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NUTRIENT MANAGEMENT FOR PULSES - A REVIEW

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ABSTRACT

Nutrient imbalance is one of the major abiotic constraints limiting productivity of pulses. The inbuilt mechanism of biological N_2 fixation enable pulse crops to meet 80-90 per cent of their nitrogen requirements, hence a small dose of 15 - 25 kg N/ha is sufficient to meet out the requirement of most of the pulse crops. However, in emerging cropping systems like Rice - Chickpea, a higher dose of N (30 -40 kg/ha) had shown beneficial effect - Phosphorus deficiency in soils is wide spread and most of the pulse crops have shown good response to 20 -60 kg P_2O_5/ha depending upon nutrient status of soil, cropping system and moisture availability. Response to potassium application is location specific. In the recent years, use of sulphur (20-30 kg/ha) and some of the micronutrients such as Zn, B, Mo and Fe have improved productivity of pulse crops considerably in many pockets. Band placement of phosphatic fertilizers and use of bio-fertilizers enhance the efficiency of applied as well as native P. Foliar nutrition of some micronutrients proved quite effective. The amount and mode of application is determined by indigenous nutrient supply, moisture availability and genotypes. Balanced nutrition is indispensable for achieving higher productivity. At the same time, in view of increasing nutrients demand, there is immense need to exploit the alternate source of nutrients viz., organic materials and bio-fertilizers to sustain the productivity with more environment friendly nutrient management systems. The environmental issues and other hazards emerging out of the imbalanced use of nutrients should also be addressed properly.

Nutrient requirement for pulses

Out of 16 essential elements, pulses specially need adequate amount of P, Ca, Mg, S and Mo. Phosphorus is required for proper root growth and growth of rhizobia. Calcium and magnesium are required to stimulate growth and to increase the size of the nodules, pod formation and grain setting. Sulphur is required for nodulation and protein synthesis. Molybdenum for nitrogen fixation and assimilation and boron for reproduction are the requirement.

Nutrient removal and uptake

For producing one tonne of biomass, pulse crops in general remove about 30-50 kg N, 2-7 kg P_2O_5, 12-30 kg K_2O, 3-10 kg Ca, 1-5 kg Mg, 1-3 kg S, 200-500 g Mn, 5g B, 1g Cu and 0.5 g Mo from soil (Ahlawat and Ali, 1993). Hegde and Dwivedi (1993) projected the nutrient removal of various pulse crops for the target production level of 21 million tonnes of grains and 30 million tonnes of straw by 2000 AD (Table 1). They further stated that chickpea and pigeonpea together would require more than 50% of the nutrients for consumption. A crop of pigeonpea producing 1.20 tonnes/ha of economic yield removes 85 kg N, 8 kg P, 16.0 kg K and 9.0 kg S/ha (Tandon, 1995) while chickpea producing 1.50 tonnes/ha removes 91, 6, 49, 13 kg NPKS/ha respectively (Table 2).

Nutrient management

Nitrogen: Balance supply of nitrogenous fertilizers not only affects nodulation but also crop yield and nutrient use pattern in pulses (Rao, 1980 and Thakuria and Ioikham, 1991). Favourable response of soybean to nitrogen up to 240 kg ha^{-1} was indicated by Singh and Saxena (1972). Velayutham *et al.* (1985) reported more than 100 per cent efficiency of fertilizer nitrogen in pulse crops. Singh and Bahadur (1990) noticed an addition of 45kg N and 80 kg P_2O_5 ha^{-1} promoted maximum vegetative growth and produced the highest yield of green pods in pea. Singh *et al.*(1993) reported that application of 20 kg N ha^{-1} improved the yield (726 kg and 687 kg ha^{-1}) of blackgram and

Table 1. Estimated nutrient removal by pulse crops by 2000 AD

Crop	Targeted production (m.ton)	Nutrient removal (m. ton)		
		N	P_2O_5	K_2O
Pigeonpea				
Grain	3.00	0.106	0.024	0.042
Straw	7.50	0.098	0.019	0.030
Chickpea				
Grain	9.00	0.297	0.090	0.014
Straw	9.00	0.144	0.027	0.045
Other pulses				
Grain	9.00	0.300	0.081	0.135
Straw	13.50	0.200	0.041	0.054
Total pulses				
Grain	21.00	0.703	0.195	0.307
Straw	30.00	0.464	0.087	0.129

Source : Hegde and Dwivedi (1993)

