FOLIAR NUTRITION IN CROPS - A REVIEW

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ABSTRACT

Fertilizer is a vital input in agriculture to boost the crop yields. Among the methods of fertilizer application, foliar nutrition is recognized as an important method since it facilitates easy and rapid utilization of nutrients. Foliar application is advantageous in specific occasions in certain crops. The results of the investigations on foliar nutrition in various crops are reviewed.

Agriculture still remains the backbone of Indian economy in spite of various technological advancements and industrial development with 70% of people dependent on agriculture and 25% of country's Gross Domestic Product coming from agricultural sector. Among the various inputs in agriculture, fertilizer is a vital input since it replenishes the nutrients removed from the soil by crops and also boosts the yield of crops. Method of fertilizer application is a non-monetary input which influences growth and consequently the crop yields. Foliar nutrition is recognized as an important method of fertilization, since foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients. It is advantageous over soil application in specific occasions in certain crops. For instance, in calcareous soil, deficiencies of Iron, Zinc and Boron is inevitable due to precipitation of Zinc and Iron as insoluble carbonates and Calcium-Boron antagonism. In soils with high indigenous phosphorus supply, Zinc and Iron deficiency are common, some of the other nutrient antagonism commonly encountered are Copper-Molybdenum, Copper-Iron, Potassium-Magnesium etc. On such occasions, soil application of Zinc sulphate or Borax may not be useful. So resorting to foliar application is the best option. Similarly in pulses, the time gap between the maximum vegetative and flower initiation stage is small. Foliar application of diammonium phosphate to reduce flower drop and increase the yield of pulses is a regular practice. Thus specificity of crop and soil conditions warranting foliar application of nutrients is encountered. Several scientists have attempted to conduct studies on foliar nutrition and its effect on yield and quality parameters in various crops. The present paper is a review of work done on this aspect.

Foliar spray of macronutrients

The macronutrients viz., Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur are tried in foliar application by several researchers in various crops.

Rice is the staple food crop in India grown in 42 million hectares and consumes the major share of fertilizers. Urea, super phosphate and muriate of potash are the major fertilizers used as sources of nitrogen, phosphorus, potassium, respectively by the farmers for rice. It is usually applied by broadcasting. But in case of urea, the crop takes only 30-40% and the remaining N is lost through leaching and volatilisation leading to ground water pollution and green house effect. So combined application of Nitrogen and Phosphorus through Di Ammonium Phosphate along with recommended fertilizer to minimize the losses is being tried. In an experiment conducted in Tamil Nadu Agricultural University, Coimbatore during Kharif season with IR 50 rice as the test crop in 1993, Annadurai and Palaniappan (1994) observed that 2% Di Ammonium Phosphate
spray given at boot leaf stage, 50 per cent flowering and at post milk stage recorded more grain and straw yields along with the recommended dose of 38 kg P₂O₅ ha⁻¹. Kumaresan (2001) conducted a field experiment in ratoon rice to study the residual effect of green manuring combined with foliar spray of nutrients. He concluded that yield and nutrient uptake in ratoon rice increased with the application of green manure Sesbania rostrata @ 12.5 t ha⁻¹ as basal, applied 7 days before transplanting of the main crop and spraying 2% glucose at fifth day and 2% Di Ammonium Phosphate spray on 30th day for the ratoon crop in rice var. Bhavani in wetlands of Tamil Nadu Agricultural University, Coimbatore.

Next to cereals, pulses are the second important group of crops which constitute the vegetation diet and cater their protein needs. Pulse crop itself is a mini-fertilizer factory by contributing substantially to the enrichment of the soil. Pulses occupy nearly 23 million hectare of land and yield roughly 12 million tonnes of grain. Per capita availability of pulses is around 40 g as against the minimum requirement of 60 g and the optimum requirement of 104 g per person per day. To attain this optimum estimated requirement is around 24 million tonnes (Jeswani and Saini, 1981). So production of pulses has to be doubled in coming years. Since pulses are raised under rainfed and rice fallow conditions without fertilizers and irrigation, their yields are poor. So to augment their production, foliar application of nutrients can be done. Also the time gap between the maximum vegetative and reproductive stage in pulses is small. Also flower drop is a common phenomenon. So to avert all these problems, foliar nutrition is a better tool in nutrient management of pulses.

