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Foliar application of macro and micronutrients and productivity of oilseed crops: A review

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Abstract
Macro and Micronutrients in oilseeds essential for plant growth, but plants require macro nutrients in large quantity and micronutrients relatively in smaller quantity. Macronutrients include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S). They play major role in protein and starch synthesis, fruit formation, nodulation, pegging, oil synthesis and chlorophyll production. Micronutrients include iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo) and boron (B). They play major role in translocation of photosynthesis, increases seed setting percentage, essential for translocation of sugar, germination of pollen grains, stigma receptivity, amino acid and protein synthesis which ultimately increase the productivity of oilseed crops.

Keywords: Growth, macronutrients, micronutrients, oilseed crops, productivity

Introduction

India is the largest producer of oilseeds in the world and oilseed sector occupies an important position in the agricultural economy of the country. Oilseeds are among the major crops that are grown in the country apart from cereals. In terms of acreage, production and economic value, these crops are second only to food grains. India is the 4th largest vegetable oil economy in the world, next only to USA, China, Brazil and Argentina, and has an annual turnover of about Rs 80000 corer. India accounts for 12-15 per cent of oilseeds area, 7-8 per cent of oilseeds production, 6-7 per cent of vegetable oils production, 9-12 per cent of vegetable oils import and 9-10 per cent of the edible oils consumption (Anonymous 2014) [2].

Almost 72% of the total oilseeds area is confined to rainfed farming, cultivated mostly by small and marginal farmers. Macronutrients include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S). They play major role in protein and starch synthesis, fruit formation, nodulation, pegging, oil synthesis and chlorophyll production. Seven of the sixteen essential plant nutrients are referred to as micronutrients. Micronutrients are essential for plant growth, but plants require relatively in smaller quantity. They include iron (Fe), manganese (Mn), zinc (Zn), boron (B), copper (Cu), molybdenum (Mo) chlorine (Cl). In oilseeds these micronutrients play a major role in translocation of photosynthates, increasing seed setting percentage, essential for translocation of sugar, germination of pollen grains, stigma receptivity, amino acid and protein synthesis which ultimately increase the productivity of oilseed crops (Anonymous 2012) [1]. Almost 72% of the total oilseeds area is confined to rainfed farming, cultivated mostly by small and marginal farmers. The problem of micronutrient deficiency is becoming more serious due to introduction of high yielding varieties, increasing cropping intensity, use of high analysis fertilizers and limited use of organic manures. These are causes for poor productivity of oilseed crops. Hence, it is necessary to adopt the proper micronutrient management practices to increase the productivity of oilseed crops. The work of various research workers discussed above indicated that macro and micronutrient management practice may plan an significant role to promote growth, productivity, uptake of nutrients and oil content of oilseed crops in sustainable basis as well as soil health.

