Maximising Yield of Cowpea through Soil Test-Based Nutrient Application in Terai Alluvial Soils

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Highest cowpea yields were obtained when N, P, and K were applied at rates 25% higher than the soil test-based optimum rate, keeping S, Zn, and B at their optimum levels. Omission of all the limiting nutrients was found to reduce yields at varying levels. Farmers' field validation of on-station results showed significant yield improvement compared to farmers' practice and the State recommendation.

Cowpea (*Vigna unguiculata* L.) is one of the important kharif pulses grown in India. It is a warm season crop, well adapted to many areas of the humid tropics and subtropical zones. Cowpea is tolerant to heat and dry conditions, but is intolerant to frost (Davis et al., 2000). The crop is grown from March to April and is harvested between June and July depending upon its end use. Incorporation of cowpea as a legume in crop sequences enriches soil fertility and provides a dense soil cover to check wind erosion and evapo-transpiration loss of soil water. It is grown throughout India for its long, green vegetable pods, seeds, and foliage for fodder.

In India, cowpea is grown on about 0.5 million ha with an average productivity of 600 to 750 kg grains/ha. Cowpea is highly responsive to fertiliser application and the dose of fertiliser depends on the initial soil fertility and moisture availability (Ahlawat and Shivakumar, 2005). Although cowpea is a legume, it still responds to a small application of starter N. Depending on soil status, application of P at 30 to 50 kg P_2O_5/ha was found optimum in several studies (Chauhan, 1972; Kumar and Singh, 1990). Response to applied K has not been uniform, but application of NPK at 25-50-25 kgN-P_2O_5-K_2O/ha was found optimum by Maharudrappa and Sharanappa (1990). This study was initiated to explore the possibility of improving productivity of cowpea through yield target-based fertiliser application in the Terai soils of North Bengal.

The field experiment was conducted at the University farm at Pundibari, West Bengal, for two consecutive seasons. Soil fertility was determined from random soil samples (0 to 15 cm) from the experimental field following the Agro Services International (ASI) analytical methods (Portch and Hunter, 2002). Before the start of the experiment, a yield target-based recommendation for a target grain yield of 1 t/ha was developed for cowpea. The experiment was set up in a randomized complete block with 12 treatments and four replications. The treatments were based on the full soil test-based fertiliser recommendation of 30 kg N, 80 kg P_2O_5, 80 kg K_2O, 35 kg S, 8 kg Zn, and 1.5 kg B/ha, which was considered as the OPT. The first six treatments included the OPT and subsequent omission of P, K, S, Zn, and B from the OPT. Treatment T_7 amounted to 125% of the OPT where three major nutrients were applied at 25% higher than that of the OPT rate and the rates for S, Zn, and B where kept at the OPT level. Treatments T_8 to T_{12} were the corresponding omission treatments at the 125% OPT level. All the nutrients were applied basally. Uniform cultural practices and plant protection measures were used in all treatments. Harvesting was done at green pod stage to obtain the treatment-wise yields.

Abbreviations and notes: OPT = optimum; SR = State recommendation; STB = best soil test-based recommendation; FFP = farmers' fertilization practice; N = nitrogen; P = phosphorus; K = potassium; S = sulphur; Zn = zinc; B = boron; CD = Critical Difference, equivalent to Least Significant Difference.

Table 1. Effect of nutrients on yield of cowpea.

Treatments	---- Grain yield, kg/ha ---- First year	Second year	Mean	#Δ yield, kg/ha	% yield loss
T_1 (OPT)	1,102	1,123	1,113	-	-
T_2 (OPT-P)	807	965	886	227	20
T_3 (OPT-K)	944	954	949	164	15
T_4 (OPT-S)	944	988	966	147	13
T_5 (OPT-Zn)	670	890	780	333	30
T_6 (OPT-B)	1,118	1,179	1,149	-36	-3
T_7 (125% OPT)	1,108	1,705	1,407	-	-
T_8 (125% OPT-P)	817	855	836	571	40
T_9 (125% OPT-K)	919	978	949	458	32
T_{10} (125% OPT-S)	1,010	1,046	1,028	379	27
T_{11} (125% OPT-Zn)	1,042	1,025	1,034	373	26
T_{12} (125% OPT-B)	1,108	1,159	1,134	273	19
CD (p = 0.05)	390	530	-	-	

#Δ yield = Yield of OPT – yield of omitted nutrient treatment.

Table 2. Nutrient uptake expressed as kg/t of cowpea grain yield.

