

Yield target approach under Integrated Nutrient Management for assessing fertilizer requirements of Mustard in inceptisol

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ABSTRACT

A field experiment was conducted in Jharigawan, Naugarh block of Chandauli district during 2023–2024 to evaluate the relationships between yield, soil, plant, and fertilizer nitrogen, phosphorus, and potassium (NPK) levels, as well as to calibrate optimal fertilizer doses for achieving specific yield targets. Fertilizer adjustment equations were developed by the All India Coordinated Research Project at the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The findings demonstrated that the targeted mustard yield of 20 quintals per hectare was successfully achieved using the targeted yield concept, specifically soil test crop response (STCR) technology. Yield improvements of 30.84% and 31.90% were recorded at the first and second experimental locations, respectively, compared to traditional farmer practices, which yielded 15.50 and 15.20 quintals per hectare. The highest net returns were observed in the STCR treatment, with Rs. 48,490.50 at the first location and Rs. 48,680.50 at the second location. This technology also helped maintain soil nutrient availability. Therefore, applying plant nutrients based on soil test values (STCR technology) is crucial for maximizing returns and sustaining soil fertility. The fertilizer doses were validated for achieving the 20 quintals per hectare yield target in farmers' fields, with yields within a 10% deviation, confirming the superiority of soil test-based fertilizer recommendations. This approach could be extended to regions with similar soil and agro-climatic conditions worldwide to enhance mustard yields.

Key words: Soil test crop response, target yield, economics, mustard and B:C ratio.

INTRODUCTION

Mustard is an annual, cool-season cash crop with a short growing season, often cultivated in rotation with small grains. The term "mustard" refers to two closely related species within the Brassica family: yellow mustard (*Sinapis alba* L., also known as *Brassica hirta* L.) and Indian or oriental mustard (*Brassica juncea* L.). Native to the temperate regions of Europe, mustard has historical roots in this region. However, mustard production shifted to North America as a specialty crop during World War II, following disruptions in supplies from Western Europe. Today, Nepal, Russia, and Canada are the largest global producers of mustard. Mustard and rapeseed are also used as cover crops due to their ability to suppress certain soil-borne pests. When green mustard plants are incorporated into the soil, their decomposition releases glucosinolates, which break down into compounds believed to have biofumigant

properties. Mustard seeds are primarily used in the food and condiment industries, either as ground seeds or oil. Yellow mustard, known for its mild flavor and lower oil content, is widely used to make "mild" prepared mustard for table use and as dry ground mustard in mayonnaise, salad dressings, and sauces. The flour from yellow mustard serves as an excellent emulsifier and stabilizer for processed meats. Brown and oriental mustard varieties are used for making "hot" table mustard, as well as for oil and spices. Additionally, the edible leaves and flowers of brown mustard are consumed as salad greens, while its seeds are pressed for mustard oil. Mustard is one of the oldest recorded spices, with mentions dating back to 3000 BC (Mehra, 1968). Originally known as a condiment, the term "mustard" derives from the Latin word *mustum*. Over time, different combinations of mustard seeds have led to the development of various mustard varieties worldwide. Beyond its use as a spice, mustard serves multiple purposes, including as a

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vegetable, oilseed crop, green manure, and fodder.

The targeted yield approach, introduced by Troug (1960) and Ramamoorthy (1967), optimizes fertilizer application and maintains soil fertility through soil testing and crop response analysis (STCR). This approach has been widely adopted in India since 1967 under the All India Coordinated Research Project on STCR. By employing multiple regression equations, it evaluates nutrient interactions to ensure sustainable crop production. To further enhance soil quality and boost yields, the integration of chemical fertilizers with organic manures, as part of the Integrated Plant Nutrient System (IPNS)-based STCR approach, is recommended.

MATERIALS AND METHODS

On-farm testing trials were carried out during the Rabi season of 2023–24 in Hadahi village, Naugarh block, Chandauli district, Uttar Pradesh, India, on alluvial soils classified as Inceptisols. The initial soil properties of the study area are summarized in Table 1. Soil samples were collected from a depth of 0–15 cm, air-dried, sieved through a 2 mm mesh, and analyzed for their physical and chemical characteristics following the methods described by Jackson (1973). Available nitrogen was determined using the alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus was measured using the Olsen method (Olsen *et al.*, 1954), and available potassium was analyzed using the ammonium acetate method (Hanway and Heidal, 1952), as outlined by Jackson (1973).