Table 2. Nutrient uptake by pulse crops

Crop	Yield (t ha^{-1})	Total uptake (kg ha^{-1})			
		N	P	K	S
Pigeonpea	1.2	85.0	8.0	16.0	9.0
Chickpea	1.5	91.0	6.0	49.0	13.0
Lentil	2.0	114.0	13.0	36.0	6.0
Urdbean	0.89	70.0	5.6	50.1	5.1
Mungbean	0.87	82.6	12.5	90.4	6.5

Source : Tandon (1995)

greengram respectively irrespective of inoculation. Kushwaha (1994) reported increase in plant height and pods/plant with increased level of nitrogen application. Substantial increase in protein content of legumes due to nitrogen application has also been observed by Singh and Singh (1968), Kesavan and Morachan (1973). In nodulated legume pulses, higher yields were obtained when nitrogen was applied to the extent of 120 kg ha^{-1} or more (Durante and Carpne 1981).

Srivastava and Srivastava (1997) found that application of higher dose fertilizer nutrients (N, P and K) to pigeonpea intercropped with mungbean and urdbean recorded higher grain yield and available nitrogen in soil. Gangwar *et al.* (1998) indicated that 8.25, 1.03 and 5.65 kg of nitrogen, phosphorus and potassium are required to produce one quintal of pea seed. Beneficial responses on different vegetative growth parameters in peas due to application of N and P_2O_5 were noticed by various workers (Singh and Tripathi, 1994; Srinivas and Naik, 1990 and Singh *et al.*, 1987). Kale *et al.* (1997) found that the fertilizer dose of 75 kg N and 150 kg P_2O_5 ha^{-1} was found optimum for getting more vegetative growth and highest yield of quality pods.

Application of 20 kg N ha^{-1} with rhizobium appeared as a compromising in recording nodule parameters and vegetative growth of pigeonpea (Malipatil and Padashety (1997). Application of 20 kg N ha^{-1} and Rhizobium inoculation significantly increased the number of nodules and dry weight of nodules per plant, relative growth rate and blackgram grain yield (Sharma *et al.,* 1999). Similar trend of results was also observed by Kaushik *et al.* (1993), Naidu and Ram (1996) and Sudhakar *et al.*(1998). Nitrogen application and rhizobium inoculation play an important role in relation to yield. The successive levels of nitrogen progressively increased the grain yield of blackgram. Maximum seed yield of blackgram was obtained with 20 kg N ha^{-1} (Panwar *et al.*, 1977.; Kaushik *et al.*, 1993; Naidu and Ram, 1996; and Nagre *et al.*, 1991).

Increase in dose of nitrogen from 0 to 120-kg ha^{-1} resulted in significant increase in all yield contributing factors and peas yield (Table 3). Split application of 50% N as basal + 50% N at branching proved to be the most effective mode of application to french bean (Ghosal *et al.*, 2000).

Phosphorus: Phosphorus is the second most critical plant nutrient overall, but for pulses it assumes primary importance owing to its important role in root proliferation and thereby atmospheric nitrogen assimilation. Phosphorus is involved in metabolic and enzymatic reaction and is a constituent of ATP and ADP (Singh and Ali, 1994). Response to applied P to the tune of 17-26 kg P ha^{-1} has been observed in most of the pulse crops on low to medium available P soils (Ahlawat and Massod Ali, 1993). Chickpea is more efficient than other pulses in taking up P from soil, as it secretes more acid which helps in solubilizing Ca-P. The response to applied P varies considerably in pigeonpea (17-43 kg) depending upon the P status of soil.

Dubey *et al.* (1990) found that application of 75 kg P_2O_5 ha^{-1} improved the grain and straw yield of chickpea followed by 50 kg P_2O_5 ha^{-1}. Sonboir and Sarawgi (1998) studied that 60 kg P_2O_5 ha^{-1} along with phosphobacteria and rhizobium increased the yield by 68.12 per cent over control in chickpea. This study was confirmed by Mukherjee and Rao (1999) in chickpea, Modak *et al.* (1993) in pigeonpea and Bahl and Arora (1991) in soybean. There was no significant yield difference between P_{30} and P_{60} in cowpea and hence 30 kg P ha^{-1} was adequate to get maximum yield (Okeleye and Okelana, 1997).

Jain *et al.* (1999) found that increase in P levels from 30 to 60 kg ha^{-1} increased the seed yield and protein content and 60 kg ha^{-1} showed marked increase over 30 and 45 kg ha^{-1} (Table 4). They also observed that biofertilizer (Rhizobium + PSB) inoculation with 60 kg P_2O_5 ha^{-1} gave the highest seed yield. These results are in close conformity with Somani *et al.* (1990).

