent or liquid Boron with 1.5 g per l at 30 days after planting. Dissoky and Kadar (2013) conducted experiment at two locations of alluvial soils in Dakahlia Governorate, Egypt, at Batra village and El-Tawila village to evaluate the effect of boron as a foliar application on some potato cultivars by application of boron at four levels (0, 30,60 and 90 mg per l). Here the quality of potato tuber parameters (i.e. dry matter, protein and starch percentage) was also significantly increased with foliar B application. Singh *et al.* (2013) were studies on different fertility levels (F_1: 30-20-2.5, P_2O_5-S-Zn kg per ha and F_2: 60-40-5, P_2O_5-S-Zn kg per ha) and micronutrients on plant growth, nodulation, production potential of pea were studied. Experiment results signified that combined application of micronutrients enhanced the plant yield, grain yield and nutrient uptake (N, P and S) by crop also increased to a great extent by the combined application of micronutrient (B 0.3 per cent + Co 2 per cent + Mo1 per cent kg per ha) under fertility level F_2. Abdur and Ihsan (2012) reported that influence of $CaCl_2$ and borax on growth, yield, and quality of tomato. Calcium chloride (0.3 per cent and 0.6 per cent) and borax (0.2 per cent and 0.4 per cent) solutions were applied as foliar sprays either alone or in combination. Borax alone significantly enhanced the number of flowers per cluster, fruits per cluster, and fruits per plant, fruit weight, fruit firmness, and total soluble solid content of the fruits. Sitapara *et al.*, (2011) studied the effect of plant growth regulators (GA_3 and NAA) and micronutrient (boron) on cauliflower (*Brassica oleracea* L.) cv. SNOWBALL-16. Two foliar sprays (15 and 30 DAT) of gibberellic acid with 100ppm and boric acid at 0.2 per cent were found better for yield attributes (*viz.*, diameter, volume and weight of curd) and early curd yield. Huang and Snapp (2009) While studying the effects of K and B on yield and quality of fresh market tomato cv. 'Mountain

Spring' with three fertigation regimes (1N:0.8K, 1N:1.7K, and 1N:2.5K) in the presence and absence of a weekly foliar spray of B (300 mg per l). Boron foliar spray of 1N:1.7K increased tomato marketable yield and fruit quality, reducing shoulder check incidence by 50 per cent compared to zero-B treated plants and found it as a cost effective treatment.

Effect of combined foliar application of boron and zinc nutrients on vegetable crops:

Growth attributes. Haleema *et al.* (2017) studied the effect of calcium, boron, and zinc as foliar application on growth and fruit production of tomato. Calcium (0, 0.3, 0.6 and 0.9 per cent), Boron (0, 0.25, 0.5 per cent) and Zinc (0, 0.25, 0.5 per cent) were applied at three times. In case of B levels, more plant height (88.14 cm), number of primary (2.61) and secondary (7.44) branches, number of leaves per plant (177), number fruits per plant (67.78) were recorded with foliar spray of B @ 0.25 per cent, while maximum leaf area was found with 0.5 per cent of B. Application of Zn (0.5 percent) alone gave significant results for the attributes such as plant height (86.53 cm), number of primary branches (2.53), secondary branches (6.42) and number of leaves (167)in tomato. Pramanik and Tripathy (2017) observed the efficacy of micronutrients in onion (*A. cepa* L. var. Arka Kalyan) and reported that there was significant improvement for different attributes. The results revealed that significant vegetative growth in terms of plant height (62.28 cm), number of leaves per plant (12.36), collar thickness (15.94 mm) was recorded when the onion plants were treated with recommended dose of NPKS (150:50:80:30 kg per ha) +20 t per ha of FYM + micronutrient mixture *i.e.* Fe-2.5 per cent, B-0.5 per cent, Zn -3 per cent, Cu -1 per cent and Mn-1 per cent with 0.5 per cent as foliar at 30 and 45 DAP. Hence, foliar application of micronutrient mixture with 0.5 per cent followed by borax (0.25 per cent) at 30 and 45 DAP enhanced the growth attributes of onion. Ali *et al.* (2013) studied the effect of spraying numbers (0, 2 and 4) of Alaska foliar fertilizer (N:12, P_2O_5 :12 , K_2O: 36 , Fe : 0.05 per cent , Cu:0.005 per cent, Mn: 0.03 per cent, Zn: 0.01 per cent , B: 0.02 per cent , Mo: 0.003 per cent) on growth and yield of 7 potato cvs. (Draga, Aladin, Elpaso, Kurado, Diseree, Provento and Red Brown). Results showed that there was a significant effect on plant height through foliar fertilization. Ain *et al.* (2016) studied the response of broccoli to foliar application of different concentrations of zinc (0, 0.25, 0.5, and 1.0 per cent) and boron (0, 0.25, 0.5, and 1.0 per cent). Maximum plant height (40.49 cm) and number of leaves per plant (13.08) was observed at 0.5 per cent Zn, while Zn (1 per cent) resulted in maximum leaf weight (9.66 g) and boron (0.25 per cent) resulted in maximum plant height (39.31cm) while maximum number of leaves per plant(12.83) and maximum leaf weight (10.17 g) was found in plants receiving B at 0.5 per cent. Mushtaq (2016) studied that effect of nine different foliar micronutrient applications on Tomato cv. Shalimar-1 under temperate conditions in Kashmir valley. Among all the treatments, T_8 (boron with 100 ppm + zinc with 100 ppm) recorded the maximum plant height (55.06cm), dry matter (6.07 g per 100g). Plant spread was found more in the plants treated with T_6 (boron at 100 ppm). Therefore, T_8 (boron with 100 ppm + zinc with 100 ppm) showed significantly better response with respect to growth characters. Pandav *et al.* (2016) conducted an experiment with different treatments *viz.*, T_1 (control-water spray), T_2 (zinc sulfate 0.3 per cent), T_3 (zinc sulfate 0.4 per cent), T_4 (zinc sulfate 0.5 per cent), T5 (iron sulfate 0.3 per cent), T_6 (iron sulfate 0.4 per cent), T_7 (iron sulfate 0.5 per cent), T_8 (borax 0.3 per cent), T_9 (borax 0.4 per cent) and T_{10} (borax 0.5 per cent). They found that the plant height was increased significantly with the increase inconcentration of micronutrients (up to 0.4 per cent) in eggplant cv HLB 12.

Saravaiya *et al.* (2014) studied the effect of foliar application of micronutrients in tomato (*Lycopersicon esculentum* Mill.) cv. Gujarat Tomato-2. Different treatments *viz.*, T_1 [N: P_2O_5 : K_2O_5 kg ha^{-1} (75 : 37.5 : 62.5), T_2 (T_1+ 100ppm B; i.e. boric acid 0.57 g per l), T_3(T_1+100 ppm Zn; i.e. zinc sulphate 0.24 g per l), T_4 (T_1 + 100ppm Cu; i.e. copper sulphate 0.42 g per l), T5 (T_1+100ppm Fe; i.e. ferrous sulphate 0.52 g per l), T_6 (T_1 +100ppm Mn; i.e. manganese sulphate 0.320 g per l) and T_7 (T_1 + mixture of all micronutrients) and T_8 (T_1 + multiplex 4 ml l^{-1}) by mixing with simple water were imposed. Among these, T_7 had significant results in terms of maximum plant height (131.73 cm), number of branches per plant (5.81), fresh weight of plants (25.65 t per ha), dry matter yield of plants (7670.03 kg per ha). Ali *et al*. (2015) conducted an experiment to increase the yield of Bari hybrid tomato 4, through foliar application of zinc and boron. Treatments were (T_0: control; T_1: 25-ppm Zn; T_2: 25-ppm Boron and T_3: 12.5-ppm Zn + 12.5-ppm Boron). Foliar application of 12.5ppm of zinc and boron had shown better results for growth attributes as compared to control. Harris and Mathuma (2015) studied on foliar application of boron, zinc and their combinations on growth and yield of tomato cv. Thilina. with the following treatments; T_1-B (150 ppm), T_2-B (250 ppm), T_3-B (350ppm), T_4-Zn (150ppm), T_5-Zn (250ppm), T_6-Zn (350ppm), T_7-B (150ppm)+Zn (150ppm), T_8-B (250ppm)+Zn (250ppm), T_9-B (350ppm)+Zn (350ppm) and T_{10}-Control. Results showed that maximum growth attributes and total dry weight were obtained with 250ppm of Zn as foliar application, which was followed by foliar application of Zn at 150ppm and dry weight of leaves, stem, roots per plant were high in 250ppm of boron when compared to control. Meena *et al.* (2015) reported that application of zinc and boron on improvement of growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Azad T-6. Treatment combinations are T_0-Control (water spray), T_1-Zinc (50 ppm), T_2-Zinc (100 ppm), T_3-Zinc (150 ppm), T_4-Boron (50 ppm), T_5-Boron (100 ppm), T_6-Boron (150 ppm), T_7-Zinc (50 ppm)+Boron (50 ppm), T_8- Zinc (100ppm)+Boron (100 ppm), T_9-Zinc (150 ppm)+Boron (150 ppm), T_{10}- Zinc (100 ppm) + Boron (50 ppm), T_{11}-Zinc (150 ppm) + Boron (50 ppm). It was found that the vegetative growth parameters were greatly influenced by the application of Zn and B. Among them, treatment T_5- Boron (100ppm)

