NUTRIENT MANAGEMENT IN SOYBEAN - A REVIEW

N.K. Prabhakaran and A. Christopher Lourduraj
Department of Agronomy,
Tamil Nadu Agriculture University, Coimbatore - 641 003, India

ABSTRACT

Though soybean is a leguminous crop, it responds to fertilizer N besides P and K requirement. In general, N application increases the P uptake. Phosphorus fertilization to soybean favourably enhances the uptake of N, P and K. Application of N, P and K together significantly increases the growth attributes and yield of soybean. Split application of nutrients is reported to be beneficial especially when the soils are coarse textured or alkaline and calcareous in nature. Foliar application of fertilizers offers considerable scope not only for better utilization of nutrients but also for economy in fertilizer application. Higher sustained soybean yields can be obtained with judicious and balanced N, P and K fertilization combined with organic amendments.

Effects of nutrients on the growth, development and seed quality of soybean

Soybean is a crop responsive not only to the added inputs but also to those available in nature. Though it is a leguminous crop, it responds to fertilizer N besides P and K (Bashir et al., 1980).

Nitrogen: Application of 20 to 25 kg N ha⁻¹ increased the plant height in irrigated soybean (Sharma and Dixit, 1987; Singh et al., 1995). Pradhan et al. (1995) observed that plant height, number of branches per plant and dry matter production (DMP) got increased even up to a dose as high as 80 kg N ha⁻¹. Ramamurthy and Shivashankar (1996) also reported that increase in N dose from 0 to 25 kg ha⁻¹ increased the leaf area index (LAI) and thereby the DMP of soybean. Number of pods per plant, grains per pod and test weight were significantly increased due to N application, recording highest value at 50 kg N ha⁻¹ (Dahatonde and Shava, 1992). Patel et al. (1996) also reported that application of 45 kg N ha⁻¹ gave significantly higher yield of seed and straw compared with lower doses and control. Patel and Sastri (1999) also reported that dry matter production, growth rate and yield generally increased with increasing N rate up to 45 kg N ha⁻¹. However, Pradhan et al. (1995) were of the opinion that significant increase in number of pods per plant could be possible up to 80 kg N ha⁻¹ and test weight up to 60 kg N ha⁻¹. But, Nguyen Thi Thu Hong and Aruna Rajagopal (1996) found no response to N up to 20 kg ha⁻¹ on number of seeds per pod and test weight. It was also observed that protein content increased from 37.9 to 39.2 per cent and oil content decreased from 21.3 to 20.3 per cent when N level was increased to 90 kg ha⁻¹ (Singh and Singh, 1995b). However, Kushwaha and Chandel (1997) reported that protein content of soybean seed was not significantly affected by N application at 20 kg N ha⁻¹ as compared to control (0 kg N ha⁻¹).

Phosphorus: Abbas et al. (1994) observed that plant height, dry weight, trifoliate per plant, relative growth rate and leaf area duration were significantly increased with P up to 40 kg ha⁻¹, whereas number of root nodules. LAI, net assimilation rate and crop growth rate significantly increased even up to 80 kg P ha⁻¹ in soybean. Haradagatti et al. (1996) also reported that the seed yield of soybean increased with up to 80 kg P ha⁻¹. According to Agarwal et al. (1996), a linear increase in different morpho-physiological attributes was registered with increased levels of P. Plant height and seed index increased up to 60 kg P ha⁻¹ while effective nodes, height of first effective node increased up to 80 kg P ha⁻¹. The number of pods and seeds, seed
weight and harvest index increased up to 100 kg P ha\(^{-1}\). Nimje and Potkile (1998) reported that soybean seed yield increased with increasing P rate up to 125 kg P\(_2\)O\(_5\) ha\(^{-1}\).

Prasad et al. (1993) revealed that P application increased the oil content up to 90 kg ha\(^{-1}\) with concomitant decrease in protein content. However, Ramamurthy and Shivashankar (1996) found that application of P at 56.25 kg ha\(^{-1}\) enhanced both oil and protein yields simultaneously.

Potassium: In soybean, the plant height, number of branches per plant and leaves per plant were significantly influenced up to 75 kg K ha\(^{-1}\) (Jose Mathew et al., 1983). Sabesan and Sathananda (1986) recorded the highest LAI in soybean for 40 kg ha\(^{-1}\) and the same was reported by Singh and Singh (1995a). whereas, Ramamurthy and Shivashankar (1996) noticed that soybean was putting up more height and higher values of LAI even for 25 kg K ha\(^{-1}\).

Application of 50 kg K ha\(^{-1}\) resulted in more number of pods per plant, seeds per pod but did not influence the test weight (Paikera et al., 1989). This was not accepted by Abbas et al. (1994), who observed that besides number of pods per plant and seeds per pod, there was also an increase in test weight with 40 kg K ha\(^{-1}\). Singh et al. (1995) noticed increase in yield attributes with 50 kg K ha\(^{-1}\) in a medium K available soil. Borkert et al. (1997) reported that to maintain a soybean yield of 2.5 - 3.5 t ha\(^{-1}\) in a soybean/wheat double cropping system, application of 120 kg K ha\(^{-1}\) is required.

