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Foliar Application of Micronutrinets in Cotton - A Review.

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Review Article

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ABSTRACT

Foliar application of micronutrients plays an important role in changing growth and physiological characteristics of cotton. In optimizing fertilization strategies, inclusion of foliar application improves fertilizer use efficiency and reduces environmental pollution. Foliar application of micronutrient mixtures during flower and boll development stages have been shown to be effective in efficient utilization of nutrients by cotton and thereby reduce boll shedding and increase the yield. Keeping this in view, the literatures on foliar application of micronutrients on the growth, yield and quality of cotton are reviewed in this paper.

INTRODUCTION

Cotton, the "king" of fibre crop is the most important commercial crop in the world, belongs to the family Malvaceae. Apart from major nutrients, micronutrients also play an important role in seed production. The dire need for intensive land use drew attention for applying micronutrients to cotton. Essential micronutrients like Zinc, Iron, Manganese, Copper, Boron and Magnesium play an important role in physiology of cotton crop and these are being a part of enzyme system or catalyst in enzymatic reactions. They are required for plant activities such as aspiration, meristamatic development, chlorophyll formation, photosynthesis, energy system, protein and oil synthesis, gossypol, tannin and phenolic compounds development. Certain micronutrients may help to secure uniform emergence, rapid seedling growth and healthy plant stand. Some beneficial effects on seed yield and quality as reflected in viability may be achieved by applying micronutrients. Effects of foliar application of micronutrients on cotton yield and fibre quality have been widely studied. Generally, the plant requires a wide variety of elements to improve the growth and yield. Boron and Magnesium are the essential elements required for the growth and development having specific role in cell division and cell metabolism. In cotton, flowering is a continuous process. However, all the flowers produced are not retained and harvested. About 40 to 50 per cent of the flowers and bolls are shed due to boll worm attack or due to nutritional stress. Hence there is need to supplement the plant with proper micronutrients to produce more number of flowers and retain them on the plant to develop into bolls for final harvesting, so that yield can be increased considerably. The role of micronutrients in various physiological and biochemical processes in plant is well known, which enables a rapid change in the physiology of plant within one season to achieve desirable results. The essential mineral elements which are required in higher concentrations by the plant have major role in determining the growth and development cotton often produces more vegetative growth, than needed for maximum boll production and yield especially when climatic condition favour vegetative growth, these by directing the nutrients and photo assimilates towards vegetative growth rather than reproductive growth.

EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENTS ON GROWTH AND YIELDPARAMETERS

Kamalanathan et al. [32] reported that foliar application Zn, Mo, Fe, B and Mn applied @ 2.0, 0.5, 5.0, 0.5 and 2.0 lb per acre respectively on 60th day after sowing increased seed cotton yield, ginning percentage and fibre quality of cotton. Burkalov [7] indicated that, spraying with 0.5 per cent boron increased the seed cotton yield by 14.4 per cent. Similarly, application of boron @ 116 lb per acre increased the yield of cotton (Koegh and Mapples [35], Braud*et al.* [6] observed increased number of bolls in cotton Cv. D-9 when grown in

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solution culture containing 0.21 to 3.4 mg boron. Hunasagi*et al.* [26] observed non-significant difference in seed cotton yield due to micronutrients spray. However, boron sprayed at 0.25 kg per acre recorded higher yield of585 g per plot. Highest yield of 591 g per plot was obtained by spraying all micronutrients in conjunction with NAA at 10 ppm.

Dubey and Chokhey Singh [14] studied the efficacy of the soil and spraying of micronutrients on cotton, combination of Mn + Zn + Cu + B + Mo increased the seed cotton yield both in soil and spraying (820 and 868 kg/ha, respectively).The practice of foliar feeding with plant nutrients gives quick benefits and economizes nutrient element as compared to soil application [81]. Foliar feeding is often effective when roots are unable to absorb sufficient nutrients from the soil due to a high degree of fixation, losses from leaching, low soil temperature and lack of soil moisture. Chowdary and Hisani [44] reported increased seed cotton yield with spraying of 20ppm boron. Murphy and Lancaster found significant increase in yield of seed cotton with boron (0.1 kg/ha) sprayed at weekly interval for five weeks.

Honischo [23] reported that, foliar application of boron to cotton Cv. Albar 637increased the seed cotton yield in five out of eight trials, highest yield was obtained with application of two to four kg boron per ha. Elgala*et al.* [15] reported that, in field trials at Shabkan, Egypt, cotton Giza-69 was given foliar spray of NPK and other micronutrients (10.1% N, 5.6 % P2O5, 5.29 % K2O, 0.16 %Mg, 0.007% Fe, 0.0025% Cu, 0.059% Zn and 0.021% B) have increased seed cotton yield by15.34 to 26.87 per cent over that of soil fertilization, but increase was not significant.

