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Research Article

Validation of soil test and yield target-based fertilizer prescription model developed for Greengram on *Alfisol*

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Abstract

The studies on STCR-IPNS for desired yield targets were conducted on Greengram crop at farmer field during 2022-2023 climate on an *Alfisol* of Tamil Nadu to verify the fertilizer prescription models over the available technology and to analyze the economics of the adoption of these models to enhance the productivity and profitability of the crop greengram. The treatments include control, blanket recommendation (100% RDF), blanket recommendation (NPK+FYM @ 12.5t ha^{-1}), soil test crop response (STCR) based fertilizer dose for a yield target of 0.8, 1.0 and 1.2 t ha^{-1}, STCR-IPNS based fertilizer dose for an yield target of 0.8, 1.0 and 1.2 t $ha^{-1}$and farmer's practice. The N, P and K fertilizer for different targets was calculated based on the initial soil test values of the respective locations. The cultivation practices were carried out periodically and the grain yield was recorded at harvest. Using the data on grain yield and fertilizer doses applied, parameters viz., per cent achievement, and response ratio (RR) were computed. The results revealed that the targeted yield has been achieved within +/-10 per cent variation proving the validity of the equations.

Keywords: IPNS; Greengram; Grain Yield; Validation; *Alfisol*

Introduction

Fertilizer is one of the key inputs for achieving the estimated food grain production of our country. The indiscriminate use of fertilizers by the farmer without knowing the crop requirement and fertility status of the soil leads to the adverse effect on soil health and crop productivity. The escalating cost coupled with increasing demand on inorganic fertilizers and depletion of soil health necessitates the safe and efficient method of fertilizer application. Greengram scientifically known as *Vigna radiata* is a plant species in the legume family and commonly called as mung bean, moong in India. India is its primary origin and is mainly cultivated in East Asia, Southeast Asia and the Indian subcontinent. It is the third important pulse crop of India grown in nearly 16 per cent of the total pulse area of the country. It contains protein rich seed with 20-25% protein and sometimes plants are cut and ploughed into the soil to enrich soil nitrogen.

India is the major producer of green gram in the world and grown in almost all the States. It is grown in about 4.5 million hectares with the total production of 2.5 million tonnes with a productivity of 548 kg/ha and contributing 10% to the total pulse production. According to Government of India 3rd advance estimates, green gram production in 2020-21 is at 2.64 million tonnes. In the marketing year 2020-21, the consumption of green gram was 22.5 lakh tonnes against the production of 21.42 lakh tonnes with the rest of the demand-supply gap was covered by importing around 1.08 lakh tones along with the opening stocks 2.10 lakh tonne.

Materials and Methods

Field experiments were conducted during Summer 2023 to validate the fertilizer prescription equation developed for Greengram (TNAU Greengram CO 8) at one location village of Dindigul district (Southern zone). The fertilizer prescription equations developed

for desired yield target of Greengram for Palaviduthi soil series are furnished below

STCR - NPK alone

FN = 9.75 T - 0.29 SN

FP_2O_5 = 12.12 T - 2.83 SP

FK_2O = 8.65 T - 0.14 SK

STCR - IPNS (NPK + FYM)

FN = 9.75 T - 0.29 SN - 0.70 ON

FP_2O_5 = 12.12 T - 2.83 SP - 0.79 OP

FK_2O = 8.65 T - 0.14 SK - 0.62 OK

Where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1} respectively. T is the yield targeted in q ha^{-1}; SN, SP and SK are soil available N, P and K in kgha^{-1} respectively; ON, OP and OK are N, P and K supplied through FYM in kg ha^{-1}.

The validation experiments were laid out in Randomised block design with three replications. The treatments imposed were as follows (i).Blanket fertilizer dose (100% RDF (25:50:25 kg N, P_2O_5 and K_2O)), (ii) Blanket + FYM @12.5tha-1, (iii) STCR based fertilizer dose for an yield target of – 0.8t ha^{-1} (iv) STCR based fertilizer dose for an yield target of-1 t ha^{-1} (v) STCR based fertilizer dose for an yield target of-1.2 t ha^{-1}, (vi) STCR-IPNS based fertilizer dose for an yield target of 0.8t ha-1, (vii) STCR-IPNS based fertilizer dose for an yield target of1 t ha-1, (viii) STCR-IPNS based fertilizer dose for an yield target of 1.2t ha-1, (ix) farmer's practice and (x) Absolute control. Initial soil samples were collected in location and analysed for alkaline $KMnO_4$-N [19], Olsen-P [9] and NH_4OAc-K [2]. The fertility status of the soil indicated that the KMnO4-N 230 kg ha^{-1}, Olsen-P 25 kg ha^{-1} and NH_4OAc-K 370 kg ha^{-1}(Table 1). Based on the initial soil test values, the fertilizer doses were calculated and applied (Table 2). The test crop TNAU Greengram CO 8 was raised during summer 2023 and the grain yield was recorded at harvest. Using the data on grain yield and fertilizer dose applied, the parameters, viz., percent achievement {(yield obtained/yield targeted) × 100} and response ratio (RR) were worked out (Response ratio=response in kg ha^{-1}/quantities of fertilizer N, P_2O_5 and K_2O applied in kg ha^{-1}). The details of fertiliser doses applied, grain yield, percent achievement, response ratio and BCR.