Effect of foliar application on growth parameters of oilseed crops

Mary Schon and Dale Blevins (1990) [22] revealed that foliar application of B at 1.12 kg ha^{-1} and 2.24 kg ha^{-1} increased the number of branches $plant^{-1}$ (2.2) at the end of the season and significantly stimulated the formation of groundnut pods (42.7). This rate also further tended to increase the number of seeds plant^{-1} (98.8) and seed yield plant^{-1} (13.2 g) of groundnut as compared to absolute control i.e. number of branches plant^{-1} (0.6), formation of groundnut pods (24), number of seeds plant^{-1} (56.1) and seed yield plant^{-1} (9.5 g) respectively. Patra *et al*. (1995) [33] reported that application of 0.5% KNO_3, 0.5% $Ca(NO_3)_2$ and 2% urea increased growth rate about 7.2 g m^{-2} day^{-1}, 20.89 pods plant^{-1}, 100 kernel weight 47.70 g, shelling% 70.65 and pod yield 3732 kg ha^{-1} of groundnut compared to absolute control i.e. growth rate about 5.36 g m^{-2} day^{-1}, 12.7 pods plant^{-1}, 100 kernel weight 44.3 g, shelling% 68.7 and pod yield 2077 kg ha^{-1} respectively. Reinbott and Blevins (1995) [36] reported that foliar application of B increased the plant height and nodulation of the soybean over absolute control. Sarkar *et al.* (1999) [38] revealed that foliar application of 0.25% KNO_3 + 0.203% $Ca(NO_3)_2$ in groundnut resulted in higher plant height (48.6 cm), dry matter production (14.60 g plant^{-1}) and growth rate (0.285 g plant^{-1} day^{-1}) over without spray. Kulkarni *et al*. (2002) [19] concluded that foliar application of boron at 0.2% at 45 and 55 DAS of sunflower has recorded significantly higher number of leaves (11.9 plant^{-1}) and dry matter production (45.4 g plant^{-1}) as compared to control 10.4 leaves plant^{-1} and 39.3 g plant^{-1} of dry matter production of sunflower. Sharma and Jain (2003) [42] reported that foliar application of zinc at 0.5% at flower initiation and 50% flowering stage in Indian mustard has recorded significantly higher plant height (166.2 cm) and primary branches (7.17 plant^{-1}) as compared to control (154.6 cm and 5.00 plant^{-1}, respectively).

Thalooth *et al*. (2005) [45] showed that increasing the level of phosphorus fertilization to 48 kg P_2O_5 acre^{-1} and foliar spraying with zinc 1 g L^{-1} has a favorable effect on enhancing growth and yield of sunflower plants grow under salinity condition compared to without spray. Veerabhadrappa and Yeledhalli (2005) [47] conducted the field experiment on groundnut at College of Agriculture, Raichur to study the effect of foliar spray of nutrients (formulation of urea, SSP and MOP at 1%) at 60 DAS along with 100% RDF recorded the number of leaves plant^{-1} (27.90), leaf area plant^{-1} (5.85 dm^2 plant^{-1}) and total dry matter production (22.91 g plant^{-1}) compared to absolute control i.e. number of leaves plant^{-1} (23), leaf area plant^{-1} (4.79 dm^2 plant^{-1}) and total dry matter production (19.63 g plant^{-1}) respectively. Tejeswara Rao and Subbaiah (2006) [43] reported that combined (Zn, B and Mo) foliar application of micronutrient recorded significantly higher plant height (176 cm), primary branches (7.0 plant^{-1}) and dry matter production at different stages of Indian mustard as compared to control (144 cm, 5 plant^{-1} and dry matter production at different stages, respectively). Ravi *et al*. (2008) reported that combined foliar application of iron at 0.5% + zinc 0.5% at 30 and 65 DAS of safflower has recorded significantly higher growth parameters like plant height (97.5 cm), no. of leaves (81.5 plant^{-1}), primary (10.8 plant^{-1}), secondary (17.3 plant^{-1}) and dry matter production (2440.7 kg ha^{-1}) as compared to control (80.4 cm, 65.4 plant^{-1}, 7.6 plant^{-1}, 13.7 plant^{-1} and 2029.6 kg ha^{-1}, respectively).