Oosterhuis [48] reported that, foliar application of boron along with insecticides increased the yield of seed cotton, boll weight and plant height from 1.2 to 1.4 tonnes per ha, 4.1 to 4.4 g and 1.1 to 1.4 m, respectively. Boron (17.5 kg/ha) through soil and (0.2%) foliar application increased the yield of seed cotton 26 and 32 per cent, respectively more over control. Varma [79] reported that the boll weight and seed cotton yield increased linearly due to the foliar application of 0.4 per cent urea with 0.4 per cent $ZnSo_4$.

Madzhidove [38] found that, increased seed cotton yield in case of fine fibre cotton, with application of boron at bud formation stage.Eweida*et al.* [16] reported that, seed cotton yield was significantly increased with the foliar application of 2 per cent magnesium and 0.2 per cent zinc and also with combination of zinc sulphate and magnesium sulphate. Savithri reported that the foliar application of 1 per cnet $MnSo_4$ increased the yield of cotton by 14.8 percent in black clay soil over control. Sangale*et al.* [59] observed that, the foliar application of 0.2 per cent boron on safflower at 60 and 90 days of crop age significantly increased the 1000 kernel weight, seed and oil yield. Silva *et al.* [69] reported that, application of boron @ 1.23 kg per ha significantly increased seed cotton yield, boll weight and induced earliness. Khodzhaev and Stesnyagina [33] reported the spraying of plants at the flowering stage with a mixture of 0.02 per cent boric acid and 0.1 per cent zinc sulphate markedly increased heat and drought resistance during the period of moisture stress in cotton.

Hosny*et al.* [24] observed that, foliar application of Boron and copper with different concentrations increased the seed cotton yield and number of bolls per plant but boll weight was unaffected by boron or copper application. Suryanarayana Reddy *et al.* [75] reported that significantly more number of fruits per plant (29.2), fruit weight (61.29 g) and fruit yield (194.0 q/ha) were obtained with soil application of borox (15 kg/ha) along with recommended NPK compared to NPK alone intomato crop. Similarly in tomato, significantly increased number of fruits (1.10) and fruit yield per plant (1039.4 g) were recorded with foliar application of boron at the rate of 4 ppm compared to control (10.5 and 990.1 g, respectively) [78]. Mishra *et al.* [42] recorded that the addition of Mn and B along with recommended doses of N, P, K increased seed yield and thousand seed weight in sunflower. Thilakov et al. [76] in their study that the application of manganese increased the cotton yield from 3.15 to 3.46 t ha-1. Hegab et al. [22] observed that foliar application of manganese at the rate of 1.28 kg per ha increased the seed yield plant-1 in cotton.

Ziolek and Ziolek [85] found that foliar application of boron, manganese and molybdenum and their combination increased number of pods seed per plant, hundred seed weight and seed yield of soybean. Sharma and Gupta [67] observed that foliar application of 0.5 per cent Zinc sulphate increased seed cotton yields by 6.8 per cent over control. Sharma et al. [68] recorded that the foliar application of 0.5 per cent Zn at 50 and 60 days after sowing seed cotton yields of 1.59 to 1.61 tha^{-1} compared with 1.18 t ha^{-1} without Zn. $ZnSo_4$ spraying also increased the DMP, number of bolls per plant and boll weight of cotton. Chandel*et al.* [10] observed increased in seeds, pods per plant and thousand seed weight of soybean by the application of trace elements (Zn, Fe, B).The plant height, number of leaves per plant, number of branches per plant, leaf areaper plant were significantly higher with 75 ppm molybdenum 2.5 ppm boron treatment in french bean [50]. Kumar and Gupta [36] stated that the foliar application of 0.5 per cent ZnSo4 alone and in combination with 2 per cent urea plus 0.25 per cent lime recorded kapas yields of 1.31 to 1.33 t ha-1 in cotton.

Singh *et al.* [70] reported that, in potato var. Kufri Chamatkar, foliar spray of 0.3 percent boric acid along with 2 per cent urea in conjunction with top dressing of 30 kg N per haresulted in higher tuber yield (201.60 q/ha) compared to control (171.00 q/ha). Stoyanow and Gikov [74] reported that the foliar application of B, Zn and Mn at different growth stage increased seed cotton yield. Foliar application of folifertil (22% N, 21% P, 17% K and small amounts of Mg, Mo, Mn, B, Cu, S, Zn and Co) increased the seed cotton yields, bolls and lint over control [57]. Singh and Verma [72] observed that, in tomato soil application of boron (2 kg/ha), potassium (120 kg/ha) and zinc (10

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kg/ha) in combination were found to be most effective and produced the higher yield of marketable fruits (285.04 q/ha) compared to control (266.92q/ha).

Malewar*et al.* [39] concluded that, the application of phosphorous through bronated single super phosphate was beneficial in increasing yield and uptake of phosphorus and boron in the cotton and groundnut. Harb [20] reported that, soaking the cotton seeds in manganese, zinc and boron significantly increased the plant height and seed cotton yield. Mc Connel*et al.* [41] found that, foliar application of boron at different growth stages increased the seed cotton yield and lint yield significantly.

