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MICRONUTRIENT MANAGEMENT FOR ENHANCING PRODUCTION OF MAJOR FODDER CROPS - A REVIEW

CHARAN SINGH[1]*, BHAGAT SINGH[2], SATPAL[3], PRAMOD KUMAR[2], ANKUSH[1], MANOJ KUMAR GORA[2] AND ANIL KUMAR[1]

[1]Department of Soil Science, [2]Department of Agronomy,
[3]Forage Section, Department of Genetics & Plant Breeding
CCS Haryana Agricultural University, Hisar-125 004, Haryana, India
(e-mail : charansinghhau1997@gmail.com)
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SUMMARY

At present time, scope to increase area under forage crops cultivated is limited; the reason is increasing day by day pressure and preference of people for food and commercial crops. But India is a home to about 512 million livestock population also. Hence, the per unit production of fodder crops should be increased to feed this huge livestock population. Growth, development and biological yield of the crops affected by the balanced use of fertilizers shows positive effects over use of nutrients in single and in combination. Importance of micronutrients for upholding soil health and boosting crops productivity is well known. A very small amount of these micronutrients is required. For desired growth and development of plants the soil must supply micronutrients. Adoption of HYVs (high yielding varieties) results increased removal of micronutrients and intensive cropping results in high application of NPK fertilizers which is the reason behind below normal level of micronutrients in soil at which sustainable crop productivity cannot be achieved. Zinc and iron play an important role in crop nutrition and thought to be necessary for plant development and production, as their role in plant auxins bio-synthesis, oxidation-reduction reactions, plant nitrogen metabolism, formation of chlorophyll, respiration, chief enzyme system and photosynthesis in plants. Economical and efficient way of getting micronutrients into the crop production system is application of fertilizers having micronutrients through soil which requires higher quantity of micronutrients as compare to foliar application. The method of foliar application is broadly used in many crops. Soluble salts are mainly used for foliar sprays. Deficiency symptoms can be corrected within few days by foliar application of micronutrients and at time of new crop sowing the appropriate micronutrients source is applied to the soil.

Key words : Forage crops, micronutrients, foliar application, soil application, fertilizers, HYVs

India is a home to 512.05 million livestock, being the leader in cattle (16%) and buffalo (5.5%) population (DAHD & F, 2012). Currently, India is facing a net deficit of 35 percent green fodder and 11 percent dry fodder due to increasing population of livestock (Meena *et al*., 2019). This gap in green fodder can be narrowed down by growing high yielding varieties. Apart from the location specific variety, adequate fertilization is another important factor to realize the potential green fodder production of forage crops. Adequate fertilization in terms of primary, secondary and micro-nutrients is essential to ensure the quantity and quality of green fodder. Therefore, in the present review paper the role of micronutrient management for enhancing production of major fodder crops is covered extensively. The important annual forage crops grown in Kharif season are sorghum, pearl millet, maize and cowpea and in Rabi berseem, lucerne, oats and barley.

Sorghum

Sorghum (*Sorghum bicolor* L. Moench) is one of the important forage crop to get high crop production and having good nutritive value for animals. The requirement of nutrients for sorghum crop is high, which is grown for fodder, is partially through organic sources and mainly supplemented through inorganic fertilizers. Growth, development and biological yield of the crops affected by balanced fertilization shown positive effects. Micronutrients increase productivity of crops and also maintain soil health. A very small amount is needed. The soil application of micronutrients is preferential for desired