Arvind Kumar *et al.* (2010) [5] reported that foliar application of zinc at 0.5% at 35 and 55 DAS on sunflower has recorded significantly higher plant height (65.66 cm), number of leaves (23.02 plant^{-1}) and stem girth (4.13 cm) but it was statistically on par with boron at 0.3% application compared to absolute control plant height (64.33 cm), number of leaves (22.30 plant^{-1}) and stem girth (4.13 cm), respectively. Nofal *et al.* (2011) [29] observed significantly higher plant height (72.17 cm), stem length (60.22 cm), stem diameter (2.02 mm) and length of fruiting zone (12.79 cm) due to foliar application of 2% zinc in linseed as compared to absolute control higher plant height (67.47 cm), stem length (59.33 cm), stem diameter (1.76 mm) and length of fruiting zone (8.78 cm), respectively. Hafiz and El-Bramawy (2012) [14] reported that the foliar spraying of sesame plants with 2% potassium sulphate induced significant increases number of capsules plant^{-1} (108.20) and seed yield plant^{-1} (20.97 g) compared to unsprayed plants number of capsules plant^{-1} (91.45) and seed yield plant^{-1} (17.67 g), respectively. Naveenkumar (2012) [28] reported that basal application of 20 kg N, 60 kg P_2O_5, 25 kg K_2O ha^{-1} + foliar application of nitrogen at 7 kg N ha^{-1} at 45 days after sowing and foliar application of nitrogen at 7 kg N ha^{-1} at 60 days after sowing recorded significantly higher leaf area plant^{-1} (17.45 dm^2), leaf area index (5.82), leaf area duration (136.54 days) and total dry matter production (39.36 g) of groundnut than absolute control.

Effect of foliar application on yield and yield attributing character of oilseed crops

Kulkarni *et al.* (1989) [18] reported that higher pod yield of groundnut was obtained with the soil application of Zn at 20 kg ha^{-1} (1150 kg ha^{-1}) followed by foliar spray of Mn 0.6 per cent (1222 kg ha^{-1}) and B 0.2 per cent (1213 kg ha^{-1}). Balerao *et al*. (1994) [8] reported that mean dry pod yield was increased by 5.6 – 20% by foliar applications including individual or combined trace elements (borax at 2%), urea, phosphorus and plant growth regulators (tricontanol). Khilari (1994) [17] reported that the foliar application of either 0.5% $FeSo_4$ or 0.5% Fe-EDTA along with 1% DAP controlled yellowing in groundnut and increased the pod yield and haulm yield and also iron uptake over without foliar spray.

Haq and Mallarino (2000) [15] reported that foliar application of N, P, K at 1% each at reproductive stage slightly increased seed yield due to increase pod number compared to absolute control. Hugar and Kurdikeri (2000) [16] observed at Dharwad (Karnataka), that the application of Zn and Mo through seed treatment 2 g kg^{-1} seed each + foliar spray (0.025% Zn and 0.5% Molybdenum) resulted in soybean crop the highest seed yield (24.34 q ha^{-1}), oil content (20.20%) and test weight (14.41 g) in soybean compared to lower levels. Sesay and Shibles (2000) [40] studied the effect of N, P, K foliar application at 1% each on soybean during seed filling stage and observed that foliar nutrients application gave significant yield increase over control. Padma *et al.* (2001) [31] concluded that foliar spray of boron at 0.2% at ray floret stage in sunflower has recorded significantly higher seed set (84.2%), total number of seeds head^{-1} (901), test weight (6.00 g), seed yield (11.689 q ha^{-1}) as compared to control (72.6%, 708, 4.20 g and 6.95 q ha^{-1}, respectively).

Ali and Mowafy (2003) [4] observed that foliar spray of Zn (2%) improved the groundnut yield attributes and yield as well as quality over absolute control. Mahesh *et al*. (2003) [20] concluded that foliar spray of zinc at 0.5% at flowering stage of first raceme + at flowering stage of secondary racemes has recorded significantly higher the all yield parameters in castor as compared to spraying at flowering stage of first raceme. Sharma and Jain (2003) [42] reported that foliar spray of zinc at 0.5% at flower initiation and 50% flowering has recorded significantly higher yield parameters like silique plant^{-1}, 100 seed weight, seed yield and harvest index of mustard as compared to control. Shanke *et al*. (2004) [41] reported that foliar application of boron at 0.5% + soil application of molybdenum at 1 kg ha^{-1} recorded significantly higher kernel yield (21.87 q ha^{-1}), straw yield (39.89 q ha^{-1}) and oil content (45.7%) of groundnut as compared to recommended dose (15.43 q ha^{-1}, 32.52 q ha^{-1} and 43.15%, respectively). Dash *et al.* (2005) [10] reported that 100% RDF (recommended dose of NPK 20:60:40) recorded higher plant height, number of branches, LAI and dry matter accumulation of soybean over 50% RDF and the control. Patil *et al*. (2006) [32] reported that application of boron and zinc through soil as well as foliar application among them foliar application of borax at 0.1% at 55 DAS has recorded significantly higher yield parameters of sunflower as compared to soil application.