Duraisamy and Mani (2000) and Prabakaran *et al.* (1999) showed that application of 40 kg P_2O_5 ha^{-1} as rock phosphate combined with phosphobacteria and VAM produced increased grain and straw yield of horsegram in Ragi-Horsegram sequence.

Potassium: Potassium is rarely applied to pulse crops because of high content of K in the soils particularly in soils which have high K-bearing clay minerals like illite (Pasricha and Bahl, 1996). The application of potassium regulates the utilization of other nutrients in the plant system. Singh *et al.* (1992) found that super imposition of K at all the combinations of N and P improved the yield of pigeonpea considerably. Muhund Joshi and Rudraradhya (1993) proved that seed yields of soybean can be increased by increasing the potassium dosage from 25 to 75 kg ha^{-1} coupled with increase in nitrogen dose from 25 to 50 kg ha^{-1} (Table 5).

George *et al.* (1981) recorded highest grain yield of blackgram at 30 kg K_2O ha^{-1}. Singh and Badhoria (1985) found that in pot experiments, the application of 7.5 ppm K in medium K status soils increased the grain and straw yield of lentil. In a study on alluvial soils of Varanasi, Ali (1985) reported 25 per cent

Table 3. Effect of different levels of nitrogen on yield and yield attributing parameters of peas

N levels ($kgha^{-1}$)	Number of pods/plant	Number of grains/pod	1000 grain weight (g)	Yield ($t\ ha^{-1}$)
0	9.90	5.80	45.80	2.03
40	12.95	6.25	47.30	2.71
80	15.04	6.80	51.40	2.93
120	15.61	6.80	57.20	3.16
CD (P = 0.05)	0.38	0.13	0.85	0.62

Source :Singh and Singh (2000)

Table 4. Seed yield and protein content of chickpea as influenced by phosphorus and biofertilizer application

Treatments	Seed yield ($t\ ha^{-1}$)	Protein content (%)
Control	0.70	20.2
30 kg P_2O_5 ha^{-1}	1.03	20.2
45 kg P_2O_5 ha^{-1}	1.13	20.4
60 kg P_2O_5 ha^{-1}	1.37	20.9
30 kg P_2O_5 ha^{-1}+ Rhiz.	1.10	20.8
30 kg P_2O_5 ha^{-1} + PSB	1.19	20.8
30 kg P_2O_5 ha^{-1} + Rhiz.+PSB	1.31	21.1
45 kg P_2O_5 ha^{-1} + Rhiz.	1.20	21.2
45 kg P_2O_5 ha^{-1} + PSB	1.28	21.0
45 kg P_2O_5 ha^{-1} + Rhiz.+PSB	1.44	21.0
60 kg P_2O_5 ha^{-1} + Rhiz.	1.39	21.9
60 kg P_2O_5 ha^{-1} + PSB	1.46	21.8
60 kg P_2O_5 ha^{-1} + Rhiz.+PSB	1.63	22.4
CD (P=0.05)	0.20	0.34

Rhiz – Rhizobium, PSB – Phosphate solubilizing bacteria
Source : Jain *et al.*(1999)

Table 5. Response of soybean to differential dosages of N and K

Treatments	Grain yield ($t\ ha^{-1}$)
25 kg N ha^{-1}	
25 kg K_2O ha^{-1}	3.58
50 kg K_2O ha^{-1}	3.68
75 kg K_2O ha^{-1}	3.48
Mean	3.58
50 kg N ha^{-1}	
25 kg K_2O ha^{-1}	4.13
50 kg K_2O ha^{-1}	4.27
75 kg K_2O ha^{-1}	4.53
Mean	4.31
CD (P = 0.05)	0.16

Source : Muhund Joshi and Rudraradhya (1993)

increase in yield of field pea with 25 kg K_2O ha^{-1}. Chickpea, which is grown on a sizable area also found to respond to moderate application of K in Punjab soils. The results of 34 experiments revealed a significant response of gram crop to the application of 15 kg K_2O ha^{-1} in both medium and high K soils and recorded maximum response in medium soils. The response on medium and high K soils per kg K_2O applied was 18.0 and 9.8 kg grain respectively. Jeyarami Reddy *et al.* (2000) indicated that foliar application of NAA 20 ppm + KNO_3 0.5 per cent significantly increased seed yield of pigeonpea over control treatment.