*Corresponding author

growth and production of crop plants. Zinc and iron play an important role in crop nutrition and thought to be necessary for plant development and production, as their role in plant auxins bio-synthesis, oxidation-reduction reactions, plant nitrogen metabolism, formation of chlorophyll, respiration, chief enzyme system and photosynthesis in plants. The role of boron is also very important role in plant, including RNA and cytokinin production and transfer, meristem sugar and hydrocarbon metabolism and their transfer, building of pollen and formation of seed (Murthy *et al.* 2006). Choudhary *et al.* (2017) observed that combined micronutrients application *i.e.* Significantly higher grain, stover and biological yield is obtained by soil + foliar application. The results showed that significant increase in grain yield (14.15 and 12.13%), biological yields (11.37 and 9.31%) and stover yield (10.75 and 8.60%) and through combined soil and foliar spray over soil and foliar application, respectively. Dambiwal *et al.* (2017) reported that highest grain yield (32.54 q ha^{-1}) was recorded with soil application of 5 kg Zn ha^{-1} through $ZnSO_4$ along with $ZnSO_4$ @ 0.5% two foliar sprays before flowering and at dough stage and followed by 5 kg Zn ha^{-1} soil application through $ZnSO_4$ (31.52 q ha^{-1}). The soil application of 5 kg Zn ha^{-1} and two foliar spray of $ZnSO_4$ @ 0.5% increased grain yield by 3.24 per cent over soil application of 5 kg Zn ha^{-1} and 7.32%). Requirement of zinc is relatively very small for appropriate growth and production, physiological and metabolic processes in the sorghum plant. Piri (2012) documented that the significant effect of micronutrients foliar application on grain yield, biological yield plant height and length of flag leaf. Treatment having 200 kg ha^{-1} phosphorus fertilizer had significant effect on yield and grain weight. These results indicated that increase in yield of sorghum is through soil application of phosphorus fertilizer with micronutrients foliar application. Soleymani *et al.* (2012) revealed that combined application of Zn+Mn+Fe foliar application give the maximum fresh forage yield (125.2 t ha^{-1}), and differences were significant between this treatment and all other experimental treatments. Shahrajabian *et al.* (2011) reported that the highest fresh yield in forage sorghum was 138.4 t ha^{-1}. Ravi *et al.* (2010) observed the highest yield on safflower was due to combined foliar spray of Fe and Zn. Toader *et al.* (2010) also reported that the maximum parameters of efficiency is ensured in the case of foliar fertilization upon soil fertilization. Thakare *et al.* (2005) also reported that sorghum can produce high grain yield and biomass under dry conditions. Ahmad *et al.* (2018) noted that improvement in green fodder yield up to 7.15% (2014) and 7.41% (2015) through application of zinc Zn_2 (10 kg ha^{-1}) as compare to control (Zn_0). Verma *et al.* (2005) reported 8% increase in green fodder yield at 5 kg ha^{-1} of applied zinc. Response surface curves in response to applied zinc and nitrogen for dry matter yield (t ha^{-1}) during 2014 and 2015 showed that dry matter yield linearly affected by zinc and nitrogen up to Zn_2 (10 kg ha^{-1}) and N_2 (120 kg ha^{-1}) and the increase remained almost constant from Zn_2 (10 kg ha^{-1}) to Zn_3 (15 kg ha^{-1}) and N_2 (120 kg ha^{-1}) to N_3 (180 kg ha^{-1}).