Tejeswara Rao and Subbaiah (2006) [43] concluded that combined foliar application of micronutrients Zn (0.5%) + B (1 ppm) + Mo (0.1%) has recorded significantly higher number of silique $plant^{-1}$ (245), seed yield (1349 kg ha^{-1}), stover yield (2710 kg ha^{-1}) and oil content (33.5%) of Indian mustard as compared to control higher number of silique $plant^{-1}$ (186), seed yield (1020 kg ha^{-1}), stover yield (2364 kg ha^{-1}) and oil content (30.8%) respectively. Noor *et al*. (1997) [30] and Venkatesh *et al*. (2006) [46] reported that the increased in pod weight (38.37 g), seed index (43.41 g) and pod yield (27.96 q ha^{-1}) of groundnut with foliar application of Boron (2 ppm) over absolute control i.e pod weight (32.28 g), seed index (39.55 g) and pod yield (23.28 q ha^{-1}), respectively. Meena *et al*. (2007) [24] carried out experiment in TN, Coimbator with application of $ZnSo_4$ at 20 kg $ha^{–1}$ plus 0.5% foliar spray along with borax at 25 kg $ha^{–1}$ plus 0.25% foliar spray recorded the highest pod yield (19.54 q ha^{-1}) of groundnut over absolute control pod yield (13.80 q ha^{-1}), respectively. Ravi *et al.* (2008) [35] reported that foliar application of zinc and iron both at 0.5% each at 30 and 65 DAS of safflower has recorded significantly higher number of capsule (28.8 $plant^{-1}$), seed weight $head^{-1}$ (0.78 g), 1000 seed weight (56.8 g) and seed yield (1445 kg ha^{-1}) as compared to control (20.5 $plant^{-1}$, 0.62 g, 44.7 g and 1172 kg ha^{-1}, respectively).

Similar findings have been reported by Arvind Kumar *et al.* (2010) [5], Choudhury *et al*. (2010) [9], Thakur *et al*. (2010) [44], Doustan *et al*. (2011) [11], Murthy (2011) [26], Pendashtek *et al*. (2011) [34], Galavi *et al*. (2012) [12], Mostafavi (2012) [25], Naveenkumar (2012) [28], Bahrani (2015) [7] and Vinodkumar *et al*. (2016) [46] for oilseed crops.

Effect of foliar application on uptake of nutrients by oilseed crops

Mary Schon and Dale Blevins (1990) [22] revealed that foliar application of B 1.12 kg ha^{-1} and 2.24 kg ha^{-1} induced increases in leaf B concentration far above the 60 micrograms $gram^{-1}$ level that was previously accepted as the upper level of tolerance for soybeans. Revathy *et al. (*1997) [37] reported that the foliar spray of chelated mixtures of micronutrients increased the respective micronutrient concentrations in seeds of groundnut besides their nutrient uptake. Shanke *et al*. (2004) [41] reported that foliar application of boron at 0.5% + soil application of molybdenum at 1 kg ha^{-1} has recorded significantly higher uptake of boron at flowering, pod formation and at harvest stage as well as molybdenum also over recommended dose of fertilizer. Nasef *et al.* (2006) [27] observed that the highest seed yield of groundnut and yield components were obtained from plants receiving foliar spraying with 200 ppm boron and inoculated with Rhizobium strains. Also inoculated with biofertilizer (Rhizobium strains) alone or combined with different levels of boron increased significantly the uptake of N, P, K, Fe, Mn, Zn and B by straw and seeds of groundnut in both seasons as compared with corresponding treatments without biofertilizer.