S. No	Properties	Value
1.	pH	8.02
2.	EC (dS m^{-1})	0.08
3.	CEC (C mol (p^+) kg^{-1})	18.6
4.	Organic carbon (g kg^{-1})	0.35
5.	Free Calcium carbonate (%)	4.17
6.	$KMnO_4$-N (kg ha^{-1})	230
7.	Olsen- P (kg ha^{-1})	25
8.	NH_4OAC-K (kg ha^{-1})	370
9.	DTPA- Zn (mg kg^{-1})	0.78
10.	DTPA- Fe (mg kg^{-1})	0.48
11.	DTPA- Mn (mg kg^{-1})	1.13
12.	DTPA- Cu (mg kg^{-1})	4.02

Table 1: Characteristics of initial surface soil sample of the experimental field.

Tr. No.	Treatment details	FN	FP_2O_5	FK_2O
		kg ha^{-1}		
T_1	Blanket (100% RDF)	25	50	25
T_2	Blanket (100% RDF) + FYM @12.5 t ha^{-1}	25	50	25
T_3	STCR - NPK alone - 0.8 t ha^{-1}	13*	26	17
T_4	STCR - NPK alone – 1 t ha^{-1}	31	50	35
T_5	STCR - NPK alone– 1.2 t ha^{-1}	38**	74	38**
T_6	STCR-IPNS - 0.8 t ha^{-1}	13*	25*	13*
T_7	STCR-IPNS - 1 t ha^{-1}	13*	42	15
T_8	STCR-IPNS - 1.2 t ha^{-1}	26	66	32
T_9	Farmer's practice	-	-	-
T_{10}	Absolute control	-	-	-

Table 2: Treatment structure for test crop experiment.

Results

Grain yield

The highest grain yield among the four locations were recorded in the treatment STCR-IPNS 1.2 t ha^{-1} (1270 kg ha^{-1}) followed by STCR -NPK alone -1.2 t ha^{-1} (1153 kg ha^{-1}), STCR -IPNS - 1.0 t ha^{-1} (1067 kg ha^{-1}) and STCR -NPK alone -1.0 t ha^{-1} (1009 kg ha^{-1}) indicating that the STCR-IPNS treatment was recorded relatively higher yield over blanket alone and Farmer's practices (Figure 1). Lowest yield recorded in Farmer's practice (645 kg ha^{-1}) compare to all other treatments. STCR-IPNS 1.2 t ha^{-1} recorded a yield increase of 96.9% over Farmer's practices. All the treatments are significantly different in which STCR-IPNS 1.2 t ha^{-1} receive highest grain yield.

Per cent achievement (Table 3)

As stated by [12] the equation is deemed valid if the achieved yield falls within a variation of ± 10 percent from the targeted yield.

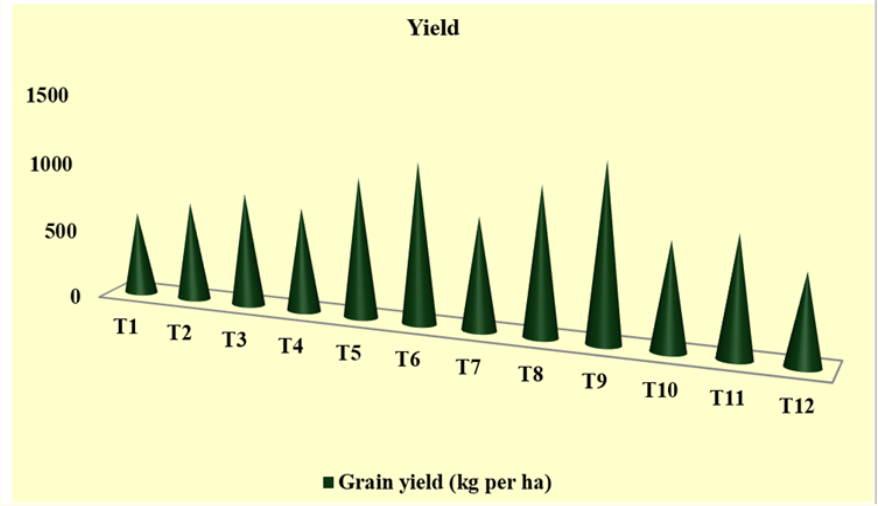

Figure 1: Effect of fertilizer of N, P_2O_5, K_2O, organic manure and IPNS treatments on grain and haulm yield of green gram.