Namdeo*et al.* [45] reported that, the foliar application of Micnelf (1%) at 30, 65 and90 days after sowing increased the number bolls per plant but boll weight was increased by magnesium sulphate (2%) and Murate of potash (2%) at 90 DAS. Micnelf (1%) at 30, 65 and90 DAS gave significantly higher seed cotton yield over control, which was followed by magnesium sulphate (2%) at 30 and 60 DAS. Ishag(19920 reported that foliar sparying of trace element fertilizers Wuxal suspension, containing Fe, Zn, Mn, Cu, Mo and Co twice at flowering and three weeks later increased the seed cotton yield of Gossypium barbadensecv. Sawan et al [62] observed that foliar spraying of 37.5 ppm Cu and 50 ppm Mn applied at 85 and 105 days after sowing increased seed yield, seed index and oil content of cotton.

Prasad and Prasad [53] observed that, application of 80:40:20 kg NPK per hectarein combination with or without zinc sulphate, Gypsum, Borax, Manganese sulphate or Magnesium sulphate resulted in increased seed cotton yield, the highest yield being observed with NPK + Zn or Mg Patil and Malewar [52] reported that, foliar application of 0.2 per cent boron in combination with Fe and Zn to cotton proved its superiority in the production of chlorophyll 'a'and 'b'. Wankhade*et al.* [82] revealed that, foliar spray of 0.1 per cent borax at peak square and peak flowering stages recorded significantly more seed cotton yield over control. Similar results were also recorded with respect to bolls per plant and seed cotton yield. Haq Nawaz *et al.* [19] studied that, seed cotton yield were increased in the order Cu>Zn>Fe>Mn>B trace elements applied together. Singh and Singh [71] reported that, curd yield of cauliflower (367.5 q/ha) significantly increased with the application of boron at the rate of 1 kg per ha compared to control. Mangal Prasad and Rajendra Prasad [53] reported that, application of micronutrients (Zn, S, Bo, Mn and Mg) did not affect plant height and boll weight.

Verma*et al.* [80] noticed that, yield of marketable fruits (285.04 q/ha) was markedly increased with the application of boron at the rate of 2 kg per ha when compared to control (266.92 q/ha) in tomato. Dong Jinfeng [11] reported that, spraying boron as borax or boric acid with 0.2 percent at the seedling stage, early flowering and boll formation stage increased the yield of 16.1per cent over control. Sharma [66] concluded that, boron exhibited pronounced beneficial effect on number of fruits per plant (23.1), fruit yield (762.7 q/ha) and seed yield (246.2 kg/ha) with thesoil application of 20 kg borox per ha compared to 10 kg borax per ha (18.9, 635.7 q/ha and176.5 kg, respectively) in tomato. Dong [12] reported that foliar application of 0.2 per cnet borax or boric acid increased the cotton yield by 16 per cent over control. Response of cotton to foliar spraying of multi micro nutrient mixture formulations (consisting of Fe, Zn, Cu, B, Mn and Mo) under different trade names viz., Trace, Multiplex, Agromine in increasing the yiled of cotton was reported by Nateson [46].

Raja Rajeswari [55] reported that, foliar application of 0.5 per cent boron increased the number of bolls per plant, mean boll weight and kapas yield significantly. Carvalho*et al.* [8] observed that, boron applied to the cotton Cv. IAC-17 side dressing by 0.75 kg and 0.15 kg or by foliar application of boron at the early growth stages increased yield and fibre length. Similarly, application of boron at planting time and foliar spray at 45 to 80 days increased yield and fibre length [9]. Zhu Hongxun*et al.* [89] concluded that, the foliar application of boron at seedling and inter node elongation stages gave better results than seed treatment or basal application. Concentration of boron in the spray solution in the range of 0.1-0.25 per cent increased seedyield significantly in rape, 0.2 per cent being the optimum concentration with a17.8 per cent yield increase over the control.

Bowszys [5] reported that, foliar spray of boron (0.4 kg /ha) at the bud stage significantly increased the seed yield and seed oil content in rape. Application of boron as foliar spray significantly increased number of seeds persiliqua, 1000 seed weight, seed yield, seed-oil content and oil yield in toria [64]. Sawan et al. observed that foliar application of plant growth regulator (Pix (Mepiquat), cycocel (Chlormequat) or Alar (aminozide) each applied once at 300 ppm, 75 days after sowing and zinc (0 to 50 ppm, 80 and 95 DAS) increased the dry matter, boll weight, seed index, seed plant-1 and seed cotton.