Ravi *et al*. (2008) [35] reported that foliar spray of iron at 0.5% + zinc at 0.5% sprayed at 30 and 65 DAS has recorded significantly higher nutrient uptake of major nutrients (N 84.38 kg ha^{-1}, P 9.49 kg ha^{-1}, K 66.35 kg ha^{-1} and S 12.41 kg ha^{-1}) and micronutrients (Zn 409 g ha^{-1}, Fe 1396 g ha^{-1}) as compared to control major nutrients (N 43.83 kg ha^{-1}, P 2.23 kg ha^{-1}, K 27.82 kg ha^{-1} and S 5.21 kg ha^{-1}) and micronutrients (Zn 102 g ha^{-1}, Fe 566 g ha^{-1}), respectively. Aslihan *et al*. (2011) [6] reported that foliar applications of KNO_3, Mg $(NO_3)_2$ and $Ca(NO_3)_2$ increased the concentrations of N, K, Mg, Ca, and P but not Na under salinity stress. It is not surprising that supplementary KNO_3, Mg $(NO_3)_2$, and $Ca(NO_3)_2$ enhanced concentrations of N, K, Ca, and Mg, but those element contents of plants receiving supplementary KNO_3, $Mg(NO_3)_2$, $Ca(NO_3)_2$ were still much lower than those receiving non saline treatment. Phosphorus, Fe, and Zn contents in the leaves also increased with foliar applied treatments and still were much lower than those of the no saline treatment. Abd EL-Kader and Mona (2013) [3] reported that application of sulfur fertilization (200 kg $acre^{-1}$) and foliar spraying and their combinations with Zn or B (3.33 g or 0.83 g L^{-1} $plot^{-1}$) increased significantly the nutrient content of N (63.18 kg $acre^{-1}$), P (7.45 kg $acre^{-1}$), K (11.62 kg $acre^{-1}$) and S (5.25 kg $acre^{-1}$) in peanuts seeds as compared to the control plot N (39.98 kg $acre^{-1}$), P (4.10 kg $acre^{-1}$), K (7.18 kg $acre^{-1}$) and S (1.74 kg $acre^{-1}$), respectively.

Manasa *et al*. (2015) reported that the application of FYM + 100% RDF + foliar spray of fertilizers at 2% at 30, 45 and 60 DAS recorded higher uptake of N (223 kg ha^{-1}), P (43.89 kg ha^{-1}), K (207 kg ha^{-1}), S (35.10 kg ha^{-1}), Cu (187 g ha^{-1}), Zn (278 g ha^{-1}), Fe (3301 g ha^{-1}) and Mn (650 g ha^{-1}) over absolute control N (113 kg ha^{-1}), P (16.17 kg ha^{-1}), K (132 kg ha^{-1}), S (12.13 kg ha^{-1}), Cu (117 g ha^{-1}), Zn (174 g ha^{-1}), Fe (2099 g ha^{-1}) and Mn (505 g ha^{-1}), respectively.

Effect of foliar application on quality of oilseed crops

Sathiyamoorthy and Vivekanandan (1988) [39] observed that foliar spray of KNO_3, thiourea and DAP increased the protein yield without affecting the oil content in soybean in moderate saline or alkaline soil. Veerabhadrappa and Yeledhalli (2005) [47] recorded higher oil content 4.92% and higher oil yield 25.63% with spray of urea, SSP, MOP at 1% as compared to application of 100% RDF alone. Gobarah *et al*. (2006) reported that the application of 60 kg P_2O_5 $acre^{-1}$ with foliar spraying with 1.0 g L^{-1} zinc having oil yield (633 kg $acre^{-1}$) and protein yield (368 kg $acre^{-1}$) compared to control oil yield (456 kg $acre^{-1}$) and protein yield (251 kg $acre^{-1}$) respectively. Nasef *et al.* (2006) [27] observed that the highest oil (50.13%) and protein (32.11%) of peanut seeds in both of seasons were attained when the highest level of B (300 ppm) applied as compared to control oil (44.33) and protein percentage (23.41), respectively.

