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The study in Chandauli district of Uttar Pradesh aimed to achieve a target yield for spinach using Soil Test Crop Response (STCR) Technology

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Abstract

In the year 2018-19, a study was conducted in five different locations within the Naugarh block of Chandauli district. The aim of the study was to examine how the use of Soil Test Crop Response (STCR) technology impacts the yield and economic aspects of spinach crop cultivation. The fertilizer adjustment equations used in this study were provided by the All India Coordinated Research Project, Institute of Agricultural Science, B.H.U., Varanasi center. The results of the study showed that when plant nutrients were applied based on the targeted yield concept using STCR technology, the desired spinach yields of 10 quintals per hectare and 12 quintals per hectare were successfully achieved. Furthermore, the study revealed that this approach resulted in maximum net returns in each of the five locations: First location: Rs. 21,923 and Rs. 29,939, Second location: Rs. 21,773 and Rs. 31,439, Third location: Rs. 22,523 and Rs. 29,189, Fourth location: Rs. 21,423 and Rs. 30,489 and Fifth location: Rs. 20,773 and Rs. 30,189. Importantly, this technology also helped maintain the availability of plant nutrients in the soil. In conclusion, to achieve the highest profits and sustain soil fertility, it is essential to apply plant nutrients based on soil test values using the STCR technology approach.

Key words: Spinach, target yield, soil test crop response and FYM etc.

Introduction

In intensively cultivated areas of India, spinach is grown so extensively that it leads to the removal of nutrients from the soil in significant quantities. This removal often exceeds the replenishment provided by fertilizers and manure, ultimately resulting in the deterioration of soil health. This decline in soil quality, coupled with diminishing total factor productivity, has been documented. Farmers, in their quest for higher yields, tend to apply excess chemical fertilizers (Dobermann *et al*. 2003)[3]. However, making informed decisions about fertilizer use requires an understanding of expected crop yields and how they respond to nutrient application (Ray *et al*. 2000) [10]. This response is influenced by factors such as the crop's nutrient requirements, the availability of nutrients from local sources, and the short- and long-term fate of the applied fertilizer nutrients. One contributing factor to lower production is the imbalanced use of fertilizers by farmers who may not be aware of the soil's fertility status and the specific nutrient needs of their crops (Ahmed *et al.,* 2002)[1]. This can lead to adverse effects on both the soil and the crop, including nutrient toxicity and deficiency. To address this issue, it is possible to provide farmers with tailored fertilizer recommendations at the micro-level, accounting for variations in soil fertility conditions and farmers' targeted yield levels. These recommendations are designed to balance the supply of primary nutrients (N, P, and K) based on crop-specific estimates and models that predict the expected yield response, taking into account nutrient interactions. These models are developed by establishing significant relationships between soil test values and the effects of added fertilizer (Ramamurthy *et al.,* 2009)[9]. In light of these considerations and the absence of Soil Test Crop Response (STCR) data for spinach in eastern Uttar Pradesh, this study was conducted to address this knowledge gap.

The goal of this study was to establish a reliable foundation for recommending fertilizer use in wheat cultivation within alluvial soil (Inceptisol) at various soil fertility levels, especially in situations where fertilizers are in short supply. The primary objective was to maximize the efficiency of fertilizer application. Additionally, the study aimed to establish a correlation between the nutrients naturally present in the soil and those introduced through inorganic sources, examining their uptake by the crops. The ultimate aim was to create a set of guidelines, utilizing the Soil Test Crop Response (STCR) model, that would enable the prudent application of fertilizers to achieve desired coriander yields. By doing so, this approach would ensure the efficient utilization of fertilizers while maintaining profitability in crop production.

Materials and Methods

The on farm testing trials were conducted in village – Persiya, block - Naugarh of Chandauli district, Uttar Pradesh, India during year *rabi*- 2018-19 on alluvial soil (Inceptisol). Soil samples (0-15 cm in depth) were collected, dried and passed through 2 mm sieve and analyzed for physico chemical properties as described by Jackson (1973)[3]. Available nitrogen, by the alkaline permanganate method (Subbiah and Asija, 1956)[14]; available phosphorus, by Olsen *et al.* (1954)[8] and available potassium, by the ammonium acetate method (Hanway and Heidal, 1952)[4] as described by Jackson (1973)[5]. Seven fertilizers treatments viz., Control, Farmers practice, General recommendation dose of fertilizer, soil test crop response (STCR) for 10 q ha^{-1} target yield, soil test crop response (STCR) for 12 q ha^{-1} target yield, soil test crop response (STCR) for target yield 10 q ha^{-1} with 2 t ha^{-1} FYM and soil test crop response (STCR) for target yield 12 q ha^{-1} with 2 t ha^{-1} FYM in spinach targeted yield were taken. The targeted yield of crop was decided as per yield potential of varieties Pusa Harit. Pre sowing soil samples were analyszed according to the standard procedures. Soil resource inventory of the study area in given in the table 1. Quantities of nitrogen, phosphorus and potassium were calculated with the help of fertilizer adjustment equations as follow.