With increase in level of K up to 40 kg ha\(^{-1}\), protein and oil contents of soybean seeds were progressively increased (Nayak et al., 1989). Pradhan et al. (1995) observed considerable increase only in protein content due to K application at the rate of 40 kg ha\(^{-1}\). However, Annadurai et al. (1994) observed no increase in oil content for a dose of 40 kg K ha\(^{-1}\).

**Uptake of Nutrients**

In general, N application increases the P uptake (Dang et al., 1984). Application of 20 kg N ha\(^{-1}\) increasing the uptake of N, P, Ca and Mg and subsequent grain yield (Sharma and Dixit, 1987) and 60 kg N ha\(^{-1}\) increasing the N uptake (Ramakrishna Reddy et al., 1990; Singh et al., 1995) indicates the usefulness of N application.

Phosphorus fertilization to soybean at 80 kg ha\(^{-1}\) favourably enhanced the uptake of N, P and K (Nimje and Jagadish Seth, 1987; Purushothaman et al., 1991; Rajput and Shrivastava, 1994). However, Singh et al. (1995) revealed that application of even 35 kg P ha\(^{-1}\) increased the N uptake considerably. Increasing trend of N, P and K uptake with increasing trends of P from 37.50 to 56.25 kg ha\(^{-1}\) was observed by Ramamurthy and Shivashankar (1995). Nakabayashi et al. (1999) also reported that in soybean, the absorption of N and crop yield were increased by the application of P. Pannerselvam et al. (2000) reported that application of biogas slurry + 30:120:40: kg NPK gave the highest P uptake and yield of soybean.

Application of K fertilizer, increased its availability and also uptake by soybean plants (Bharathi et al., 1986; Ritchy et al., 1990). In a sandy loam soil, application of 60 kg K\(_2\)O ha\(^{-1}\) increased the availability of K and uptake by soybean plants (Nguyen Thi Thu Hong, 1992).

**Balanced fertilization**

**Basal**: Rationalized fertilizer recommendation should depend on nutrient supplying power of the soil as well as the crop requirement (Rani Perumal et al., 1986). Fenner (1987) reported that fertilization of soybean at 20-30 kg N, 40-50 kg P\(_2\)O\(_5\) and 30-40 kg K\(_2\)O ha\(^{-1}\) was optimum. Mishra and
Vyas (1992) observed significant increase in grain yield up to 20, 60 and 20 kg N, P and K ha\(^{-1}\) respectively and thereafter reduction in yield has been recorded. Similar results in conjunction with FYM, rhizobium and cycocel were noticed by Mishra et al. (1994). The fertilizer level of 20-80-20 kg N, P\(_2\)O\(_5\) and K\(_2\)O ha\(^{-1}\) gave the highest grain yield and net return up to 35.1 q ha\(^{-1}\) and Rs. 15278 ha\(^{-1}\) respectively (Dube et al., 1995). Cheng Guangtua et al. (1999) reported that application of N, P and K together to soybeans significantly increased root weight and length, number and weight of root nodules, plant height, pod number per plant, seed number per plant and seed weight per plant compared with N applied alone or in combination with P.

Split application: The crops grown under irrigation especially in sandy loam soils, where the loss of applied fertilizers occurred through leaching particularly when the entire fertilizer is applied as basal, split application of nutrients was found to be advantageous (Chitkala Devi and Ramakrishna Reddy, 1991). Similarly, when the soils are alkaline and calcareous in nature with clay, loss of N due to volatilization in the form of ammonia gas associated with a high P-fixing capacity were the major problems in the nutrient management (Dighe et al., 1994).

Purushothaman et al. (1990) observed that application of 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) as basal and 20 kg P\(_2\)O\(_5\) ha\(^{-1}\) as applied in three splits gave better yield of soybean over all basal application of 80 kg P\(_2\)O\(_5\) ha\(^{-1}\). Huang et al. (1991) noticed that 33 per cent of P\(_2\)O\(_5\) applied when soybean plants were 4 cm tall and the remaining when plants were 8 cm tall resulted in better yield. Pandey et al. (1995) suggested that split application of 20 kg N ha\(^{-1}\) at sowing and pod initiation stages influenced the number, dry weight and N content of nodules and N accumulation in plant parts at later stages and thereby the soybean seed yield increased significantly as compared with basal application alone. Gan Yinbo et al. (1998) based on studies with three soybean genotypes and the effects of different N fertilizer application dates on growth, nodule formation and yield reported that the optimum time for N application in the vegetative stage was the beginning of nodule formation and in the reproductive stage was flowering.

**Foliar nutrition:** Foliar or leaf feeding of plants has attracted attention in recent years in India. The nutrient elements which are absorbed through roots can also be absorbed through foliage (De, 1971). Foliar application of nutrients reduces the loss through absorption, leaching and other processes associated with soil application (Vasias et al., 1980). Subramanian and Palaniappan (1981) reported that foliar spraying of N and P is as good as their soil application. Srivastava and Varma (1983) stated that the foliar application of fertilizers offered considerable scope not only for better utilization of nutrients but also for economy in fertilizer application.