Galavi *et al.* (2012) [12] reported that the combined application of micronutrients (Fe 4 ml + B 2 ml L^{-1}) recorded the highest oil percentage (25.25%) compared to control (21.19%). Mekki (2015) [23] reported that application of soil (115 kg ha^{-1}) or foliar (36% K_2O at 3 cm^3 L^{-1}) potassium fertilizer significantly increased the oil content compared to control plants. The highest oil yield (11.13 g) was obtained by the treatment received K_{soil}+K_{foliar} followed by K_{soil} (8.85 g) and K_{foliar} (6.58 g), while the lowest (4.02 g) with untreated plants.

Conclusion

These review papers clearly suggested that application of macro and micronutrients through foliar spray was found more beneficial than the soil application for oilseed crops. Hence, application of macro and micronutrients leads to higher yield, uptake of nutrients and oil content in oilseed crops.

References

1. Anonymous. Total oilseed area, production and productivity in India. Directorate of Economics and Statistics, 2012.
2. Anonymous. Total oilseed area, production and productivity in India. Directorate of Economics and Statistics, 2014.
3. Abd EL-Kader, Mona G. Effect of sulfur application and foliar spraying with zinc and boron on yield, yield components and seed quality of peanut (*Arachis hypogaea* L.). Research Journal of Agriculture and Biological Sciences. 2013; 9:127-135.
4. Ali AAG, Mowafy SAE. Effect of different levels of potassium and phosphorus fertilizers with the foliar application of zinc and boron on groundnut in sandy soils. Journal of Agricultural Research. 2003; 30:335-358.
5. Aravind Kumar BN, Bhat SN, Shanwad UK. Effect of micronutrients on growth and yield in sunflower (*Helianthus annus*). Current Advances in Agricultural Science. 2010; 2:51-52.
6. Aslihan E, Canan K, Ertan Y, Huseyin K, Metin T. Ameliorative effect of foliar nutrient supply on growth, inorganic ions, membrane permeability and leaf relative water content of Physalis plants under salinity stress. Communication of Soil Science and Plant Analysis. 2011; 42:408-423.
7. Bahrani A. Effect of some micro and macro nutrients on seed yield and oil content of Rapeseed (*Brassica napus* L.). International Journal of Chemical, Environmental and Biological Sciences. 2015; 3:2320-4087.
8. Balerao PD, Jadhao PN, Fulzele GR. Response of groundnut to foliar application of nutrients and growth stimulant. Journal of Maharashtra Agricultural Universities. 1994; 19:94-96.
9. Choudhury AR, Prabhakara S, Nagarathna TK. Growth and yield of sunflower (*Helianthus annuus* L.) as influenced by micronutrient application in alfisols. Karnataka Journal of Agricultural Science. 2010; 23:495-496.
10. Dash AC, Tomar GS, Katkar PH. Effect of integrated nutrient management on growth and dry matter accumulation of soybean (*Glycine max* (L.) Merrill). Journal of Soils and Crops. 2005; 15:39-45.
11. Doustan HZ, Pendashteh M, Tarighi F, Bozorgi HR. Effects of foliar zinc spraying and nitrogen fertilization on seed yield and several attributes of groundnut (*Arachis hypogaea* L.). Journal of World Applied Sciences. 2011; 13:1209-1217.
12. Galavi M, Ramroudi M, Tavassoli A. Effect of micronutrients foliar application on yield and seed oil content of safflower (*Carthamus tinctorius* L.). African Journal of Agricultural Research. 2012; 7:482-486.