Table 1: Initial soil physico-chemical properties of the experimental area

Locations	Physico chemical properties			Fertility status		
	pH	EC (dSm ⁻¹)	OC (%)	Av-N (kg ha ⁻¹)	Av-P (kg ha ⁻¹)	Av-K (kg ha ⁻¹)
Location-I	7.42	0.39	0.48	213.00	15.00	182.00
Location-II	7.49	0.36	0.48	208.00	15.60	180.00

*Av = Available

The study included five fertilizer treatments: Control, Farmer's Practice, General Recommended Dose of Fertilizer (GRDF), and Soil Test Crop Response (STCR) for a targeted yield of 20 quintals per hectare of mustard. The test crop used was the mustard variety *Ashirbad*, with the yield target set based on the potential productivity of the variety. Pre-sowing soil samples were analyzed using standard procedures to determine nutrient status. A detailed soil resource inventory of the study area is provided in Table 1. Fertilizer prescription equations for mustard under the STCR-Integrated Plant Nutrient Management System (STCR-IPNMS), specifically designed for the eastern plain zone of Uttar Pradesh, were developed by Varma *et al.* (2017) and are presented below:

Nitrogen dose (kg ha⁻¹) = 12.27*T-0.56SN-0.09*ON

Phosphorus dose (kg ha⁻¹) = 3.03*T- 1.34* SP-0.10*OP

Potassium dose (kg ha⁻¹) = 3.94*T-0.21*K-

0.22*OK

Where, FN, FP₂O₅ and FK₂O are fertilizers N, P₂O₅ and K₂O in kg ha⁻¹, respectively; T=Grain yield target in q ha⁻¹; SN, SP and SK are available N, P and K through soil in kg ha⁻¹, respectively; ON, OP and OK are N, P and K supplied through FYM in kg ha⁻¹. The treatments imposed were as follows: (i) Control, (ii) Farmer's Practices, (iii) General Recommended Dose (iv) STCR based fertilizer dose for an yield target of 20 q ha⁻¹ with 2 t ha⁻¹ FYM. Based on the initial soil test values of available N, P and K and the quantities of N, P₂O₅ and K₂O supplied fertilizer doses were calculated and applied for STCR treatments for various yield targets.

RESULTS AND DISCUSSION

Yield targeting of Mustard based on soil test

Follow-up trials as part of frontline demonstrations were conducted during 2023–

24 in farmers' fields, with data for each location presented in Table 2. These field experiments provided critical information on the nutrient requirements for producing one quintal of mustard grain and the percentage contributions of nutrients from soil (%CS), fertilizers (%CF), and farmyard manure (FYM). The data were used to develop fertilizer prescription equations for NPK application. The nutrient requirements

for producing one quintal of mustard grain were 6.22 kg of nitrogen (N), 0.99 kg of phosphorus (P_2O_5), and 4.25 kg of potassium (K_2O). The percentage contributions of N, P_2O_5 , and K_2O from soil, fertilizers, and FYM were 23.94%, 42.53%, and 4.02% for N; 70.45%, 21.44%, and 1.24% for P_2O_5 ; and 22.14%, 90.52%, and 4.96% for K_2O , respectively.

Table 2: Yield and economics of verification trails for mustard crop

Location - I: Name – Smt. Malti devi W/O. Sri. Mahendra, Village- Jharigawan							
T ₁ -Control	0-0-0	1245	-	-	-	-	-
T ₂ -FP	60-30-30	1550	305	21350	3518.7	17831.3	5.07
T ₃ -GRD	80-40-40	1685	700	30800	4691.6	26108.4	5.56
T ₄ -20 q ha ⁻¹	123-39-49-2	2028	783	54810	6619.4	48190.5	7.28
Location - II: Name – Sri Ranjar S/O Sri.Ram lakhan, Village- Jharigwan							
T ₁ -Control	0-0-0	1215	-	-	-	-	-
T ₂ -FP	60-30-30	1520	305	21350	3518.7	17831.3	5.07
T ₃ -GRD	80-40-40	1705	490	34300	4691.6	29608.4	6.31
T ₄ -20 q ha ⁻¹	123-39-49-2	2005	790	55300	6619.4	48680.5	7.35

Note: Mustard@Rs.70.00/kg, N@Rs.17.39/kg P_2O_5 @Rs.56.25/kg, K_2O @Rs.26.66/kg

A minor modification was made in the ready reckoner, FP: Farmers practice i.e. the fertilizer doses the farmers generally applied in the area, GRD: General recommendation of agricultural department of the district on the basis of soil test value, B: C ratio: benefit cost ratios

It was observed that the contribution of potassium from fertilizers was significantly higher compared to that from the soil. This elevated potassium efficiency might be attributed to the interaction effects of higher nitrogen and phosphorus doses, coupled with the priming effect of initial potassium applications in treated plots, which likely enhanced the release of soil potassium and increased uptake by crops (Ray *et al.*, 2000). Similar findings on the enhanced efficiency of potassium fertilizers in alluvial soils were reported for mustard by Ahmed *et al.* (2002).