	N	P_2O_5	K_2O	S	Zn	B
Min	147	13	102	8	0.2	0.5
Max	195	28	157	27	0.7	1.1
Mean	169	18	125	14	0.4	0.8

Farmers' field trials in the third year compared the best soil-based treatment from the on-station trial with the state recommendation and farmers' fertilisation practice to assess the advantage of adopting soil test based fertilisation practices. Five farmers were selected from different villages under *Terai* conditions in the plains of Darjeeling district, all of Jalpaiguri district, and the upper region of CoochBehar district in West

Table 3. Farmers' field validation of on-station trial results (kg/ha).

Treatments	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Mean
State Recommendation (SR)	1,120	1,130	1,100	1,080	1,080	1,100
Best Treatment (STB)	1,520	1,530	1,540	1,550	1,530	1,530
Farmers' Practice (FP)	920	920	900	920	910	910
CD (p = 0.05)	130	2	22	12	8	
CV (%)	0.48	0.08	0.84	0.46	0.29	

Table 4. Economics of production of cowpea as influenced by different treatments in farmers' fields.

Treatments	Farmers	Cost of cultivation/ha, Rs.[1]	Yield, q/ha[2]	Total benefit[3]	Net benefit, Rs.
	F_1	14,742	11.16	17,856	3,113
	F_2	14,742	11.28	18,048	3,305
SR	F_3	14,742	11.04	17,664	2,921
	F_4	14,742	10.84	17,344	2,601
	F_5	14,742	10.81	17,296	2,553
	F_1	15,906	15.21	24,336	8,429
	F_2	15,906	15.34	24,544	8,637
STB	F_3	15,906	15.38	24,608	8,701
	F_4	15,906	15.49	24,784	8,877
	F_5	15,906	15.26	24,416	8,509
	F_1	14,134	9.19	14,704	569
	F_2	14,134	9.18	14,688	553
FFP	F_3	14,134	9.02	14,432	297
	F_4	14,134	9.18	14,688	553
	F_5	14,134	9.12	14,592	457

[1] Cost of cultivation = Fixed costs (See Table 5) + treatment-wise variable costs including: DAP (Rs.13/kg), KCl (Rs.7/kg), Sulfex or wettable S (Rs.65/kg), Zn-sulphate (Rs.40/kg), borax (Rs.40/kg).
[2]Multiply by 100 to get kg/ha
[3]Based on Rs.1,600 per quintal.

Bengal. The entire region is made up of alluvium laid down by the Himalayan Rivers such as the Teesta, Torsha, Jaldhaka, and other small rivulets. The Teesta has divided the area into two parts – the western part is known as the Terai and the eastern part as the Dooars. The plant and soil samples at harvest were analysed for nutrient concentration and uptake at maturity following standard procedures (Jackson, 1967).

The average two-season grain yield of cowpea (cv. Local) varied from 780 kg/ha to 1,407 kg/ha **(Table 1)**. Maximum yield of cowpea was obtained at 125% of the OPT nutrient application rate (T_7). Omission of nutrients from the OPT caused a yield loss that varied between 13 to 30%. Yield loss was highest with exclusion of Zn from the OPT followed by P, but K and S omission had a similar impact on yield. Yield loss was much higher with omission of nutrients from the 125% OPT treatment and yields were most affected with P omission (571 kg/ha) followed by comparable yield losses in the K, S, and Zn omission plots. Omission of B from the fertilisation schedule did not impact yield in the first year. Although this may be surprising considering the general deficiency of B in Terai soils, it was likely due to application of B in the previous crops in the sequence – which was probably enough to sustain yield of about 1,100 kg/ha. This scenario changed in the second year of experimentation as yield approached 1,700 kg/ha at 125% of the OPT rate **(Table 1)** where yield was seriously hampered due to omission of B. Johnston et al. (2009) recently argued that addition of high rates of N, P, and K can stimulate deficiency of a secondary or micronutrient that was indicated to be adequate according