Pearl millet

Pearl millet (*Pennisetum glaucum* L.) is one of the important millet crops for arid and semiarid climatic condition. Due to drought escaping character, it grows well in poor sandy soil. Sustainable production of pearl millet can be attained through balanced use of nutrients to the crops with amalgamation of organic and inorganic sources. Intensive agriculture is followed in present system, mostly farmers are using exhaustive high yielding varieties of the crops, ultimately heavy withdrawal of nutrients from the soil during past few years and fertilizer consumption remained much below compared to removal. So that qualitative and quantitative improvement of crop yield must be through mineral fertilization and its quality can be improved by adequate soil nutrient and crop management practices (Ali *et al.*, 2008 and Pathak *et al.,* 2012). Zinc plays a vital important role in mankind health and functioning the various physiological and metabolic functions of plant (Alam *et al.*, 2010). In Indian soil most deficient among all the micronutrients is zinc. In many parts of India, zinc now stands third in importance next to nitrogen and phosphorus (Takkar and Randhawa, 1980). Zinc is considered as essential element for crop production, growth and development of plant (Ali *et al.*, 2008). Phosphorus and zinc interaction affects the availability and utilization of both the nutrients and imbalance of any in soil matrix affects the dynamics (Nayak and Gupta, 1995). Singh *et al.* (2017) concluded that most suitable levels of phosphorus and zinc was found phosphorus (30 kg ha^{-1}) and zinc (20 kg ha^{-1}), among all the levels under rain fed condition. Quality, content and uptake of pearl millet is significantly influenced by application of phosphorus and zinc.Increasing doses of phosphorus reduced zinc uptake and similarly increasing dose of Zinc was also reduced the content and uptake of phosphorus by pearl millet. It might be due to antagonistic effect of P and Zn. Kadivala *et al.* (2018) observed that multi-micronutrient mixture 1% foliar application of Grade-III (grade for Fe deficiency) at 15, 30 and 45 DAT recorded significantly higher grain yield of pearl millet (2291 kg ha^{-1}), wherein an overall increase of 299 kg ha^{-1} was observed over control (1992 kg ha^{-1}) and was at par with three foliar spray of 1% multi-micronutrient mixture Grade-II (grade for Zn deficiency) and Grade-IV (for Zn & Fe deficiency) and soil application of Grade-V (T_6) and Soil Test Value (STV) treatment. The improvement in grain yield of pearl millet could be attributed to greater response of applied Grade-III (Fe deficiency) may be due to experimental soil was deficient in available Fe. Shekhawat and Kumawat (2017) indicated that at tiilering stage application of $ZnSO_4$ @ 20 kg ha^{-1} as soil application and foliar 4 spray 0.5% increase the growth characters, yield attributes and yields. Similarly at tillering stage of pearl millet under rainfed condition, the maximum net return and B:C was also observed under $ZnSO_4$ @ 20 kg ha^{-1} as soil 4 application and foliar spray 0.5%. Meena *et al.* (2018) concluded that pearl millet grain yield (36.6 q ha^{-1}) and mustard seed yield (22.7 q ha^{-1}) were 57.1% and 42.8% higher over control by combined application of Zn 5 kg + Fe 10 kg + FYM 10 t ha^{-1}. However, with the application of 5 kg Zn + 10 kg Fe ha^{-1} without FYM improve yield 35.6 and 20.7 % which was higher over control in pearl millet and mustard, respectively. Significant increase in yields of pearl millet and mustard than control was with alone soil application of 7.5 kg Zn ha^{-1} and 12.5 kg Fe ha^{-1}. Soil application of 5 kg Zn ha^{-1} and 7.5 kg Fe ha^{-1} alone increase the yield of pearl millet and mustard similarly as the foliar applications, spray of 0.5 % $ZnSO_4$ +1% $FeSO_4$ twice.