significantly increased the plant height (61.23 cm at 90 DAT), number of branches (16.17 per plant at 90 DAT). Jafari- Jood *et al.* (2013) reported the effect of boron and manganese micronutrients and nitrogen levels on growth traits of two potato cultivars Sprit and Marfona. Results showed that the effect of micronutrient on plant height, leaves number and shoot weight was statistically significant. Manna (2013) was conducted experiment with 4 levels of boron (0, 0.1, 0.2 and 0.5 per cent) and 4 levels of zinc (0, 0.1, 0.2 and 0.5 per cent) as foliar application started from 30 days after transplanting sprayed three times on onion cv. Baswant 780. Foliar application of boric acid and zinc sulphate had significantly improved the vegetative growth in onion. Results revealed that 0.5 percent boron significantly increased the plant height (63.9 cm) over control. Sivaiah *et al.* (2013) studied the foliar application of micronutrients on vegetative and reproductive growth attributes in two varieties of tomato namely Utkal Kumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all and control. All the micronutrients except manganese sprayed at 50ppm and 100ppm in three sprays at an interval of ten days starting from 30 days after transplanting. In cv. Utkal Kumari, maximum growth rate (85.7 per cent) was observed with application of zinc, followed by application of micronutrients mixture (78.2 per cent) and boron (77.5 per cent). While, in cv. Utkal Raja, maximum number of branches per plant were obtained with the application of micronutrient combination followed by application of boron and zinc.