Basavarajappa*et al.* [3] reported that, foliar application of FeSO4 (5 kg/ha) recorded significantly superior cotton yield followed by boron (soil), CuSO4 (soil), ZnSO4 (foliar), CuSO4 (foliar) as against of absolute control. Bednarz et al[4] reported that foliar fertilizer treatments (8-8-8 N:P2O5:K2O with B, Cu, Zn, Mn) applied at 0, 2, 4, 6, 8 weeks after sowing increased the plant growth and yield characters. Foliar application of 0.11 kg B plus 4.1 kg K ha-1 and foliar application 0f 0.11 kg B ha-1 alone registered an yield increase of 13 and 8 per cent respectively over control [25]. Witten et al.[83] observed that foliar application of Microplex R consisting of Mg 5%, B 0.5%, Cu 1.5%, Fe 4%, Mn 4%, Mo 0.1%, Zn 1.5% gave significantly higher lint yield that control. Increased Zinc sulphate was reported by Kairon and Venugopalan[30].

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Rathinavel*et al.* [56] reported that, the number of sympodia per plant (30.0%),number of bolls per plant (39.2%), boll weight (49.8%), seed weight per boll (36.8%) number of seeds per boll (10.8%) were significantly higher for plants given combined soil applicationof ZnSO4 and borax (50 kg/ha and 10 kg/ha, respectively). The seed cotton yield and seed yield were 47.1 per cent 19.2 per cent higher for the same treatment over control. Oosterhuis and Steger [40] reported that spraying of 0.4 lb B/acre increased lint yield of cotton. Howard et al. [25] reported that application of 0.11 kg Boron through foliage significantly increased the cotton yield by 10.3 per cent. Sasthri*et al.* [60] studied the effect of foliar nutrition on non aged and aged seeds of cotton Cv. MCU5 with 2 per cent MgSO4, 2 per cent DAP and 0.5 per cent Borax at 75 and90 days after sowing. Seed cotton yield and seed yield of both aged and non aged were significantly higher with 2 per cent DAP over control and other treatments. Roberts et *al.* [58] observed that boron deficiency in cotton may be corrected with foliar or soil boron applications. Foliar application of boron at the @ of 0.11 kg/ha and soil application of boron @ of 0.56 kg/ha provided about the same net returns. Both methodswere economically superior to not applying boron.

Dongre *et al.* [13] recorded the maximum fruit yield per plant (395.33 g) and per ha(109.8 q) when sprayed boron in the form of H3BO3 at 0.25 per cent to chilli as against control(324.33 g/plant and 90.08 q/ha), further recorded the highest average fruit length (11.12 cm)and fruit diameter (1.175.cm) when sprayed with 0.1 per cent H3BO3, while average number of seeds per fruit (55.66) and weight of 500 seeds (2.549 g) were recorded at 0.50 per cent spray of H3BO3 (boric acid). Ullagaddi [77] indicated that, the foliar spray of ZnSO4 (0.1%) plus Boron (0.1%) in combination with GA3 (50 ppm) significantly increased the number of squares, flowers and matured bolls per plant and highest seed yield. Pratima Sinha *et al.* [54] studied that, the spraying of boron concentration of (0.33mgl-1) significantly increased the seed yield, weight of 100 seeds and fibre within cotton. Whereas, Low (0.0033 mg l-1) and excess (3.3 mg l-1) boron reduced the weight of fibres, biomass, seed yield and the content of starch, proteins and oils. Muhammad Hussain*et al.* [43] studied that, foliar application of magnesium asMgSO4 (300 ml/m-3) on lentil Cv. Mazoor 93 recorded the highest number of pods per plant, number of seeds per pod and 1000 seed weight and significantly highest seed yield compared to control. Similarly, fertilizer application of NPK, farmyard manure, magnesium sulphate and zinc sulphate treatment recorded the highest seed yield in niger [51]. Sawan et al. [65] reported that foliar application of plant growth retardants and Zinc @ 50 ppm at 80 and 95 days after sowing increased cotton seed yield ha-1. Sawan et al. [65] found that foliar application of chelated Zn and Ca increased seed, protein and oil yields of cotton over control.

Niranjana *et al.* [47] reported that, application of micronutrients (B, Zn and Mo) showed significantly increase in yield, oil content and growth parameters of groundnut. Kalyanasundaram and Kumar [31] studied the soil application of the recommended dose of NPK with foliar application of Ca, B and GHOM twice at 45 and 60 DAS favorably increased the growth and yield characters of cotton crop. Kuruppaiah [37] stated that, the foliar application of borax (0.5%) at 35.50 and 65DAT was found to be best in terms of number of flowers per plant, number of productive flowers per plant, number of fruits per plant, individual fruit weight and yield (32.15 t/ha),flowered by copper sulphate (0.5%) and zinc sulphate (0.5%) sprayed at 35.50 and 65 DAT in brinjal cv. Annamali

EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENTS ON THE NUTRIENT CONTENT ANF UPTAKE BY COTTON.