Maize

The third most important cereal crop is Maize (*Zea mays L.*) in the world and India. It is grown in both temperate and tropical regions of the world. It is the most important cereal crop for livestock feed. In India, 45 percent of maize production is utilized in the various forms of staple food (Prasanna *et al.*, 2001). It is estimated that maize together with rice and wheat provide at least 30% of the food calories to more than 4.5 billion people in 94 developing countries. Demands for animal feed and biofuel can be meet by increased maize production (Chen *et al.*, 2011). Zinc plays a vital role in stomatal regulation and it creates ionic balance in plant system resulting in reduction of less water tension (Baybordi, 2006) and regulates various physiological processes like carbohydrates and protein synthesis (Yadavi *et al.*, 2014). Similarly, boron increases growth, boosts tolerance against stress in plants and improves crop production. Basic plant functions as protein, photosynthesis and chlorophyll synthesis are controlled by zinc and boron (Cakmak, 2008). These are also involved in growth of roots, increase setting of flowers, synthesis of carbohydrates and proteins (Moeinian *et al.*, 2011) and minimization of kernel abortion especially. The application of micronutrients can be done in a variety of ways as seed treatment, soil and foliar application (Rehim *et al.*, 2012), which depends upon the soil characteristics and climate of the area. Maize productivity can be improved by soil application of Zn and B (Kanwal *et al.*, 2010). Wasaya *et al.* (2017) noted that mixed application of zinc and boron increased grain yield upto 45% as compare to control. Similarly, foliar application of these micronutrients obtained grain yield more than 9% as compare to priming. Maize plants produced 39% higher yield over controlled treatments, while foliar application of micronutrients produced only 6% higher biological yield over seed priming with mixture of Zn and B. Kumar and Salakinkop (2018) concluded that increase in grain yield was 19.8, 18.5 and 11.9% respectively over control (no application of Zn and Fe by soil application). Similarly incease in dose of Zn and Fe boost the stover yield. FYM enriched with $ZnSO_4$ and $FeSO_4$ each soil application @ 25 kg ha^{-1}, FYM enriched $ZnSO_4$ and $FeSO_4$ each @ 15 kg ha^{-1} and recommended dose of $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} increase the stover yield to 9.9, 9.8 and 3 % respectively over control.

Cowpea

Cowpea (*Vigna unguiculata*) is a leguminous crop and used as a fodder crop grown in kharif season which requires only starter dose of nitrogen (15-25 kg N ha^{-1}). Most of the nitrogen requirement if fulfilled through symbiotic nitrogen fixation. High application of NPK fertilizers have induced the deficiencies of micronutrients in many part of the country. To achieve high yields and sustaining the same over years, it becomes very pertinent to foresee the emerging nutrient deficiencies and to develop suitable ameliorating technologies. Balanced fertilization is unavoidable to lift the crop productivity. Among the micronutrients Zn, Fe, B, Mn and Mo improved the yield appreciably and foliar spray of micronutrients proved to be economical in pulses. Deficiencies of micronutrients have been observed in pulses, it might be due to the low levels of micronutrients in soil and their reduced availability. Correction of micronutrient deficiency should be done to boost the yield potential of pulses. Anitha *et al.* (2005) revealed that yield of cowpea significantly increases with foliar application of iron and zinc. The seed yield was highest when the crop is sprayed with mix application of 0.5% $FeS0_4$ and 0.5% $ZnSO_4$ at 45 DAS followed by mixed application of 0.5% $FeS0_4$ and 0.5% $ZnS0_4$ at 25 DAS. The seed yield was increased by 40.14 and 43.09% when mixed foliar application of 0.5% $FeS0_4$ and 0.5% $ZnS0_4$ done at 25 and 45 DAS respectively over control. The increase in yield might be due to increase in the growth and yield parameters. The treatment having micronutrient produced higher Pods per plant and straw yield. Chakirwa *et al.* (2019) concluded significant grain yield under Zinc fertilizer application in all the two seasons. Cowpea grain yield recorded on the application of Zinc fertilizer at 5 kg ha^{-1} increased at 28 % for Agyenkwa > Zamzam (20%) > Asontem (19%) over control in major season and the minor follows the same trend. The Zinc levels increased the cowpea grain yield in order: 5 kg Zn ha^{-1} > 10 kg Zn ha^{-1} > 0 kg Zn ha^{-1} during all cropping seasons (2016 major and minor seasons). Upadhyay and Singh (2016) reported that soil application of zinc @ 15 kg ha^{-1} increased significantly number of nodule per plant, active nodule per plant and active nodule weight per plant. The maximum number of nodule per plant and active nodule were recorded in treatment including 15 kg Zn ha^{-1} while minimum in recorded in control. The grain yield was greatly influenced by application of N and Zn. The significantly maximum grain yield (16.35 q ha^{-1}) was observed in 30 kg N ha^{-1} over control 13.20 q ha^{-1}. Application of Zn also influenced the grain yield of cowpea observed by Chawan *et.al*. (2012). The grain yield increased significantly with application of 15 kg Zn ha^{-1} because Zn influenced the synthesis of IAA in plants which indirectly enhanced the growth and development and uptake of nutrient in plants.