$$FN = 1.46\,T - 0.48\,SN - 0.07\,NFYM$$

$$FP_2O_5 = 0.19\,T - 0.75\,SP - 0.04\,PFYM$$

$$FK_2O = 0.51\,T - 0.22\,SK - 0.02\,KFYM$$

Where - T = Yield target (t ha^{-1})

F.N. = Fertilizer N (kg ha^{-1})

$F.P_2O_5$ = Fertilizer P (kg ha^{-1})

$F.K_2O$ = Fertilizer K (kg ha^{-1})

SN = Soil available nitrogen (kg ha^{-1})

SP = Soil available phosphorus (kg ha^{-1})

SK = Soil available potassium (kg ha^{-1})

OFYN = Amount of Nitrogen thorough FYM (kg ha^{-1})

OFYM = Amount of Phosphorus thorough FYM (kg ha^{-1})
OFYM = Amount of Potassium thorough FYM (kg ha^{-1})

In the spinach crop, one-third of the nitrogen (N) was applied initially along with the full dose of phosphorus (P_2O_5) and potassium (K_2O) as a basal application. The remaining half of the nitrogen was then applied 27 days after sowing. For nitrogen, urea was used, single superphosphate was used for phosphorus, and muriate of potash was used for potassium. The spinach variety used in the experiment was Pusa Harit, and this same variety was employed in both the standard control (STCR) treatment and other treatments.

Table 1. 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	7.2-8.1	0.48-0.55	0.59-0.71	180.75	10.20	160.45
Location-II	6.8-8.4	0.45-0.51	0.62-0.71	181.25	10.50	161.55
Location-III	7.0-7.4	0.47-0.58	0.65-0.78	180.80	10.62	162.10
Location-IV	7.0-7.8	0.51-0.59	0.60-0.75	180.72	10.35	162.27
Location-V	7.2-8.1	0.50-0.57	0.65-0.79	182.58	10.38	162.74

Table 2. The cost of verification Crop trails for spinach

Fertilizer dose N, P_2O_5, K_2O (kgha^{-1}) & FYM (t ha^{-1}) Treatmnets	Actual mean grain yield (kg ha^{-1})	Actual mean straw yield (kg ha^{-1})	Additional yield (kg ha^{-1})	Value of additional yield (Rs.)	Cost of fertilizer (Rs.)	Net Benefit (Rs.) Over T_1	B/C ratio
Location - I: Name – Sri. , Sohanlal, Village-Persiya							
T_1-0-0-0	510	765	-	-	-	-	-
T_2-35-15-30	630	945	120	6000	2240.2	3760	1.68
T_3-50 -30- 60	740	1243	230	11500	4132.6	7367	1.78
T_4-92-22- 44-2	1060	1781	550	27500	5576.9	21923	3.93
T_5 -127- 30-64-2	1252	2141	742	37100	7160.7	29939	4.18
Location - II: Name – Anand Mohan, Village-Persiya							
T_1-0-0-0	498	822	-	-		-	-
T_2-35-15-30	610	1006	112	5600	2240.2	3360	1.50
T_3-50 -30- 60	710	1207	212	10600	4132.6	6467	1.56
T_4-92-22- 44-2	1045	1776	547	27350	5576.87	21773	3.90
T_5 -127- 30-64-2	1270	2159	772	38600	7160.72	31439	4.39

Location - III: Name – Smt. Phuleswari Devi, Village-Persiya							
T_1-0-0-0	518	777	-	-	-	-	-
T_2-35-15-30	638	957	120	6000	2240.2	3760	1.68
T_3-50 -30- 60	765	1300	247	12350	4132.6	8217	1.99
T_4-92-22- 44-2	1080	1836	562	28100	5576.87	22523	4.04
T_5 -127- 30-64-2	1245	2116	727	36350	7160.72	29189	4.08
Location - IV: Name – Smt – Shakuntala devi, Village-Persiya							
T_1-0-0-0	515	824	-	-	-	-	-
T_2-35-15-30	610	976	95	4750	2240	2510	1.12
T_3-50 -30- 60	720	1152	205	10250	4133	6117	1.48
T_4-92-22- 44-2	1055	1899	540	27000	5577	21423	3.84
T_5 -127- 30-64-2	1268	2282	753	37650	7161	30489	4
Location - V: Name – Sri. Ramlakhan, Village – Persiya							
T_1-0-0-0	538	796	-	-	-	-	-
T_2-35-15-30	647	957	109	5450	2240	3210	1.43
T_3-50 -30- 60	762	1379	224	11200	4133	7067	1.71
T_4-92-22- 44-2	1065	1928	527	26350	5577	20773	3.72
T_5 -127- 30-64-2	1285	2326	747	37350	7161	30189	4.22