Foliar application with Mn resulted in an increase in nitrogen concentration and its uptake by cotton crop [1,28,76]. Ibrahim [27] reported that foliar application of GA and Boron increased Na, K and B content of cotton leaf over control. Khodzhaev et al. [33] reported that foliar application of 0.02 per cnet boric acid and 0.1 per cnet zinc sulphate in 1:1 ratio ta the beginning and full flowering stages increased B and Mn contents over control.

Ibrahim et al. [28] reported that foliar application of manganese in cotton at different rates increased the uptake of nitrogen, phosphorus and potassium significantly compared to the unsprayed treatments. Sharma and Gupta [67] observed that foliar application of Zinc @ 0.5 per cent increased the zinc concentration in leaf, petiole and seed cotton. Stoyanov and Gikov [73] reported that foliar application of B, Zn and Mn at different growth stages increased the concentration of Zn , B, Mn in cotton. Rehab et al. [57] observed that N, P, Zn, Fe, Mnabd Cu concentration of cotton leaf increased with Folifertil foliar application (Folifertil comprised 22% N, 21% P, 17% K and amounts of Mg. Mo, Mn, B, Fe, Cu, S, Zn and Co). Ishag [29] reported that foliar application of trace element fertilizers Wuxed suspension each containg Fe, Zn, B, Cu and Mo increased leaf N and micro nutrients concentration.

Sawan et al. [62] found that foliar application of Cu-EDTA and Mn-EDTA increased the uptake of Cu and Mn by Cotton cv. Giza 75 over control. Bansal and Nayyar [2] observed that spraying of 0.5 percnet MnSO4 increased the content and uptake of Mn by cotton at all the stages. Guertal et al. [18] observed that B concentration in the plant increased with the rate of foliar applied from 8-11 mg kg-1 that water spray.

El-Fouly et al. [17] found that foliar application of 50 ppm Fe increased the growth and nutrient content by cotton cv.Giza 75 over control. Sawan at al. [63] observed that application of P fertilizers + foliar application of Zn and Ca increased the P, Ca and Zn uptake by Egyptian cotton. Sawan et al. [64] found that application of N fertilizer + foliar application of zinc incresesd the N and Zn uptake by cotton. Bednarz et al. [4] in a field experiment on clay loam soil in Texas reported that foliar application of Mn, Fe, Zn and B increased the concentration of these nutrients in cotton.

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CONCLUSION

From the above review it can be concluded that Foliar feeding with plant nutrients gives quick benefits and economizes nutrient element as compared to soil application. Foliar feeding is often effective when roots are unable to absorb sufficient nutrients from the soil due to high degree of fixation,losses from leaching, low soil temperature and lack of soil moisture and hence foliar application of micronutrients in cotton can be considered as a beneficial practice for enhanced cotton production.