**Effect of foliar nutrition on growth attributes of soybean**

Rajendran (1991) reported that diammonium phosphate at the rate of 50 kg ha\(^{-1}\) as basal dose followed by foliar spraying twice significantly increased the leaf area index and dry matter production in soybean. Similar results on plant height were obtained by Srinivasan and Ramaswamy (1992) with diammonium phosphate 2 per cent foliar spray at 20 and 30 days after sowing.

Foliar application of 12.5 kg K ha\(^{-1}\) through MOP increasing the plant height and LAI (Subbaraj, 1986) and DMP (Jha and Chandel, 1987) has been reported.

Trace elements such as Fe, Mn, Zn and Mo increased root nodulation and dry weight per plant (Hegazy et al., 1990), while Fe and Zn increased total chlorophyll content
of leaves and number of nodules per plant (Bhanavase et al., 1994) in soybean are well documented.

Effect of foliar nutrition on yield attributes and yield

A series of findings are available on the beneficial effects of foliar nutrition on reproductive characters in soybean. Jha and Chandel (1987) with Zn on yield attributes and yield, Sabir Ahamed (1989) with DAP one percent on pods per plant, Hegazy et al. (1990) with trace elements (Mn, Zn, Mo and Fe) on seed yields, Setty et al. (1992) with DAP on the yield of soybean, Kalarani and Moosa Sheriff (1994) with N, P, K and B nutrient mixture on higher productivity and retarding leaf senescence, Singh and Singh (1995a) with Zn on number of pods per plant, number of seeds per pod, and thousand seed weight and seed yield and Annamalai (1995) with one percent DAP on the seed yield in soybean are some of the well proven results.

Seed quality

Kumar et al. (1981) observed that S and Zn were most critical for oil and protein syntheses and for improvement of quality of soybean by their enzymatic and metabolic efforts. Chamber (1987) reported that 2, 3 or 4 times foliar application of N+P+K+S given at 7 to 14 days interval to soybean not only increased the seed protein but also the oil content. Kalarani et al. (1994) also observed similar findings with 1% foliar spraying of urea on protein content followed by 2% DAP.

Combined use of organic and inorganic sources of nutrients

Higher sustained crop yields can be obtained with judicious and balanced N, P and K fertilization, combined with organic amendments (Kang and Balasubramanian, 1990). Sharma and Misra (1997) have reported that soybean seed yield, water use efficiency, uptake of N, P, K, S, Ca, and Mg, seed protein content were highest with application of 6 t FYM + 20 kg N ha⁻¹. Organic manures in combination with inorganic fertilizers particularly those of N, serve to counteract the negative effects of the fertilizers like acidification and depletion of nutrients other than those from applied fertilizers (Ridder de and Van Keulen, 1990). Coir pith plus N and P gave higher crop yield than N, P and K alone (Ramaswami and Sree Ramalu, 1983). Coir pith application at 10 t ha⁻¹ with N and P fertilizers aided in building the soil N content (Ramaswami and Kothandaraman, 1985). Nagarajan et al. (1986) reported that application of coir pith inoculated with Pleurotus sp. in combination with either N or P and K or N, P and K increased the pod yield in another leguminous crop, i.e. groundnut. Lourduraj (2000) has also reported that the combined application of inorganic and organic manures significantly enhanced the growth attributes and yield of soybean as compared to the sole application of either of them.

Management of nutrients is an important aspect of maintaining soil productivity (Abrol, 1988). Deterioration in soil health can be minimised by supplementing the chemical fertilizers with organic manures. Ability of bulk organic manure to neutralize the rapid fall in yield with the continuous use of chemical fertilizers and to sustain productivity was reported by Mondal et al. (1985), Nambiar (1985) and Abrol and Katyal (1990). Misra and Kapoor (1992) were of the view, that the objectives of maximizing yields and maintaining soil productivity can be met by balanced use of inorganic fertilizers and organic sources of nutrients. Reddy and Reddy (1999) reported that the DTPA extractable cationic micronutrients (Fe, Cu, Mn and Zn) were significantly increased with the integrated use of manures and fertilizers in a maize - soybean cropping system. Panneerselvam et al. (1999) reported that application of bio-digested slurry @ 5.0 t ha⁻¹ + 30:120:40 kg NPK ha⁻¹ recorded
the highest N uptake by soybean in both summer and kharif season as well as higher soil available nitrogen and seed yield. This treatment also recorded the highest K uptake (Parneerselvam et al., 1998). Mondal et al. (2000) also reported that application of 100% recommended NPK + 10 t ha\(^{-1}\) of FYM was significantly superior to 100% recommended NPK or no fertilizer/manure in respect of dry matter accumulation, crop growth rate, pods plant\(^{-1}\), seed and stover yield and agronomic efficiency of fertilizer nutrients.

Under tropical climatic conditions, prevailing in southern parts of India, organic matter is quickly lost and fresh applications are necessary to obtain increased yields and to maintain soil fertility (Gaur et al., 1984). Nagarajan et al. (1991) reported that the continuous use of coir pith increased available P and K status on a sandy loam soil.

REFERENCES