In other words, if Validation on the actual yield is within 10 per cent of the expected yield, the equation is considered to be acceptable and accurate. The validation experiment results for greengram variety CO 8 demonstrated that the achieved yield percentage fell within a variation of ± 10 per cent (90-110%) at all yield target levels. This indicates the successful validation of the fertilizer prescription equations for greengram variety. The equations were found to be accurate and reliable for predicting and achieving the desired yields for the specific crop. The highest percentage achievement was observed with the yield target of STCR - IPNS - 1.0 t ha^{-1} (106.7%), followed by STCR - IPNS - 1.2 t ha^{-1} (105.8%), STCR - IPNS - 0.8 t ha^{-1} (101.4%), and STCR - NPK alone - 1.0 t ha^{-1} (100.9%). These results indicate that the STCR - IPNS treatments achieved yields exceeding their respective targets, demonstrating their effectiveness in enhancing crop productivity. The results clearly showed that the highest percentage achievement was better attained with the lowest yield target (1.0 t ha^{-1}) than with the highest yield target (1.2 t ha^{-1}) for both NPK alone and IPNS treatments. These findings are consistent with previous studies, as mentioned by [18] in pearl millet, and [13] in maize. These studies also reported that lower yield targets often resulted in higher percentage achievements, suggesting that lower but achievable yield goals may yield more favorable outcomes in certain agricultural systems.

Response Ratio (RR)

Among the STCR treatments, the STCR-IPNS treatments demonstrated relatively higher response ratios compared to their corresponding NPK alone treatments. This indicates that the integrated application of STCR-IPNS resulted in more significant and favorable responses in terms of crop productivity and yield, highlighting the effectiveness of this approach in enhancing agricultural outcomes. The response ratio for blanket treatment was 1.71 kg kg^{-1}, and for blanket plus FYM at 12.5 t ha^{-1}, it was 2.56 kg kg^{-1}. Both of these response ratios were relatively lower when compared to the response ratios of STCR-NPK alone and STCR-IPNS treatments with yield targets of 0.8, 1.0, and 1.2 t ha^{-1}. This suggests that the integrated STCR-NPK and STCR-IPNS treatments resulted in higher yield increases per unit of input compared to the blanket and blanket plus FYM treatments. The increase in response ratio achieved

Sl. No.	Treatments	Per cent achievement	RR (kg kg^{-1})
T_1	Blanket (100 % RDF)	-	1.71
T_2	Blanket (25:50:25) + FYM@ 12.5t ha	-	2.56
T_3	STCR - NPK alone -0.8 t ha^{-1}	94.1	2.75
T_4	STCR -NPK alone -1.0 t ha^{-1}	100.9	3.53
T_5	STCR -NPK alone -1.2 t ha^{-1}	96.1	3.69
T_6	STCR -IPNS – 0.8 t ha^{-1}	101.4	3.79
T_7	STCR -IPNS - 1.0 t ha^{-1}	106.7	4.03
T_8	STCR -IPNS - 1.2 t ha^{-1}	105.8	4.47
T_9	Farmer's practice	-	1.31
T_{10}	Absolute control	-	-

Table 3: Results of validation experiments on green gram.

by using STCR-IPNS at 1.2 t ha^{-1} over blanket recommendation was 1.61 kg kg^{-1}, while over blanket plus FYM at 12.5 t ha^{-1}, it was 0.75 kg kg^{-1}, and over farmer's practice, it was 2.41 kg kg^{-1}. The STCR-IPNS treatments demonstrated a significantly higher magnitude of yield increase and response ratio compared to the blanket (100% RDF), farmer's practice, and absolute control treatments. This indicates the superiority of the STCR-IPNS approach in enhancing crop yield and productivity compared to conventional practices and the use of inorganic fertilizers alone.

Indeed, the superiority of STCR-IPNS over blanket (100% RDF) and farmer's practice has been reported in various studies.[18] These studies collectively support the effectiveness and advantage of the STCR-IPNS approach in improving crop yield and productivity compared to conventional blanket recommendations and traditional farming practices in different agricultural systems.