13. Gobarah ME, Mohamed MH, Tawfik MM. Effect of Phosphorus fertilizer and foliar spraying with zinc on growth, yield and quality of groundnut under Reclaimed Sandy Soils. Journal of Applied Science Research. 2006 2:491-496.
14. Hafiz SI, El-Bramawy MAS. Response of sesame (*Sesamum indicum* L.) to phosphorus fertilization and spraying with potassium in newly reclaimed sandy soils. Basic Research Journal of Agricultural Science and Review. 2012; 1:117-123.
15. Haq MU, Mallarino AP. Soybean yield and nutrient composition as affected by early season foliar fertilization. Journal of Agronomy. 2000; 92:16-24.
16. Hugar AB, Kudikeri MB. Effect of application method and level of zinc and molybdenum on field performance and seed yield in soybean. Karnataka Journal of Agricultural Science. 2000; 13:439-441.
17. Khilari JM. In Seminar on Recent Trends in Micronutrient Research in Soils and Plants in Maharashtra. Marathwada Agricultural University, Parbhani, 1994.
18. Kulkarni JH, Sojitra VK, Bhatt DM. Effect of micronutrient application on nodulation and pod yield of groundnut (*Arachis hypogaea* L.). Legume Research. 1989; 12:49-51.
19. Kulkarni SS, Babu R, Pujari B. Growth, yield and yield parameters of sunflower as influenced by organic manures, biofertilizers and micronutrients under irrigation. Karnataka Journal of Agriculture Science. 2002; 15:253-255.
20. Mahesh H, Sharma D, Babu B. Influence of micronutrient spraying on different stages of caster. Journal of Oilseeds Research. 2003; 17:146-148.
21. Manasa V, Hebsur NS, Malligawad LH, Shiva Kumar L, Ramakrishna B. Effect of water soluble fertilizers on uptake of major and micro nutrients by groundnut and post harvest nutrient status in a vertisol of northern transition zone of Karnataka. Journal of Environment Science. 2015; 9:1-5.
22. Mary Schon K, Dale Blevins G. Foliar boron applications increase the final number of branches and pods on branches of field-grown soybeans. Journal of Plant Physiology. 1990; 92:602-607.
23. Mekki BB. Yield and yield components of groundnut (*Arachis hypogaea* L.) in response to soil and foliar application of Potassium. American-Eurasian Journal of Agricultural and Environmental Science. 2015; 15:1907-1913.
24. Meena S, Malarkodi M, Senthilvalavan P. Secondary and micronutrients for groundnut–a review. Agricultural Reviews. 2007; 28:295-300.
25. Mostafavi K. Grain yield and yield components of soybean upon application of different micronutrient foliar fertilizers at different growth stages. International Journal of Agricultural Research and Review. 2012; 2:389-394.
26. Murthy, IYLN. Zinc response to oilseed crops. Indian Journal of fertilizers. 2011; 7:104-117.
27. Nasef MA, Nadia, Badran M, Amal, Abd El-Hamide F. Response of peanut to foliar spray with boron and/or rhizobium inoculation. Journal of Applied Science of Research. 2006; 2:1330-1337.
28. Naveen Kumar BT. Productivity of groundnut as influenced by different nutrient ratios of nitrogen and phosphorus. M.Sc. (Agri.) Thesis, University of Agricultural Science, Dharwad, Karnataka (India), 2012
29. Nofal OA, Zedian MS, Bakry BA. Linseed yield and quality traits as affected by zinc foliar application under