Yield and quality attributes. Bharati *et al.* (2018) studied the foliar application of different micronutrients in view of rising temperature to enhance the productivity and better quality in bitter gourd. It was observed that the foliar application of micronutrients mixture (100ppm) sprayed at 30, 40, 50 DAS resulted in the maximum fruit length (25.01 cm), fruit girth (10.75 cm), fruit weight per vine (2.197 kg), yield (197.01 q per ha) and it was at par with boric acid @100ppmsprayed at 30, 40, 50 DAS. Moklikar *et al.* (2018) observed that the effect of micronutrients on cauliflower (*Brassica oleracea* var. *botrytis*) cv. Sungro-Anandi with the application of Zn (0.5 per cent), Bo (0.2 per cent) Fe (0.5 per cent) and Fe (0.3 per cent) for growth, yield and quality attributes. Maximum yield per plot (34.80 kg) and total biomass production ((2849. 20 g) was obtained in the treatment received with foliar application of $FeSO_4$ 0.5 per cent + Borax spray 0.2 per cent + $ZnSO_4$ 0.5 per cent. Babaleshwar *et al.* (2017) conducted an experiment on application of zinc sulphate, borax and micronutrient mixture through soil and foliar application and reported that the foliar application of zinc sulphate with 0.5 per cent at 30 and 45 DAT had resulted in the significant improvement of growth and yield contributing characters such as marketable and total yield of 34.13 t per ha and 38.28 t per ha which was followed by soil application of zinc sulphate (10 kg per ha)in Onion. In onion (*Allium cepa* L.) cv. Agrifound dark red, different treatments consists of four micronutrients, *viz*., Zn, Mn, B and Cu alone and in combination were applied on foliage by Goyal *et al.* (2017). In their study, foliar application of micronutrient (Boran with 0.25 per cent (T3)) had produced the best results in terms of bulb yield and quality. Pandiyan *et al.* (2017) studied the foliar application of micronutrients on tomato hybrid COTH-2 with three sprays at an interval of 10 days starting from 40 days after transplanting and spraying of micronutrients mixture (Boric acid @100ppm, $ZnSo_4$ @ 100ppm, Ammonium molybdate (50ppm), Copper sulphate @ 100ppm, Ferous sulphate (100ppm), Manganese sulphate @ 100ppm) and commercial formulation (multiplex) with 4ml per lit also included in the treatment combinations. Results revealed that the highest yield of 564.1 q per ha in micronutrients mixture followed by spraying of commercial formulation (Multiplex) (558.8 q per ha). Pramanik and Tripathy (2017) studied the efficacy of micronutrients on the performance of onion (*Allium cepa* L. var. Arka Kalyan) and the results revealed that significantly better vegetative growth, average bulb weight (60.55 g), total bulb yield per plot (32.19 kg) and total bulb yield (268.28 q per ha) in the plants treated with recommended dose of NPKS @ 150:50:80:30 kg per ha +20 t per ha FYM + micronutrient mixture *i.e.* Fe-2.5 per cent, B-0.5 per cent, Zn -3 per cent, Cu -1 per cent and Mn-1 per cent with 0.5 per cent as foliar at 30 and 45 DAP. Hence, foliar application of micronutrient mixture (0.5 per cent) followed by borax (0.25 per cent) at 30 and 45 DAP not only enhanced the growth attributes but also increased the total yield of onion. Moinuddin *et al.* (2017) conducted an experiment on foliar application of macro and micronutrients in potato. The treatments comprised of T_1-Foliar application of zinc(Zn-EDTA) with 1 g per l, T_2- Foliar application of boron (20 per cent) with 1.5 g per l , T_3- Foliar application of iron ($FeSO_4$) with 10 g per l, T_4- Foliar application of manganese ($MnSO_4$) with 5 g per l, T_5- Foliar application of NPK(19-19-19) with 10 g per l, T_6 – Foliar application of mixture of Zn, B, Fe, Mn, T_7- Foliar application of mixture of Zn, B, Fe, Mn and NPK, T_8-Control(water spray). Among the treatments, foliar application of micronutrients mixture (Zn, B, Fe, Mn along with NPK (19-19-19)) produced the highest tuber yield of 22.45 t per ha which was 32.01 per cent higher as compared to control. Shnain *et al.* (2017) studied the effect of zinc and boron on growth of tomato (*Lycopersicon esculentum*. Mill.) cv. Heem Sohna, under protected environment. Maximum fruit weight of 72.67 g,number of clusters per plant (12.33), numberof fruits per cluster (7.17), number of fruit per plant (88.33), yield per plant (6.33 kg), total yield (113.628 t per ha) were recorded in T_6 with the application of B @ 1.25 g per l. In broccoli, an experiment was conducted with the foliar application of zinc (0, 0.25, 0.5, and 1.0per cent) and boron (0, 0.25, 0.5, and 1.0 per cent) and maximum number of curd per plant (9.17 and 8.41) was noticed with the application of Zn and boroneach at 1 per cent respectively by Ain *et al.* (2016). Mushtaq (2016) studied the response of nine different foliar micronutrient applications on Tomato cv. Shalimar-1 under temperate conditions in