The yield target of 20 quintals per hectare was achieved with relatively lower applications of nitrogen and phosphorus but higher potassium application compared to the fertilizer doses typically used in farmer practices and soil-based recommendations. For instance, in the alluvial soils of West Bengal, winter mustard yields peaked at 6.0 t/ha regardless of nitrogen levels but increased to 7.4 t/ha with higher potassium application (Tiwari, 2002). This effect is likely due to improved nitrogen use efficiency and increased nitrogen uptake by crops under higher potassium application (Marschner, 1995). In all cases, the mustard variety *Ashirbad* achieved

the yield target of 20 q ha⁻¹, as shown in Table 2. Mustard grain yields using general recommended doses (GRD) of fertilizers consistently fell short of the fixed 20 q ha⁻¹ target, aligning with the findings of Singh *et al.* (2014a) and Singh *et al.* (2015). The higher yields and response ratios at the 20 q ha⁻¹ target may be attributed to the improved efficiency of NPK fertilizers at lower yield target levels (Singh *et al.*, 2014; Singh *et al.*, 2015).

Economic Analysis

The results in Table 2 demonstrate that the 20 q ha⁻¹ yield target resulted in the highest yields and profits compared to other treatments. The average net profits recorded at Site 1 and Site 2 were Rs. 48,490.50 and Rs. 48,680.50, respectively, under the 20 q ha⁻¹ yield target treatment, followed by the general recommendation dose treatment. For efficient fertilizer utilization, other soil parameters, such as pH and organic carbon status, should also be considered, as these significantly influence soil nutrient retention and availability. Incorporating these factors is essential for developing an effective fertilizer schedule and ensuring better nutrient absorption and assimilation by plants.

Soil fertility

Post-harvest soil analysis revealed a significant buildup and maintenance of available nitrogen (SN), phosphorus (SP), and potassium (SK) in the Soil Test Crop Response (STCR) treatment compared to farmer practices and the general recommended dose (GRD). Despite higher nutrient removal due to greater yields in the STCR treatment, post-harvest soil fertility remained higher in these plots. The highest post-harvest soil nitrogen level was observed in the STCR plot for a 20 q ha⁻¹ yield target at Location 1 (Smt. Malti Devi, W/O Sri Mahendra, Village Jharigawan) with 245.00 kg ha⁻¹. Similarly, the highest post-harvest soil potassium level was recorded at Location 2 (Sri Ranjar, S/O Sri Ram Lakhan,

Village Jharigawan) with 198.00 kg ha⁻¹, and the highest post-harvest soil phosphorus level was found at Location 1 (Smt. Malti Devi, W/O Sri Mahendra, Village Jharigawan) with 23.60 kg ha⁻¹, as shown in Table 3.

The superior nutrient buildup in the STCR treatment can be attributed to the balanced application of chemical fertilizers in combination with organic manure. This integrated approach enhanced the chemical and physical properties of the soil, promoting improved and sustainable crop production (Singh *et al.*, 2019). Consistent profits, along with the maintenance of soil fertility, were achieved when fertilizers were applied based on precise yield targets over consecutive years using the STCR methodology (Singh *et al.*, 2015a).

Table 3: Post harvest soil fertility status of various treatments under different locations of Village-Jharigawan, Naugarh block in district Chandauli

Treatments	Location 1			Location 2		
	N	P	K	N	P	K
Control	210	18.4	180	210	17.1	196
Farmer's practice	219	19.3	184	218	18.3	189
GRD	238	21.7	189	228	20.1	192
STCR 20 q ha ⁻¹	245	23.6	194	232	22.0	198
CD at 5%	0.86	1.51	1.05	0.74	1.26	1.25

Where: GRD – General recommended dose and STCR-Soil test crop response

These soils, while regarded as highly fertile, are deficient in nitrogen and humus but have moderate levels of phosphorus and potassium. Post-harvest analysis showed an improvement in the available N, P, and K levels, with the highest amounts recorded under the soil test-based fertilizer recommendations. The 20 q ha⁻¹ yield target treatment resulted in the highest available nitrogen at both sites, followed by the general recommended dose treatment. The lowest nitrogen levels were observed in the control plots. The application of STCR (20 q ha⁻¹) fertilizer significantly enhanced the available phosphorus levels in the soils across both sites compared to the control. This increase in

phosphorus availability is attributed to the targeted yield treatment.

These findings suggest that fertilizer recommendations for mustard can be tailored to farmers' financial capabilities, with the targeted yield approach proving more effective than the current soil test-based method for chickpea cultivation in Inceptisol soils.

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