Jeswani and Balder (1990) have reported the usefulness of 2% Di Ammonium Phosphate (DAP) foliar spray in rainfed and rice fallow pulses. They have suggested popularization of quick growing green gram, black gram and cowpea as a second crop in monocrop paddy areas and as a third crop in double crop paddy areas in coastal regions. Ramesh and Thirumurugan (2001) conducted field experiments at Agricultural College and Research Institute, Madurai in Tamil Nadu during rabi 1998-99 in red sandy clay loam soil with soybean as test crop and found that foliar spray of benzyl adenine 25 ppm twice with DAP 2% and Potassium chloride (KCl) 1% at flowering and 15 days after first spray increased the yield of soybean var. Co 1. Ramesh et al. (2001) also studied the effect of the spray on regulation of leaf senescence in soybean var. Co 1. They found that Benzyl adenine along with DAP and KCI spray retained the greenness of leaves by preventing chlorophyll breakdown and delay of thylakoid system in senescing leaves. The same effect was reported by Choudhry and Imaseki (1990).

In an experiment conducted by Pandian et al. (2001) in rice fallow green gram in Agriculture College and Research Institute, Killikulam, Tamil Nadu for yield maximisation, during 1998-99, the results showed that basal application of N and P at 12.5 and 25 kg ha⁻¹ and 2 per cent DAP spray twice at flower initiation stage and 15 days after the first spray increased the grain yield to a tune of 165 per cent over conventional method of raising rice fallow pulses Baskar and Saravanan (1997) conducted a pot culture experiment with Co 2 cowpea as test crop and reported that application of 50% of N and P as basal and 50% through fertigation at 10 days interval and 2 rounds of 3% DAP foliar spray gave higher green pod yield than basal application of full dose of Nitrogen and Phosphorus.

Oil seeds constitute essential component in regular diet. Sulphur is very essential for oilseed crops. Khafi (1997) conducted an experiment in Udaipur, India with
Indian Mustard var. Kranti in a vertisol and reported that two foliar sprays of 0.1% Sulphuric acid and Thiourea at 45 days after sowing and 15 days after the first spray increased the yield of mustard. Though cotton is a minor oilseed crop, it is a major fibre crop. An experiment was conducted during the winter season of 1993-94 at Cotton Research Station, Srivilliputhur by Chellaiah et al. (2001) with SVPR 2 cotton. The results revealed that foliar spraying of humic acid one per cent twice at peak squaring and peak flowering combined with 2% DAP and 1% KCl spray leads to significant yield increase in summer irrigated cotton. Similar findings were observed by Sivasankaran (1993) and Solaiappan (1995). Venkatakrishnan (1994) found that foliar spray of 3% DAP along with recommended fertilizer, NAA and topping improved the bundle strength in MCU 9 cotton in Coimbatore, India. Sastin et al. (2000) observed similar yield increase in MCU 5 cotton by foliar spray of 2% DAP twice at 75 and 90 days after sowing (DAS).

Sugarcane is an essential cash crop. An experiment was conducted by Annadurai et al. (2001) in Tamil Nadu Agricultural University, Coimbatore in sugarcane. Under early drought conditions, application of 168 kg K$_2$O ha$^{-1}$ or application of 112 kg K$_2$O ha$^{-1}$ along with 2.5% foliar spray of KCl at 45, 75 and 105 days after planting recorded more dry matter production, leaf area index and cane yield. This is due to the fact that the foliar KCl spray reduced the transpiration loss and turgidity of plant cells was maintained.