Sulphur: Like N, P and K, S is also needed in large amount by pulse crops. Sulphur deficiency is common under intensive cropping systems due to use of high analysis sulphur free fertilizers (e.g. Urea and Diammonium phosphate). Tiwari *et al.* (1984) reported S deficiency in 90 districts which cover about 30 million hectare area. The deficiency of sulphur is more pronounced in pulses than cereals due to comparatively higher need of the former for producing grain. In multilocation trials under AICPIP during 1991-94, pigeonpea responded favourably to 40 kg S ha^{-1} whereas chickpea, lentil, urdbean and mungbean showed significant response upto 20 kg S ha^{-1} (Table 6). The mean response of pigeonpea, chickpea, lentil, urdbean and mungbean at this level of S was 392, 476, 450 and 166 and 194 kg ha^{-1} respectively (Ali and Singh, 1995). Higher nodulation, nitrogenase activity and seed yield in pea with soil application of 40 kg S ha^{-1} has also been reported by Kasturi (1995). Results of multilocation trials of AICPIP showed that different sources of sulphur i.e., gypsum, pyrite and single super phosphate were almost identical in their efficacy (Ali and Singh, 1995). Chickpea require higher amount of sulphur for their yield and quality (Thakur *et al.*, 1989; Singh and Ram, 1992). Application of 40 kg S ha^{-1} significantly increased the grain and straw yield of chickpea and thereafter decreased at 60 kg S ha^{-1} (Tripathi *et al.*, 1997) (Table 7). Similar findings were reported by Srinivasan *et al.* (2000) in blackgram.

Application of Sulphur @ 25 kg ha^{-1} along with other recommended fertilizers increased the soybean yield (Table 9) and in each year, an average of 11.8% increase was observed (Shrivastava *et al.*, 2000; Raghuwanshi *et al.*, 1997). Inoculation with phosphate solubilising bacteria and rhizobium in the presence of recommended fertilizer reached significant yield level. Similar results were reported by Pramilarani and Kondadaramaiah (1997).

Table 6. Productivity (kg ha^{-1})of different pulse crops as influenced by sulphur application

Pulse Crops	No.of locations	Seed yield (t ha^{-1})		
		Control	20 kg S ha^{-1}	40 kg S ha^{-1}
Chickpea	5	0.14	0.19	0.19
Lentil	3	0.10	0.15	0.15
Pigeonpea	6	0.12	0.14	0.15
Urdbean	3	0.08	0.10	0.10
Mungbean	3	0.10	0.12	0.17

Source : Ali and Singh (1995)

Table 7. Effect of different sulphur levels on cowpea yield

S levels (kg ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
0	2.16	3.16
20	2.47	3.56
40	2.62	3.80
60	2.56	3.72
CD(P=0.05)	0.064	0.087

Source : Tripathi *et al.* (1997)

Table 8. Contribution of micronutrients in increasing the productivity of different pulse crops

Micronutrients	Dose/ha	Crop	Increase over control (%)	Reference
Zinc	25 kg $ZnSO_4$	Chickpea	22.2	Kushwaha (1997)
	10 ppm $ZnSO_4$	Lentil	54.3	Mishra and Tewari (1998)
	15 kg $ZnSO_4$	Pigeonpea	16.4	Kushwaha (1993)
	25 kg $ZnSO_4$	Urdbean	20.1	
Boron	10 kg Borax	Chickpea	33.8	Kushwaha (1997)
	10 kg Borax	Pigeonpea	4.1	
Molybdenum	1 kg sodium molybdate	Chickpea	5.8	Khushwaha (1997)
	1 kg Sodium molybdate	Pigeonpea	18.2	Mishra and Ali (1998)
	1.2 kg Sodium molybdate	Mungbean	33.5	
Iron	10 kg $FeSO_4$/ ha	Lentil	17.6	Singh *et al.* (1985)
	1 kg Fe (Chelated)	Pigeonpea	6.2	

Table 9. Effect of rhizobium inoculation on dry weight of nodules, grain yield and protein content of blackgram

Rhizobium strains	Dry weight of nodules (mg plant^{-1})	Grain yield (t ha^{-1})	Protein (%)
No inoculation	110.16	0.97	21.89
IARI, New Delhi strain	129.16	1.09	22.21
Hisar strain	127.16	1.09	22.14
Shimla strain	151.0	1.24	22.98
Ludhiana strain	147.5	1.19	22.62
Rajasthan strain	141.0	1.24	22.93
Local strain	166.16	1.30	23.99
Moong culture strain	150.66	1.09	22.72
Jabalpur strain	147.00	1.07	22.31
Ranchi strain	134.33	1.08	22.33
CD (P = 0.05)	5.92	0.07	NS

Source : Sharma *et al.* (1999)

Micronutrients: The high intensity cropping through improved production technology and use of high analysis fertilizers have rendered the soils prone to deficiencies of single or multiple micronutrients (Dwivedi *et al.*, 1990 and Singh and Sekhon, 1993). Pulse crops respond well to application of micronutrients like Zn, B, molybdenum and iron under deficient conditions. The beneficial effects of Zn, B, Mo, etc., applications to soybean were evidenced in recent literature (Devarajan and Palaniappan, 1995 and Dhane and Shukla, 1995). A summarised statement of response of different micronutrients to pulse crops have been given in Table 8.