Berseem

Berseem (*Trifolium alexandrinum* L.) is called as king of fodders as it is most important fodder crop grown in *Rabi* season. Arora (2007) reported that application of 2.0 mg B kg^{-1} increases dry matter yield of berseem significantly in both first and second cuttings with a mean increase of 6.3 and 8.5 per cent respectively, over control. The mean B content and uptake by berseem also showed significant response to boron applied. At first cutting the total B concentration in berseem plant increased to the tune of 10.7 and 20.1 per cent over control with the application of 1.0 and 2.0 mg B kg^{-1} soil respectively. With the application of 2.0 mg B kg^{-1} the mean per cent increase in B uptake was 23.1 and 24.4 percent at first and second cutting respectively over control. Both at first and second cutting of crop boron uptake by berseem plant was significantly correlated with the dry matter yield. Arora and Chahal (2007) observed that the application of 1.0 and 2.0 mg B kg^{-1} soil increases mean dry matter yield of clover significantly showing an increase of 19.8 and 14.5 per cent, respectively compared to control. The relative boron concentration in clover plant varied from 77 to 87 per cent. With application of 1.0 and 2.0 mg B kg^{-1} the mean percent increase in B uptake was 35.0 and 43.8 over control. Dhaliwal *et al.* (2008) reported that the foliar application of micronutrients increased seed yield of berseem significantly with. Four foliar applications of boron followed by Mo and Zn results in highest seed yield (312.8 Kg ha^{-1}). Increase in seed yield of berseem may due to more absorption of micronutrients through leaves and flowers. The order of seed yield of berseem among the four micronutrients was found B > Mo > Mn > Zn. The seed yield of berseem with foliar application of B and Mo obtained nearly 50 per cent more as compared to Zn and Mn. Kaushalendra *et al.* (2009) conducted study in 19 districts of Haryana and reported, 28.6% samples of berseem were found deficient in copper content in zone-I and 27.1% in zone-II respectively. The zinc content in berseem fodder was also found deficient in Haryana districts and overall deficiency of zinc was 53.0%. However, iron content of all the berseem samples was found adequate.

Lucerne

Lucerne (*Medicago Sativa*) also called Alfa-Alfa is a multi-cut forage crop which is known as "Queen of Fodder Crops" and grown for high protein and energy rich green fodder in winter season. It has an outstanding growth habit, fast regrowth after cutting and high tillering. The reason for high micronutrient requirement is that it stands in fields for three year regularly depleting them in soil (Pathan and Kamble, 2014). Wang *et al.* (2003) and Liu *et al.* (2005) reported that application of B, Zn, and Mo increased the plant height of lucerne. Dordas (2006) reported growth, improved seed set and increased seed yield of lucerne with application of boron. Du *et al.* concluded on the basis of two years study that boron increased the highest number of fertile shoots per square meter (17–35%) over Cu (10–29%) and Fe (4–22%). The highest seed yield was increased by Mo (27–47%) compared to B (22–35%). Seed yields in study of 2004 were higher significantly compared to study of 2003 and treatments who had higher seed yields in study of 2003 also had higher yield of seeds in 2004. H. S. Grewal (2010) found that the yield of fodder lucerne was significantly higher in plots receiving combined application of P or K or Zn (22.49 t ha^{-1}) of ten cuttings compared to control (12.67 t ha^{-1}) or the plots receiving P only (13.09 t/ha). In all the ten cuttings highest total herbage yield (30.33 t ha^{-1}) achieved when K and Zn were applied along with P and S. Kherikhah *et al.* (2016) reported that individual application of PSB, B and Mn fertilizers gives highest fodder of lucerne when B applied as foliar application and soil application B (20 t ha^{-1}) compared to without any fertilizer (10.40). Kumari (2017) reported that the yield of lucerne and berseem increased by application of zinc. Each additional dose of zinc applied up to 4 kg Zn ha^{-1} increased the yield of lucerne and berseem significantly. Thereafter, a decreasing trend was noted at higher levels of zinc application. The per cent increases in yields of berseem were 21.9 and 13.0 due to 4 kg Zn ha^{-1} compared to control. This increase in yields with Zn levels may be due to increased availability of zinc to the crops.