REFERENCES

1. Ashour AZA. 1981. Effect of some elements on reddening phenomenon in cotton leaves. M.Sc.(Ag.) Theis, Fac.Agric., Tanta Univ.
2. Bansal RL, VK Nayyar. Critical levels of manganese in ustochrepts for cotton. J Indian Soc Soil Sci. 1994;42(3):489-491.
3. Basavarajappa R, Koraddi VR, Kamath KS, Doddamani MB. Response cotton cv. Abadhita (*Gossypiumhirsutum*) to soil and Foliar Application of micronutrients under Rain fed condition. Karnataka J Agric Sci.1997;10(2):287-291.
4. Bednarz CW, NW Hopper, MG Hickey. Effects of foliar fertilization of Texas southern high plains cotton leaf nitrogen and growth parameters. J Production Agric. 1998;11(1):80-84.
5. Bowszys T. Response of winter rape to foliar applicationof boron fertilizer. Zesyty Problemowe Portepow Nauk Rolniczych. 1996; 434(1):71-76.
6. Braud M, Fritz A, Megie C, Quillon TJ.Preliminary observation on boron deficiency of cotton. Cotton Fibre Tropology. 1969; 24: 465-467.
7. Burkalov N. Foliar application of B,Co, Zn, Mo and on cotton plants. NauchiTrudvisshalSelkostopInstituteVsil.Kolarov,1969; 18:17-22.
8. Carvalho LH, Silva NM, Brasil Sobrinho MOC, Kondo JI, Chiavegato EJ. Application of boron to cotton by side dressing and foliar spray. Revista Brasileviade Cienciado Solo. 196620:265-269.
9. Carvalho LH, Silva NM, Brasil Sobrinho MOC, Kondo JI, Chiavegato EJ. Methods of boron application to cotton. Revista Brasileriade Cienciado Solo. 1996;20:271-275.
10. Chandel AS, Tiwari SK, Saxena SC. Effect of micronutrient application on soybean (*Glycine max*.) growth in Uttar Pradesh foothills. Indian J Agric Sci. 1989;59:62-63.
11. DongJinfeng. 1995, The yield increasing ability ofspraying cotton with boron. Hevan Nangye Kexul, 3,6. Puyang Agricultrue and Animal Husbandary Bareau.
12. Dong JF.1995.The yield increasing ability of spraying cotton with boron. Henan Nongye Kexue,3-6.
13. Dongre SM, Mahorkar VK, Joshi PS, Deo DD. Effect of micronutrients spray on yield and quality of chilli (*Capsicumannum*L.)cv. Jayanti. Agric Sci Digest. 2000;20:106-107.
14. Dubey RM, Chokhey Singh. Effect of micronutrient on cotton. Indian J Agron.1969;14:38-41.
15. Elgala AM, EL-Leboudi A, Sakr AA. Growth and nutritional status of cotton plant subjected to foliar spray with certain nutrient solution. Agric Res Rev.1976;54:141-152.
16. Eweida MHT, Hassanein AM, Risk MA, EL-Halawany S. 1979, Interactiveeffects of Nitrogen, Magnesium and Zinc on yield and chemical properties of seed oil in Egyptian cotton. Research Bulletin, Faculty of Agriculture,Cairo,1193:16.
17. Fouly EI, ZM Mobarak, MM Shaaban. Effect of different foliar iron chelates on growth and nutrient contents of cotton plants. Egyptian J Physiological Sci. 1997;21(3):357-367.
18. Guertal EA, AO Abaye, BM Lippert, GS Miner, GJ Gascho. Sources of boron for foliar fertilization of cotton and soybean. Comm Soil Sci Plant Anal. 1996;27(15-17): 2815-2828.
19. Haq Nawaz, Saeed M, Iqbal MM, Shah, SM, Wasil Mohammad. Growth and yield of seed cotton as influenced by micronutrients. Sarhad J Agric. 1994;10:21-25.
20. Harb EZ. Effect of soaking seeds in some growth regulator sand micronutrients on growth, some chemical constituents and yield off a bean and cotton plants. Bull Faculty Agric University Cairo.1992;43:429-452.
21. Hazra P, Som MG. 1999,Technology for vegetable production and improvement. Naya Prakash,206 Bidhan Sarani Calcutta, India, pp.103-134.
22. Hegab AAT, EM Youssef, MA Mahgoub. Effect of some micronutrients and their application methods on the cotton plant growth, seed cotton yield, grade components, fibre and yam quality. Annals Agric Sci. 1986;31(1):189-205.
23. Honischo O. Boron nutrition of cotton in Zambia.Cotton Growth Rev. 1975;52:189-208.
24. Hosny AA, Kadry W, Mohamad HMH.Effect of foliar application of boron and copper on growth, yield and yield components of Giza 75 cotton variety. Ann Agric Sci. 1984;21:25-35.
25. Howard DD, CO Gwathmey, CE Sams. Foliar feeding of cotton: evaluating potassium source; potassium solution buffering and boron. Agron J. 1998;90(6):740-746.
26. Hunasagi, Gururaj, Katharki BH, Parameshwar, NS. A note on effect of micronutrients on cotton yield. Indian J Agron. 1969; 16:34.