Pulses do have specific need for some of the nutrients for specific activity. In chickpea, application of 25 kg $ZnSO_4$ ha^{-1} improved, nodulation, root growth and yield (Singh and Gupta, 1986) and also increased uptake of Zn, P and Fe (Dravid and Goswami, 1987). Khushwaha (1997) also observed favourable response of zinc (25 kg $ZnSO_4$ ha^{-1}), boron (10 kg borax ha^{-1}) and molybdenum (1 kg sodium molybdate ha^{-1}) in chickpea and pigeonpea. Further he observed that combined application of Zn, B and Mo did not improve the yield over application of boron alone. Srivastava (1993) found increased number of nodules plant^{-1}, nodule dry weight, nitrogenase activity and bacterial count in soil and grain yield of pea due to application of 0.5 kg Mo ha^{-1}.

Zinc is known to be involved in

nitrogen fixation through nodule formations (Balusamy *et al.*, 1996). In soybean, critical zinc level concentration for full bloom stage was 10 ppm (Bell *et al.*, 1995). The P:Zn ratio above 130 and below 61 might be detrimental to plant growth (Gupta and Balwant Singh, 1996). Use of zinc oxide at 20 kg ha^{-1} significantly increased the growth and yield of soybean (Singh *et al.*, 1986). Growth and yield of soybean were increased due to zinc application @ 5 kg ha^{-1} (Bisht and Chandel, 1996; Saxena and Chandel, 1997), 15 kg ha^{-1} (Gupta and Vyas, 1994) and 25 kg Zn ha^{-1} (Tomar *et al.*, 1991). The yield of soybean also indicated the most effective nature of soil application. Foliar spray of $ZnSO_4$ do not always increase the yield of pulses as observed by Dwivedi *et al.* (1990) in soybean.

Application of zinc, boron, molybdenum, NPK and FYM in combination increased the soybean yield by 181.9 per cent. Foliar application of combined micronutrients at 45^{th} day of crop growth viz., at pre-flowering stage of soybean crop in an Inceptisol enhanced the grain yield and dry matter production (Thiageshwari and Ramanathan, 1999).

Biofertilizers: Biofertilizers have major role in nitrogen assimilation and phosphorus solubilization and thereby bringing sustainability in soil fertility and pulse production. Pulses fix atmospheric nitrogen through root-rhizobium symbiosis which needs to be fully exploited. However, the quantum of nitrogen fixed by different pulse crops is influenced by the native population of bacteria, moisture availability, organic matter content of the soil, soil reaction etc. The population of native rhizobia is one of the important factor. Soil analysis of 506 locations under AICRP experiments indicated 70 per cent soil samples having medium to low bacterial population. Multilocational studies conducted under AICPIP indicated 10-15 per cent yield increase due to seed inoculation with rhizobium culture under varying agro-ecological conditions (Chandra and Ali, 1986).

Various investigations revealed that multistrain inoculation of rhizobium significantly increased the dry matter yield and N content in mungbean (Pandher *et al.*, 1991) and Lentil (Podder, 1994). Poonam Sharma and Khurana (1997) confirmed that single strain inoculation increased the soybean grain yield by 10.4 per cent over control and multistrain inoculation by 19.3 per cent over control. Tilak and Dwivedi (1991) found significant increase in VAM colonization, nodules per plant, dry weight of nodules and nitrogenase activity of chickpea with *Glomus versiforme* inoculation. Dual inoculation with rhizobium and VAM improved nodulation and yield of lentil. Studies on the efficacy of biofertilizer on nodulation and yield of lentil revealed that inoculation of seed with rhizobium and VAM improved number of nodules per plant, dry weight of nodules and seed yield under Delhi conditions on sandy loam soils (Reddy, 1992) and in greengram (Balachandar and Nagarajan, 1999).

Sharma *et al.* (1999) found that highest yield of blackgram was noticed in local strain of rhizobium with 20 kg N ha^{-1} (Table 9). Application of nitrogen and rhizobium inoculation significantly increased the nodule parameters and grain yield. Slight improvement in protein content was observed over control.

Combined inoculation of bradyrhizobium and phosphobacteria was proved to be better than individual inoculations and combined inoculation with FYM + superphosphate registered higher root length, shoot length, nodule number and yield of soybean(Sherin *et al.*, 1998)

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