newly reclaimed sandy soils. Journal of Applied Sciences Research. 2011; 7:1361-1367.
30. Noor S, Hannan MA, Islam MS. Effect of molybdenum and boron on the growth and yield of groundnut. Indian Journal of Agricultural Research. 1997; 31:51-58.
31. Padma B, Jagadeshwar K, Bharti M. Improvement of seed yield and quality through nutrient management in sunflower (*Helianthus annus* L.). Journal of Oilseeds Research. 2001; 18:48-50.
32. Patil L, Ramesh H, Patil M. Effect of boron and zinc on yield parameters of sunflower. Karnataka Journal of Agricultural Science. 2006; 16:243-250.
33. Patra AK, Tripathy SK, Samui RC. Effect of post-flowering foliar application of nutrients on growth, yield and economics of rainfed groundnut (*Arachis hypogaea* L). Indian Journal of Plant Physiology. 1995; 38:203-206.
34. Pendashtek M, Tarighi F, Doustan HZ. Effect of foliar zinc spraying and nitrogen fertilization on seed yield and several attributes of groundnut (*Arachis hypogaea* L.). World Journal of Applied Science. 2011; 13:1209-1217.
35. Ravi S, Channal HT, Hebsur NS, Dharmatti PR. Effect of sulphur, zinc, iron nutrition on growth, yield and nutrient uptake of safflower (*Carthamus tinctorious* L.). Karnataka Journal of Agricultural Science. 2008; 21:382-385.
36. Reinbott TM, Blevins DG. Response of soybean to foliar applied boron and Magnesium and soil applied boron. Journal of Plant Nutrition. 1995; 18:179-200.
37. Revathy M, Krishnaswamy R, Chitdeswar. Effect of micronutrient chelates and yield of dry matter production of groundnut and paddy. Madras Agricultural Journal 1997; 83:508-510.
38. Sarkar RK, Chakraborty A, Saha A. Effect of foliar application of potassium nitrate and calcium nitrate on groundnut (*Arachis hypogaea* L.). Indian Journal of Agronomy 1999; 44:809-812.
39. Sathiyamoorthy P, Vivekanandan M. Cumulative effect of pre-sowing seed treatment and foliar application of salts in improving biomass and grain yield of soybean in moderate saline/alkaline soil. Journal of Agronomy Crop Science. 1988; 161:107-113.
40. Sesay A, Shibles R. Mineral depletion and leaf senescence in soybean as influenced by foliar nutrient application during seed filling. Annals of Botany. 2000; 55:47-55.
41. Shanke GM, Naphade PS, Ravankar HN, Sarappa PA, Hadole SS. Effect of boron and molybdenum on their uptake and yield of groundnut. Agricultural Science Digest. 2004; 51:51-53.
42. Sharma PP, Jain NK. Effect of foliar sprays of agrochemicals on growth and yield of Indian mustard (*Brassica juncea* L.). Indian Journal of Agricultural Science. 2003; 73:381-383.
43. Tejeswararao K, Subbaiah G. Response of Indian mustard to foliar application of zinc, boron and molybdenum. Journal of Oilseeds Research. 2006; 23:336-339.
44. Thakur BD, Shaikh FG, Thobre PS, Kalegore NK. Response of winter season groundnut (*Arachis hypogaea* L.) to iron and zinc application. Journal of Oilseeds Research. 2010; 27:181-182.
45. Thalooth AT, Badr NM, Mohamed MH. Effect of foliar spraying with Zn and different levels of phosphatic fertilizer on growth and yield of sunflower plants grown under saline condition. Egypt Journal of Agronomy. 2005; 27:11-22.
46. Venkatesh MS, Majumdar B, Kailash Kumar, Patiram. Response of groundnut (*Arachis hypogaea* L.) to sulphur, boron and FYM doses in an Ultic Hapludalf of Meghalaya. Journal of Oilseeds Research. 2006; 23:52-54.
47. Veerabhadrappa BH, Yeledhalli NA. Effect of soil and foliar nutrition on partitioning of nutrients at different growth stages of groundnut. Karnataka Journal of Agricultural Sciences. 2005; 18:940-945.
48. Vinodkumar HM, Salakinkop SR, Angadi SS. Enhancing groundnut (*Arachis hypogaea* L.) productivity through foliar nutrition. Journal of Farm Science. 2016; 29:190-193.