In tomato, an essential component in human regular diet, Subbiah and Rani Perumal (1994) conducted a field experiment with Co 1 and Co 3 tomato in vertisol, foliar spray of 0.5% CaCl$_2$ was found to significantly influence the yield and P, K, Ca and Mg contents in tomato fruit. Foliar spray of micronutrients

Micronutrient $viz.$, Zinc, Iron, Copper, Manganese, Boron and Molybdenum though needed in small amounts are essential for influencing the growth and yield of crops. 52% of the soils in India have been reported to be deficient in zinc. Similarly, deficiencies of other micronutrients are also cropping up. Due to the continuous application of major nutrient fertilizers, alone nutrient imbalance and micro nutrient deficiencies are encountered. Application of organic manures including farm wastes, crop residues, industrial wastes and biofertilizers will lead to increased soil organic matter which is a storehouse of nutrients and also sustain soil fertility and productivity. In specific situations, micronutrient fertilizers are applied to avert their deficiencies.

Subbaiah and Mitra (1997) conducted a field experiment in acid laterite soils of Kharagpur, West Bengal in rice. They found that foliar application of Zinc and Boron was essential for realizing higher yields of rice in laterite soils. Similar results were observed by Mahapatra and Gupta (1978).

In Co 1 maize, a field experiment was conducted by Poongothai and Mathan (2000) in a copper deficient soil to study the effect of organic manures and copper application on uptake of nutrients. It was found that the application of 6.25 t ha$^{-1}$ of poultry manure along with copper recorded higher yield and uptake of micronutrients in grain and stover. Foliar application was better than soil application in increasing the nutrient uptake due to better translocation of nutrients through the foliage. In groundnut var. Co 2, Revathy et al. (1997) found that foliar sprays of 0.5% chelated micronutrient mixtures of Zinc and Iron twice at 30 and 40 days after sowing increased the kernel yield and uptake of nutrients.

Lakshmi and Dharmalingam (1998) conducted a field experiment in TCB 209
cotton for observing the role of micronutrients in reproductive traits of male parent. It was found that Zinc sulphate applied through soil and foliage produced more number of flowers per plant, higher quantity of pollen and increased pollen viability, which are indicators of high yields.

Singaram and Prabha (1999) experimented on Tomato in a calcareous red soil for assessing the response to Borax and Boronated superphosphate. They found that foliar application of Boron was more effective than soil application in increasing fruit yield of tomato hybrid Naveen. Prabha and Singaram (1986) found that 0.3% foliar spray of Borax recorded the highest uptake of Phosphorus, Potassium, Magnesium and Boron than soil application in tomato. Due to Calcium-Boron antagonism in the experimental soil, which was calcareous, foliar spray was better. Similar findings were observed by Gupta (1979).

In fruit crops, micronutrient sprays are found to have significant influence on yield and quality. Balakrishnan (2001) conducted a field experiment in a sandy loam soil in Periyakulam, Tamil Nadu in Guava fruit crop. He reported that two foliar sprays of Zinc sulphate 0.25% + Ferrous sulphate 0.25% + Magnesium sulphate 0.25% + Borax 0.1% at an interval of 60 days significantly increased the vegetative growth, yield and quality attributes of fruits of Lucknow 49 guava. This corroborates with the findings of Sharma and Bhattacharya (1994).

An experiment with grapes cv. Muscat was conducted by Prabhu and Singaram (2001) at Mathampatti, Coimbatore. The results revealed that foliar application of Zinc sulphate 0.5% and Borax 0.2% combination excelled other treatments in increasing the shoot length, number of internodes shoot¹, number of leaves shoot¹ and yield. Similar findings were observed by Sanjay Kumar and Pathak (1992).

Durga Devi et al. (1997) found that soil application of 50 g/plant each of Zinc sulphate, Ferrous sulphate and Manganese sulphate combined with foliar sprays of 0.5% each of the above nutrients resulted in increased fruit yield, total sugars, ascorbic acid and juice content in Sathgudi sweet orange under conditions of micronutrient deficiency. This is in line with the findings of Manchanda (1976), Manchanda et al. (1972), Singh and Chohan (1982) and Desai et al. (1991).