Note: Spinach@Rs.50.00/kg, N@Rs.17.39/kg, P_2O_5@Rs.56.25/kg, K_2O@Rs.26.66/kg.

A miner 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

Results and Discussion

Soil characteristics

The soil type here is alluvial (Inceptisol) with a pH range between 7.52 and 7.65. The organic carbon content varies between 0.68 and 0.77. These soils have a medium level of available nitrogen (ranging from 180.72 to 182.58 kg ha^{-1}), a low to medium level of available phosphorus (ranging from 10.20 to 10.62 kg ha^{-1}), and a medium to high level of available potassium (ranging from 160.45 to 162.74 kg ha^{-1}) according to Table 1. While these soils are generally fertile, they have a deficiency in nitrogen and organic matter but are moderately supplied with phosphorus and potassium.

Yield targeting of spinach based on soil test

Experimental data on follow up trails as frontline demonstration, for each location during the period 2018-19 were conducted in farmers field and are given in Table 2. From the field experiment the basic data on nutrient requirement for producing one quintal grain yield of wheat, percent contribution of nutrients from soil (%CS) and fertilizer (%CF) were evaluated. These basic parameters were used for developing the fertilizer prescription equations under NPK alone and NPK with FYM. The nutrient requirement of N, P_2O_5 and K_2O were 0.75, 0.08 and 0.70 kg q^{-1} of grain yield, respectively. The percent contribution of nutrients from soil and fertilizers were found to be 24.74 and 33.96 for N, 29.95 and 51.22 for P_2O_5 and 45.08 and 138.51 for K_2O, respectively. It was noted that contribution of potassium from fertilizer for wheat was higher in comparison to soil. This high value of potassium could be to the interaction effect of higher doses of N, P coupled with priming effect of starter K doses in the treated plots, which might have caused the release of soil potassium form, resulting in the higher uptake from the native soil sources by the crop (Ray *et al.* 2000) [10]. Similar type of higher efficiency of potassic fertilizer was also reported for rice by Ahmed *et al.* (2002)[1] in alluvial soils and for finger millet by Kadu and Bulbule (2007)[6].

Target yield of 10 and 12 q ha^{-1} has been achieved with comparatively lower application of N and P_2O_5 fertilizers but higher application of K_2O, in comparison to doses applied in farmer's practice and soil based recommendations. As for example in the alluvial soil of West Bengal, In the winter season highest rice yield was 6.0 t/ha regardless of the N level used but could be raised to 7.4 t/ha with increased application of K fertilizers (Tiwari, 2002) [15]. This is probably due to the higher N use efficiency as well as increased N recovery by crop under increased K application (Marschner, 1995) [7].Yield targets of 40 and 50 q ha^{-1} for wheat (GD 2937) were achieved in table 2 from the expected yield targets in all the cases. In all sites, grain yields of wheat through general recommendation (GRD) of fertilizers lagged behind the yield obtained at 40 and 50 q ha^{-1} fixed target. These results accorded with the findings of Singh *et al.* (2014)[13] and Avtari *et al.,* (2010)[3]. Between the two targets tried, targeting for 50 q ha^{-1} recorded relatively higher response ratio than with 40 q ha^{-1} though it has also recorded higher yields. This might be due to the better use efficiency of applied NPK fertilizers at low yield target levels (Santhi *et al.*, 2002) [12] and Singh *et al.*, (2014) [13].

To use fertilizer efficiently, it's important to consider factors like soil pH and organic carbon levels. These factors play a significant role in how the soil retains nutrients. By taking them into account, we can develop a fertilizer schedule and nutrient supply plan that helps plants absorb and use nutrients effectively.

Conclusion

This study will create recommendations for the right amount of fertilizer to use when growing spinach. By using a yield equation that factors in soil health, we can ensure that spinach cultivation is sustainable and helps farmers make cost-effective decisions about using expensive fertilizers based on their finances and the current crop prices in the market.

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