Kashmir valley. Among all the treatments, T_8 (boron + zinc each at 100ppm) showed significantly better response with respect to yield and quality attributes i.e., maximum fruit length (5.14 cm), fruit width (5.26 cm), average fruit weight (20.90 g)and the TSS (5.72ºB), dry matter (6.07 g per 100 g), fruit firmness were maximum in the treatment T_6 (boron with 100 ppm). Moreover, treatment T_6 (boron at 100ppm) had beneficial effect on increasing the shelf life of tomato. Pandav *et al.* (2016) conducted an experiment with different doses of zinc sulfate and iron sulfate. In this study, the yield parameters such as number of fruits per plant, fruit length and diameter and average fruit weight were increased significantly with the increase in concentration of micronutrients (up to 0.4 per cent) in brinjal. Harris and Mathuma (2015) conducted an experiment with the foliar application of boron, zinc and their combinations in tomato cv. Thilina for growth and yield attributes. The treatments consists of T_1-B (150 ppm), T_2-B (250 ppm), T_3-B (350 ppm), T_4-Zn (150 ppm), T_5-Zn (250 ppm), T_6-Zn (350 ppm), T_7-B (150 ppm)+Zn (150 ppm), T_8-B (250 ppm)+Zn (250 ppm), T_9-B (350 ppm)+Zn (350 ppm) and T_{10}- Control. Foliar application of Zn (250 ppm) at flowering stage had significantly increased the yield. Meena *et al.* (2015) reported that application of zinc and boron had improved the growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Azad. Results revealed that the application of zinc and boron each at 100 ppm (T_8) had shown early flowering (31.95 DAT), maximum number of flowers (75.21) and fruit yield (93.10 t per ha). Saravaiya *et al.* (2014) studied the influence of foliar application of micronutrients in tomato (*Lycopersicon esculentum* Mill.) cv. Gujarat Tomato-2. Among the treatments, T_7 (N: P_2O_5 : K_2 O kg per ha (75 : 37.5 : 62.5) + mixture of all micronutrients) had obtained significant results in terms of maximum days to last picking (166.68), number of fruits per plant (34.26), fruit length (5.52 cm), fruit diameter (4.64 cm), fruit volume (67.53 cm^3), single fruit weight (49.20 g), fruit weight per plant(1.68 kg), number of locules per fruit (3.03), pericarp thickness (6.23 mm), fruit yield per ha (46.78 t per ha) and marketable fruit yield ha (45.62 t per ha).Ali *et al*., (2013) studied the effect of spraying numbers (0, 2 and 4) of Alaska foliar fertilizer (N:12, P_2O_5 :12 , K_2O: 36 , Fe : 0.05 per cent , Cu:0.005 per cent , Mn: 0.03 per cent , Zn: 0.01 per cent , B: 0.02 per cent , Mo: 0.003 per cent) on growth and yield of 7 potato cvs. (Draga, Aladin, Elpaso, Kurado, Diseree, Provento, and Red Brown). Results showed that foliar fertilization had a significant and positive effect on tuber weight and total yield of potato cultivars. Higher yields were noticed in the cultivars Red Brown, Provento and Dragacvs. However, interactions had shown significant effect for most of the parameters studied in the experiment. Manna (2013) conducted an experiment with boron at 4 levels (0, 0.1, 0.2 and 0.5 per cent) and zinc at 4 levels (0, 0.1, 0.2 and 0.5 per cent) as foliar application for thrice started from 30 days after transplanting on onion cv. Baswant 780. Foliar application of boric acid and zinc sulfate had significantly improved the yield and quality parameters in terms of total soluble solids of onion. Satpute *et al.* (2013) reported that the response of summer okra (cv. Phule Utkarsha) to iron, zinc and boron on growth, yield, quality, nutrient uptake of okra in inceptisols at Pune. Results revealed that foliar spray $FeSO_4$ + $ZnSO_4$ (0.5 per cent each) + boric acid (0.2 per cent), Foliar spray $FeSO_4$ + $ZnSO_4$ (0.5 per cent each) and the combined application of $FeSO_4$+ $ZnSO_4$with 20 kg per ha each + borax with 5 kg per ha as soil application and foliar sprays of $FeSO_4$ (0.5 per cent) + $ZnSO_4$ (0.5 per cent) + boric acid (0.2 per cent), both treatments were found significantly effective in increasing the yield of okra. Sivaiah *et al.* (2013) studied the foliar application of micronutrients on vegetative and reproductive growth characteristics in two varieties of tomato namely Utkal Kumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all micronutrients and control. All the micronutrients except manganese were sprayed at 50 ppm and 100 ppmat an interval of 10 days in three sprays starting from 30 days after transplanting. In cv. Utkal Kumari, maximum fruit yield per plant ranged from 1.3-1.87 kg with the application of micronutrients mixture (78.2 per cent) and boron (77.5 per cent). Singh and Tiwari (2013) studied the five levels of micronutrients and each micronutrient with two levels of concentrations on tomato. The maximum number of flowers per plant, number of fruits per plant, fruit yield per plot, TSS content and ascorbic acid were found superior with the application of (Boric acid + Zinc sulphate + Copper sulphate @ 250ppm each).