Foliar spray of macro and micronutrient mixtures

Balanced fertilization is the judicious combination of optimum amounts of macro and micronutrients applied at right time using right method of application. Foliar spray of major and micronutrient mixtures leads to increased yield in various crops.

Sundaravadivel et al. (1998) conducted a field experiment with MCU 10 cotton in Kovilpatti, Tamil Nadu under rainfed condition. They advocated foliar spray of 2% DAP and 0.5% Zinc sulphate at 45 days after sowing for getting increased seed cotton yields. Similar results were reported by Venkatakrishnan and Potheraj (1994). Rathinavel et al. (1999) reported the beneficial effect of foliar spray of Zn and Borax in TCB 209 cotton.

Field experiments were conducted by Kalyanasundaram et al. (2002) in Annamalai Nagar, Tamil Nadu. It was found that foliar application of Penshibao (macro and micronutrient mixture) at 50 ml ha⁻¹ along with plantoyme (liquid biofertilizer) recorded an additional grain yield of 214 Kg ha⁻¹ (24.4 per cent) in Blackgram. Foliar application of 2% DAP was also followed.

Jagadeeswaran et al. (2001) conducted a field experiment with groundnut in a calcareous red soil to evaluate the efficiency of ferrogypsum in comparison to gypsum and...
Ferrous sulphate as soil application or foliar spray. Application of ferrogypsum along with ferrous sulphate spray is equivalent to recommended gypsum along with ferrous sulphate application. Fields in soil applied and foliar-sprayed plots were comparable with each other. Similar results were obtained by Prabhakaran and Subramanian (2001) for the application of nutrient mixture spray consisting of 1% DAP, 0.5% MOP and micronutrient mixtures of Copper, Manganese, Zinc and Iron (2%) at 30 and 45 days after sowing in Aliyarnagar, Tamil Nadu, Venkatakrishnan and Balasubramanian (1996) conducted a field experiment with Co 2 sunflower during rabi 1992 and kharif 1993, foliar spray of 0.2 per cent Borax along with recommended level of fertilizer and 25 Kg Sulphur ha⁻¹ as Gypsum was recommended for yield maximization. Similar results were observed by Prabhuraj et al. (1993) for the combined application of P, S and Zn.

Teak is an important commercial tree grown in wastelands for its wood. Masilamani et al. (2000) found that 0.5%, Potassium sulphate spray influenced the seedling attributes viz., root length, collar diameter and root dry weight and foliar spray of 0.5% Zinc sulphate was good for influencing shoot length and number of secondary roots per seedling. Urea 1% spray had good effect on root and shoot dry weight in teak nursery. Similar results were reported by Chinnathurai et al. (1997).

Thus foliar nutrition is advantageous in several crops. Indiscriminate fertilizer use in large quantities leads to various types of losses of nutrients including volatilization causing green house effect contributing to global warming. Global warming due to gaseous emissions from developed countries is likely to bring significant stress on soil, water and crop productivity in developing countries facing the challenges of ensuring food and nutritional security to their growing populations. According to Klaus Toepfer (2002), climate change is a serious threat to developing nations like India. It has been reported that there may be 30% decrease in farm output by 2050 due to 1.4 to 5.8°C warming in climate. Research in IRRI, Philippines has concluded that for every 1°C rise in temperature, there will be a 10% fall in the yield of rice. Gaseous losses from agricultural fields are one of the reasons contributing small proportions in global warming. Though fertilizer application is not in alarming quantities in India compared to other nations, still increased fertilizer consumption to boost the yield of crops may be advocated in future. To avert crisis due to high amounts of fertilizer application, integrated nutrient management involving judicious combination of organic manures and inorganic fertilizers should be practised. Right method of fertilizer application should be adopted to avoid various losses of costly input viz., fertilizer. If foliar nutrition is resorted, reducing the cost of cultivation reduces amount of fertilizer thereby reducing the loss and also economizing crop production. So foliar nutrition can be adopted wherever possible except for unavoidable circumstances where soil application is only feasible and advantageous over foliar application just as in tall tree crops like coconut and forest trees.

REFERENCES