27. Ibrahim AA. Effect of GA3 and boron on growth, yield and accumulation of Na, K and Cl in cotton under saline conditions. Annals Agric Sci. 1984;21(2): 519-531.
28. Ibrahim SA, AM Selim, AS Elneklawy. Effect of foliar application of manganese under different levels of nitrogen fertigation on growth, yield and nutrient content of cotton plants. Egptian J Soil Sci. 1987;27(2): 157-170.
29. Ishag HM. Effects of foliar micronutrient fertilizers on the yield of irrigated cotton on the vertisols of the Sudan Gezira. Expl Agric. 1992;28(3): 265-271.
30. Kairon MS, MV Venugopalan. Nutrient management research in cotton. Fert News. 1999;44(4):137-144.
31. Kalyanasundaram D, Kumar DS. Studies on the effect of Ca, B and GHOM on growth and yield of rice fallow cotton. Advances-in-plant Sciences. 2005;18(1):189-193.
32. Kamalanathan S, SS Narayamin, PV Marappan. The effect of micronutrients on yield and quality of MCU 3 cotton. Madras Agri J. 1965;255-258.
33. Khodzhaev DKH, Stesnyagina TYA. Effect of top dressing with trace elements on heat and drought resistance of cotton. Uzbekeskii Biologicheskii Zhurnal. 1983;6:19-23.
34. Khuzhanazarov SH, Dzhumaev N, Mamanov SH. Effect of copper and zinc in the composition of basal fertilizer on yield of fine fibred cotton. Field Crop Abstracts. 1983;37:780.
35. Koegh JL, Mapples R.1969,Boron for cotton and soybeans on hoersial plains soil. Bull Agric Exp Studies,p.1119.
36. Kumar V, VK Gupta. Response of cotton to zinc application and its residual effect to succeeding wheat crop. Agric Sci Digest. (Karnal). 1989;9(3): 130-132.
37. Kuruppaiah P. 2005,Foliarapplication of micronutrients on growth, flowering and yield characters of brinjal cv. Annamalai. Plant Arch. 2005;5(2):605-608.
38. Madzhidove KS. Effect of boron and molybdenum on yield of fine fibre cotton in the Bakhshriver valley.Trudy.1977;27:110-118.
39. Malewar GU, Syed II, Indulkar BS. EffectofphosphoruswithandwithoutBoronon the yield and uptakeof Boron and phosphorusin cotton,groundnutcroppingsequence. Annals Agric Res.1992;13:269-270.
40. Mangal Prasad, Rajendra Prasad. Response of upland cotton (*Gossypiumhirsutum*) to micronutrients and sulphur. Indian J Agron. 1994;39(4):707-141.
41. Mcconnel JS, Baker WH, Frizzel BS, Varvil. Response of cotton to nitrogen fertilization and early multiple application of mepiquate chloride. J Plant Nutr. 1992:15:457-468.
42. Mishra NM, Ramkrishna Reddy MG, Subramanyam MVK. Effect of micronutrients on sunflower. The Andhra Agric J. 1985; 32: 149-159.
43. Muhammad Hussain, Shah SH, Nazir MS. Effect of foliar application of calcium cum magnesium on different agronom ictraits of three geno types of Lentil*(Lensculinaaris*Medic). Pakistan J Agric Sci. 2002;39:123-125.
44. Murphy BCV, Lancaster JD. Response of cotton to boron. Agron J. 1971;63:539-540.
45. Namdeo KN, Sharma JK, Mandoli KC. Effect of foliar feeding of micronutrients on rain fed hybrid cotton (JKHy.1).Crop Research. 1992;5:451-455.
46. Nateson. 1995. Compendium on multi nutrient fertilizers in India. Crop response and industry. Micronutrient Manufacturers Association, Pune.
47. Niranjana SS, Prakash, Basavegowda, Yelladhalli NA, Chandranath HT. Effect of micronutrient seed treatment on growth and yield of groundnut. Seed Res. 2005;33(2):138-141.
48. Oosterhuis DM. 1976, Boron trial cotton, Research Institute. Annual Report, 1975 (October),pp.19-20.
49. Oosterhuis DM, Steger A. Characterization of boron use and distribution in the cotton plant and evaluation of the effectiveness of foliar feeding with boron. Arkanasas Special Report. 1999;193:113-118.
50. Padma M, Reddy SA, Babu R. Effect of foliar sprays of molybdenum (Mo) and boron (B)on vegetative growth and dry matter production of French bean (*Phaseolus vulgaris*L.) J Res Andhra Pradesh Agric University.1989;17:87-89.
51. Paikray RK, Mishra PJ, Mohapatra AK, Haldar J, Panda S. Response of niger (*Guizotiaabyssinica*) to secondary and micronutrients in acid red soil. Ann Agric Res. 2001;22:140-142.
52. Patil UD, Malewar GV. Yield and chlorophyll content of cotton as influenced by micronutrient spray. J Cotton Res Develop. 1984; 8:189-192.
53. Prasad M, Prasad R. Response of upland cotton (*G.hirsutum*) to micronutrients and sulphur. Indian J Agron. 1994;39:707-708.
54. PratimaSinha, Dube BK, Chatterjee C. Boron stress induced changes in cotton. Annals Agric Res. 2001;22(3):365-370.
55. Raja Rajeswari V. Foliar application of growth regulators and nutrients on boll development and yield in cotton. J Indian Soc Cotton Improvement. 1996;21:71.
56. Rathinavel K, Dharmalingam C, Paneersewam S. Effect of micronutrient on the productivity and quality of cotton seed Cv. TCB209 (*Gossypium barbadense* L.). Madras Agric J.1999;86:313-316.
57. Rehab FI, MA Gomaa, MG Nasseem, GA Darwesh. Studies on the effect of foliar and soil applications of some commercial fertilizers on yield and some fiber properties of the cotton l. The effect of foliar and soil application of urea and folifertil fertilizers on growth, yield and yield component of the cotton plant. Annals Agric Sci. 1991;29(3): 1063-1071.