Oats

Oats lowers the level of cholesterol and blood sugar as it contains a dietary fiber (?-glucan) (Yao *et al.*, 2007). At the present time oats (*Avena sativa* L.) is being popular as a food crop in India as well as in world. The uses of oats are increasing day by day as breakfast cereals, beverages, and infant foods. Nearly half of the Indian soils are deficient in zinc (Zn) and the yield of most cereal crops can be increased by the soil and foliar application of zinc (Prasad, 2006; Shivay *et al.*, 2008; Patel, 2011). Shivay *et al.* (2015) noted that significant increase in grain and straw yield of oats with zinc application and when broadcast of Zn sulfate or ZnO, increase was significant up to 5 kg Zn ha^{-1}, and difference was significant between 5 kg and 2 kg Zn ha^{-1}. The deep placement of Zn sulfate at 2 kg Zn ha^{-1} was superior significantly to the same amount of broadcast. ZnO at 2 kg Zn ha^{-1} deep placement was significant with broadcast of Zn sulfate or ZnO at 5 kg Zn ha^{-1}. Oats seed coating with ZnO or Zn sulfate at 2 kg Zn ha^{-1} resulted in the highest grain and straw yields of oats and it was superior significantly to soil application of 5 kg Zn ha^{-1}. Application of zinc after first irrigation reduced significantly grain and straw yields. Castagnara *et al.* (2012) reported that white oat plants shoot and root system significantly affected by application of boron. The number of tiller bows and leaves per plant and the production of DM fitted a quadratic regression model, while the height of plants and the production of DM of roots and total DM linearly increased with increasing boron. Application of 0.33 and 0.32 mg/dm^3 boron results in maximum number of tillers (3.2 tillers $plant^{-1}$) and leaves per plant (9.0 leaves $plant^{-1}$). Application of 0.47 mg/dm^3 boron results in maximum above ground dry matter production (4.26 g $plant^{-1}$).

Barley

Barley (*Hordeum vulgare* L.) is the modest grain with wide range of compatibility and transmittance among the other crops. Following three major cereals wheat, rice and maize, barley is the fourth main cereal in the globe (Khodabandeh, 2003). To reach self-sufficiency in agricultural products the yield of barley should be increased, because barley make up 60-70% human calorie intake in world, due to this role of micronutrients for quality improvement of agricultural products is having great importance (Malakouti *et al.*, 2000; Imam, 2007). Deficiency of micronutrients is widely spread in majority of farms in the world. The level of deficiency varies varies from one place to other (Al-Turki and Helal, 2004). Addition of micronutrients to a plant, improve the health as well as strengthen them against pests and diseases. Moreover, micronutrients meets the human nutritional status and requirement to nutrients (McCauley *et al.*, 2009). Boorboori *et al.* (2012) observed that soil application of zinc, copper, manganese and iron shows significant difference in grain yield at level of 1%, however, application of zinc and iron on foliage became significant at level of 5%. Grain yield was maximum when soil fertilized with 10 mg kg^{-1} Fe and Zn that increased grain yield to 28.71% and 35.11%, respectively over the control. Soil fertilization of 5 mg ka^{-1} Mn and Cu increased the grain yield of barley by 23.64 and 20.74%, respectively which was significant over control. Results proved that grain yield can be increased with foliar fertilization of zinc and iron by 22.01 and 23.32%, respectively. Singh *et al.* (2015) concluded that Fe and Zn treatments had a positive effect on yield and yield parameters of barley.