Effect of combined foliar application of secondary and micro nutrients on vegetable crops:

Growth attributes. Dixit *et al.* (2017) conducted experimental studies on foliar application of some micro and macro nutrients to evaluate the vegetative growth, flowering and yield of tomato cv. Arka Rakshak. Results revealed that most significant influence on all parameters (growth, flowering and yield) with T_5-mixture of all spray compared to control. Karthick *et al*. (2018) conducted experiment on effect of micronutrients along with magnesium on growth, flowering and yield of bitter gourd. Seven treatment combinations involving the micronutrients *viz*., Zn, Fe, B and Cu and magnesium were applied at various levels. Among the treatments tried, foliar application of $ZnSO_4$+ $FeSO_4$+ $MgSO_4$ each with 0.5 per cent at 35 and 45 DAS recorded significantly maximum mean values for morphological and growth parameters like vine length, number of nodes, total leaf area per plant and leaf area index. Joshi and Bhamburdekar (2015) reported that effect of different concentrations of micronutrients ($CaCl_2$, $CuSO_4$, $MgSO_4$, $MnSO_4$, $ZnSO_4$, H_3BO_4 and $FeSO_4$) with four levels of different concentrations (0, 1, 10, 100ppm and stock) on morphological characters of Spinach (*Spinacia oleracea* L.) Results showed that growth attributes, fresh and dry weight of plant were higher with the application of micronutrients at 1ppm concentration.

Yield and quality attributes. Dixit *et al.* (2018) conducted an experiment on foliar application of some

micro and macro nutrients to evaluate the vegetative growth, flowering and yield of tomato cv. Arka Rakshak. Results showed that there was significant increase in T_5-mixture treated plants for growth, flowering and yield parameters as compared to control. Karthick *et al*. (2018) studied on the effect of micronutrients along with magnesium on growth, flowering and yield of bitter gourd. Seven treatment combinations involving the micronutrients (Zn, Fe, B and Cu and magnesium) were applied at various levels. Among the different treatments of foliar application, $ZnSO_4$+ $FeSO_4$+ $MgSO_4$ each at 0.5 % were sprayed at 35 and 45 DAS had recorded significantly maximum mean values for yield attributes. Singh *et al.* (2018) conducted experiments and reported that with recommended dose of N, Pand K (120:80:100 kg N, P_2O_5 and K_2O per ha), Sulphur (wettable sulphur) and boron (borovin) were applied as both basal dose and foliar spray at 30 and 60 DAS (days after sowing). Foliar application (twice) of sulphur or boron (0.5per cent borovin and 0.25 per cent sulphur) was reported to have positive and significant effect for economic yield (360 q per ha) recorded in treatment). Panitnok *et al.* (2013) reported that combination effects of zinc, magnesium and sulphur foliar fertilizer management on yield and quality of cassava cultivars KU 50, HB 60 and HB80 where main plots are treated with 10cc to 30cc/20 liters of water and 60g/20 liters of t ha^{-1}water. The results illustrated that the foliar fertilization with Zn+Mg+S gave the highest on its, while KU 50 cultivar gave the greater effect on fresh stem weight and fresh rhizome weight, HB 60 cultivar tended to give higher fresh root yield (11.90 t per rai or 74.38 t per ha) and fresh root weight (370.10 g per root) but HB80 cultivar tended to give higher root number (13.81 root per plant) and root starch content (27.16 per cent) in HB 80 cultivar. Klikocka (2009) reported that elemental sulphur and kieserite fertilization improved potato (*Solanum tuberosum*) tuber yield, quality and resistance against *Streptomyces scabies*. Treatments with NPK and without NPK, S and Mg and microelements B, Zn, Mn, Cu fertilization were used. Among these, the application of S and Mg and micronutrients significantly increased potato tuber yield.

CONCLUSIONS

From the present investigation it is concluded that growing of potato with foliar spray of magnesium, sulphur, zinc, and boron was the most effective among the various secondary and micronutrients treatments as it influenced the crop throughout its growth which ultimately results in increase in yield and quality.

FUTURE SCOPE

The investigation gives some information and ideas on the following aspects for research works. Looking to the good response of potato crop to foliar application of different macro and micronutrients Mg, S, Zn and B in this study may be included in future study with different concentration. From this study optimum douses of macro and micro nutrient for foliar application also recommended. Research can also be done with soil application along with foliar application. Other varieties of potato can also be tried for foliar application of secondary and micronutrients. Mode of application of different macro and micro nutrients also is a new work for study. Macro and micro nutrients have any effect on disease resistance, storage life of potato.

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