58. Roberts RK, Gerkman JM, Howard DD. Soil and foliar applied boron in cotton production on economic analysis. J Cotton Sci. 2000;4(3):171-177.
59. Sangale PB, Patil GD, Daftardar SY. Effect of foliar application of Zinc, Iron and Boron on yield of safflower. J Maharashtra Agricultural Universities. 1981; 6 : 65-66.
60. Sasthri G, Thiagarajan CP, Srimathi P, Malarkodi K, Venkatasalam EP. Foliar application of nutrient on the seed yield and quality characters of non aged and aged seeds of cotton Cv.MCU5.Madras Agric J. 2000;87:202-208.
61. Savithri. 1980. Effect of $MnSO_4$ spray on the yield of cotton kapasvar.MCU 9. Annual Report, 135.
62. Sawan ZM, Mahmoud MH, Gregg BR. Effect of foliar application of che1ated copper and manganese on yield components and fibre properties of Egyptian cotton *(Gossypiumbarbadense).* J Agric Sci. 1993;121(2): 199-204.
63. Sawan ZM, Mahmoud MH, Momtaz OA. Effect of phosphorus fertilization and foliar application of chelated zinc and calcium on quantitative and qualititative properties of Egyptian cotton *(Gossypiumbarbadense*L. var. Utiza 75). J Agric Food Chem 1997; 45 (8): 3326-3330.
64. Sawan ZM, Mahmoud MH, Momtaz OA, Momtaz. Influence of nitrogen fertilization and foliar application of plant growth regulators and zinc on quantitative and qualitative properties of Egyptian cotton *(Gossypiumbarbadense*L. var. Viza 75). Agric Food Chem. 1997;45(8): 3331-3336.
65. Sawan ZM, Hafez SA, Basyorty AE. Effect' of nitrogen fertilization and foliar application of plant growth retardants and zinc on cotton seed, protein and oil yields and oil properties of cotton. J Agron Crop Sci. 2001;186(3): 183-191.
66. Sharma SK. Response of boron and calcium nutrition on plant growth, fruit and seed yield of tomato. Vegetable Sci.1995;22: 27-29.
67. Sharma JC, Gupta VK. Effect of zinc application on the yield and zinc concentration of different parts of the cotton plant. Envt Ecol. 1987; 5(2): 257-260.
68. Sharma JC, Tomar NK, Gupta VK. Effect of levels and methods of zinc application and growth, yield attributes and yield of cotton *(Gossypium hirsutum* L.). Agrl Science Digest. 1988; 8(3):165-169.
69. Silva NMDA, Carvalo LH, Chiavagaio ET, Sabino NP, Hiroce R. Effect of rate of boron application at sowing time on cotton plants in different soils. Bragantia. 1982;41:181-191.
70. Singh AR, Singh B, Singh A. Efficacy of nitrogen and boron on the growth, yield and quality of potato (*Solanum tuberosum* L.) Var Kufri Chamtkar. Prog Horticult. 1990; 22:104-107.
71. Singh, Singh. Effect of boron and manganese on yield quality and their uptake by cauliflower. Prog Horticult. 1994;26:203-208.
72. Singh SS, Verma SK. Influence of potassium, zinc and boronon growth and yield of tomato (*Lycopersicon esculentum* Mill.). Vegetable Sci.1991;18:122-129.
73. Stoyanov D, Gikov GI. Foliar application of trace elements to cotton. Pochvoznanie-i-Agrokhimiya. 1990; 25(6): 42-46.
74. Stoyanow D, Gikov GL. Foliar application of trace elements to cotton. Pochvozhanie. 1990;25:45-46.
75. Suryanrayana Reddy P, Reddy RMG, Veeraghavaiah R, Subramayam K, Reddy SD. Response of tomato to micronutrients. South Indian Hort. 1985;33:23-35.
76. Thilakov N. Effect of trace elements on nitrogen phosphorus metabolism in cotton on saline Soil. Biologicheskikh Nauk. 1976;(4):39-43.
77. Ullagaddi MS. 2000. Effect of dates of sowing and chemicals on seed yield and quality of Male parent SB (YF)-425 cotton (*Gossypium barbadonse* L.). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.
78. Umajothi K, Shanmugavelu KG. Studies on the effect of triacontanol, 2,4-D and boron on the yield and quality of chilli fruit and seed. See Research. 1985;18:114-116.
79. Varma SK. Nitrogen content in relation to abscission and effect of spraying urea singly and in combination with zinc sulphate on the abscission of flower buds and bolls of cotton. Indian J Plant Physiology. 1978; 21(2): 176-180 ..
80. Verma SK, Singh SS, Awasthi CP. Response of zinc and boron fertilization on yield and quality of tomato fruits at different stages of picking. Vegetable Sci. 1995;22:5-8.
81. Verma SS, Sahani VM. Effect of foliar application of nutrients on yield of cotton. Indian Cotton Growing Review. 1963;17:247-248.
82. Wankhade ST, Meshram LD, Kene HK. Impactoffoliarfeeding ofnutrients on hybrid seed production. Punjabrao Krishi Vidya Peeth Research Journal. 1994;18:127-128.
83. WittenTK, Cothren T, Hons FM, Dugger P, Richter D. Cotton responses to foliar and in furrow applied Amisorb R and fertility treatments. Proc. Beltwide Cotton Conferences. 1998; 2(5-9):1475-1479.
84. Zhu Hongxun, Zhang Xiang, Sun Chunhe. Characteristics of micronutrients uptake by rape plants and methods of Band Zn application. Oil Crops of China. 1996;18(2):59-61.
85. Ziolek E, Ziolek W. The effect of trace element application on yield and quality of soybean seeds. Agraria. 1987;26:195-207.