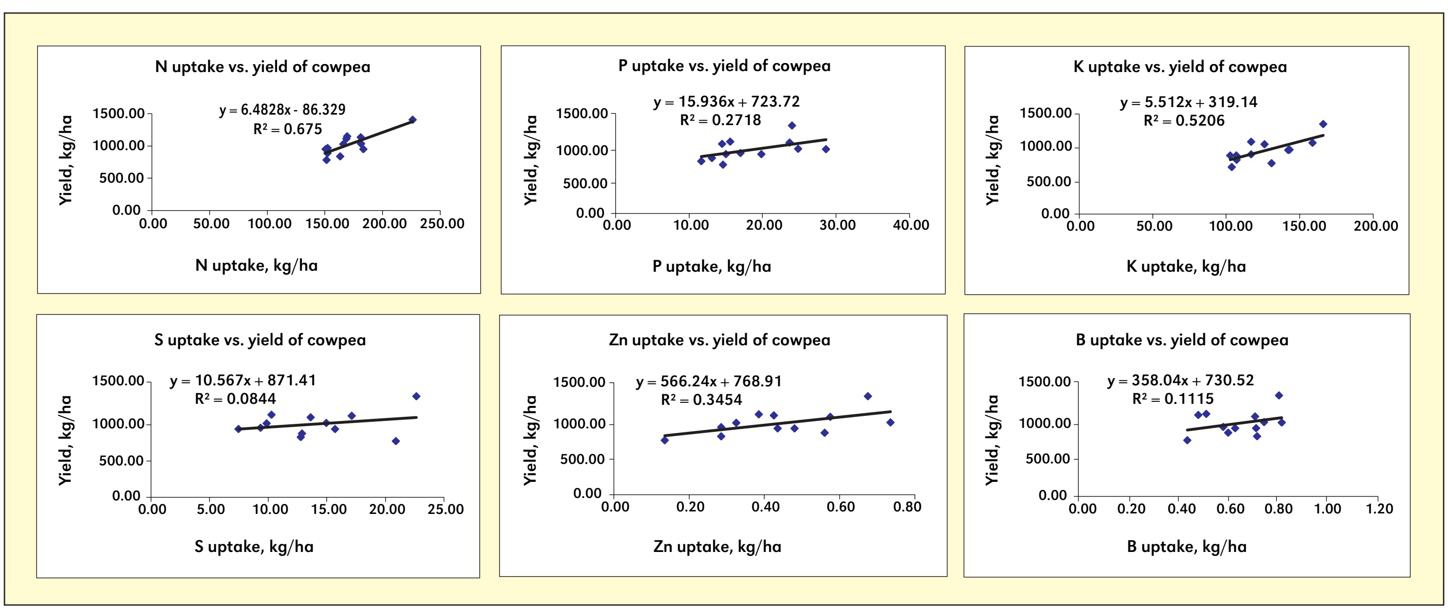

Figure 1. Interrelations between grain yield and uptake of nutrients in cowpea.

to soil testing. This experiment showed that the native B was sufficient to support a yield of about 1,100 kg/ha, but was inadequate to support 1,700 kg/ha. This suggests that the sufficiency/deficiency status of a particular soil nutrient is a dynamic parameter that varies with the yield target and this must be considered while formulating the fertilisation schedule for any crop.

The average uptake of nutrients by cowpea varied from 151 to 226 kg/ha for N, 12 to 28 kg/ha for P_2O_5, 103 to 159 kg/ha for K_2O, 8 to 23 kg/ha for S, 0.14 to 0.74 kg/ha for Zn, and 0.55 to 1.0 for B. The correlation between nutrient uptake and grain yield was poor in the first year (data not shown), but improved significantly in the second year **(Figure 1)** probably due to better utilisation of nutrients in the experimental plot that was kept fallow for 2 years before the start of the experiment. Significant correlation between yield and uptake of nutrients suggests that an appropriate range and mean uptake of nutrients per tonne of grain yield are provided in **Table 2**.

The best treatment obtained in the on-station trial was validated and compared against the current SR and FP in farm fields. Results showed that the average grain yield in the farmers' fields varied from 910 to 1,530 kg/ha depending on the treatment. The yield advantage of the best treatment was about 400 kg/ha over the SR and about 600 kg/ha over FP **(Table 3)**. Economics of production, calculated on the basis of fixed cost and treatment-wise variable cost **(Tables 4 and 5)**, revealed that the yield advantage in the best treatment translated to average extra benefit of Rs.5,000 over the SR and Rs.8,000 over the existing FFP.

Soil testing and yield target-based fertiliser recommendations significantly improved the yield of cowpea under the Terai alluvial situation of West Bengal. Along with P and K, S, Zn, and B significantly influenced yield. Further research is required to refine nutrient application rates to ensure profitability is being maximised with the nutrient treatments. Both on-station and on-farm trials suggested the need for integration of micronutrient and secondary nutrient application with macronutrients to achieve high yield of cowpea. BC INDIA

Table 5. Outline of fixed costs for cowpea production.

Fixed cost Items	Rate, Rs.	Total, Rs.
Land preparation		
a. Tractor ploughing	160/hr	640
b. Laddering by bullock	75/ploughing	150
Fertilizer application, sowing, and layout preparation	75/man unit	1,126
Seed materials	250/kg	5,000
Irrigation	200/irrigation	200
Plant protection measure	100	100
Harvesting and threshing	75/man unit	751
		Total 7,967

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