Application of Fe 20 (Fe 20 ppm) results in earlier anthesis, maximum flag leaf area (9.63 cm^2), spike number (2.33), tiller number $plant^{-1}$ (2.41), maximum number of spikelet on main spike (17.33), number of spikelet $plant^{-1}$ (50.39), spike length (8.16 cm), peduncle length (7.33 cm), number grains on main spike (46.16), number of grains $plant^{-1}$ (123.00), 100 seeds weight (4.650 g), weight grains $plant^{-1}$ (4.63 g), straw weight $plant^{-1}$ (15.16 g) and HI (22.66). However, Fe 40 (Fe 40 ppm) resulted better in increasing length of awn and promotion of early booting. Among zinc treatments, application of 20 ppm Zn performed best in early anthesis, maximum length of awn (13.76 cm) and number grains $plant^{-1}$ (133.92) *i.e.* increased by 4.70%, 22.20% and 33.65%, respectively, over control. All other yield parameters were promoted with Zn 40 (Zn 40 ppm) application. Combined application of Fe and Zn performed well as compare to their individual applications in promoting yield parameters. In inducing early anthesis 20 ppm Fe + 20 ppm Zn was best (75.75 DAS) *i.e.* earliness was 9.19% over control. For most yield parameters Fe 20 + Zn 40 was the best application i.e FLA (flag leaf area), number of tillers $plant^{-1}$, number of spikes, number of spikelets, length of awn, length of spike, number of grains on main shoot, weight of 100 seeds, weight of grains $plant^{-1}$, straw weight and harvest index. Arora and Singh (2004) observed that increasing levels of zinc upto 5.0 kg Zn ha^{-1} significantly increases grain and straw yield of barley. Maximum grain and straw yield of 45.82 and 66.38 q ha^{-1} is achieved by application of 7.5 kg Zn ha^{-1}, representing significant increase of 31.63 and 28.57 % compared to control, respectively. However, 5.0 kg and 7.5 kg Zn ha^{-1} were found at par with each other. Ishaq *et al*. (2018) observed that foliar application of Zn and Cu significantly increases grain yield, maximum grain yield (4000 kg ha^{-1}) were obtained with the sole application of Zn+Cu, while minimum (3471 kg ha^{-1}) was noted in control treatment.

CONCLUSION

Micronutrients are essential for plant growth and play vital role in balanced crop nutrition. However plants don't require as much of micronutrients but they are important to plant nutrition as primary and secondary macronutrients. Maize yield is enhanced with application of FYM enriched $ZnSO_4$ and $FeSO_4$ both @ 25 kg ha^{-1}, FYM enriched $ZnSO_4$ and $FeSO_4$ each @ 15 kg ha^{-1} and combined application of recommended $ZnSO_4$ and $FeSO_4$ dose @ 25 kg ha^{-1}. Sorghum dry fodder yield is enhanced with application of $ZnSO_4$ @ 20 kg ha^{-1} as soil and 4 foliar spray of 0.5% at tillering stage and application of 40 kg ha^{-1} sulphur, 20 kg ha^{-1} zinc and 10 kg ha^{-1} manganese along with recommended dose of NPK. Zinc fertilization as broadcasting of zinc sulphate or ZnO gave higher yield of dry matter, green herbage, and quality of oat can also be enhanced. Barley grain yield can be increased by 28.71% and 35.11% with soil application of 10 mg kg^{-1} Fe and Zn, respectively over control. Highest seed yield of cowpea can be obtained by mixed foliar spraying of $FeS0_4$ 0.5% and $ZnSO_4$ 0.5% at 45 DAS which is followed by mixed foliar spraying of the same dose at 25 DAS. Berseem should be fertilized with four foliar applications of boron followed by Mo and Zn to get higher seed yield. Increase in seed yield of berseem was due to more absorption of micronutrients through leaves and flowers.

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