Discussion

The grain yield of greengram was significantly influenced by the combination of FYM (Farm Yard Manure) and NPK (Nitrogen, Phosphorus, and Potassium) fertilizers. In the current study, the impact of STCR-IPNS (integrated plant nutrient system) on desired yield was evident, with higher yields achieved in the STCR-IPNS treatment, reaching 1.2 tons per hectare. This represented a notable increase of 10.15%, 64.64%, 48.54%, and 112.02% compared to the yields observed in the STCR-NPK alone treatment, blanket treatment, blanket + FYM treatment, and absolute control, respectively. Among the treatments evaluated, STCR-IPNS exhibited the highest impact on yield, followed by STCR-NPK alone treatments, which outperformed blanket, and absolute control treatments, respectively. The increased efficiency of STCR-NPK alone was attributed to the rapid release of nutrients from inorganic sources. On the other hand, FYM had a relatively lower impact on yield due to its slower mineralization process, as observed in previous studies by [3,7,8].

Nitrogen application during the early growth stages of plants has been found to stimulate vegetative growth, creating favorable conditions for achieving high yields. It plays a crucial role in chlorophyll formation and protein synthesis, directly contributing to increased plant protein content and, consequently, enhancing the overall yield [11,23]. Phosphorus plays a significant role in cellular respiration, facilitating the production of starch, proteins, and fats. It is essential for various metabolic processes and energy-producing reactions in plants. Phosphorus also contributes to the formation of phospholipids and nucleic acids, crucial components of cells. Moreover, it promotes blooming and seed formation, ultimately leading to increased yield [5]. The application of potassium had a notable and conspicuous impact on the grain yield of greengram, leading to both quantitative and qualitative improvements, as observed by [4]. In plots where FYM was applied, the timely and consistent supply of nutrients during the growing season likely contributed to an increase in seed yield, as suggested by [16].

The yield of treatments using organic manure alone was significantly lower due to the provision of inadequate and poor nutritional input [14,15].The combination of chemical fertilizers with Farm Yard Manure (FYM) created a favorable soil environment and provided essential nourishment for improved plant growth, resulting in maximum grain yield [1]. Indeed, the absolute control exhibited the lowest grain yield because it did not receive any fertilization, neither chemical nor organic. The absence of nutrient supplementation in this treatment resulted in limited plant growth and productivity.

The enhanced grain yield observed in the STCR-IPNS treatments can be attributed to the provision of a balanced and consistent supply of nutrients, taking into account the specific nutrient requirements of the crop. This approach considers the influence of nutrients from the soil, chemical fertilizers, and organic manure individually, resulting in optimal nutrient availability and improved crop productivity. The adoption of the STCR technique has led to an increase in grain yield, as supported by various studies [10,17]. reported increased yields in greengram, while [18] observed similar results in blackgram. Additionally, [21] in onion, and [6], all of which have contributed to the growing evidence of the positive impact of the STCR technique on crop productivity.

Post harvest soils value revealed that a sufficient build up and maintenance of SN, SP_2O_5 and SK_2O are found under STCR- IPNS study compare to farmer practices and general recommended dose. Despite removal of higher amount of nutrient in STCR- IPNS treatment due to getting a higher yield, higher post harvest soil fertility was observed in STCR- IPNS plot. Highest post harvest soil nitrogen was found in STCR-IPNMS for 1.2 t ha^{-1} in (257 kg ha^{-1}), soil potassium in (27 kg ha^{-1}), soil phosphorus in (372 kg ha^{-1}). The greater build up of nutrient in STCR- IPNS treatment was due to balance application of chemical fertilizer in conjuction with organic manure. Combined application of FYM and inorganic fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production [23]. Greater profit consistent with maintenance of soil fertility status was realized when fertilizer was

applied for appropriate yield targets in succession over years using STCR-IPNS concept [12]. Ultimately, the highest grain yield was recorded in STCR-IPNS for 1.2 t ha^{-1} and lowest for Absolute control treatment. The highest percent increment in yield over farmer practices is found in 1.2 t ha^{-1} STCR-IPNS treatment. The highest benefit cost ratio obtained in STCR-IPNMS for 1.2 t ha^{-1}. At high dose of fertilizer, increment in yield become smaller and smaller and they follow quadratic type of response curve. So, our fertilizer prescription equation for *alfisol* of Tamil Nadu is more beneficial and economical for yield targeting of 1.2 t ha^{-1} under Integrated Plant Nutrition Management System. The per cent achievement of the targeted yield of all the four verification trials was within±10% variation proving the validity of the fertilizer prescription equation for greengram. The post-harvest available soil nutrient status was very good in STCR-IPNS treatment over the other treatment which is helpful to maintain the soil fertility status and sustainable production. So we can suggest STCR-IPNS equation for yield targeting of 1.2 t ha^{-1} for *alfisol* of Tamil Nadu for improvement of soil health and sustainable production.

Conclusion

The treatment STCR - IPNS - 1.2 t ha^{-1} recorded a considerably greater yield of 1270 kg ha^{-1}, which was followed by STCR - NPK alone - 1.2 t ha^{-1} with the grain yield of 1153 kg ha^{-1}. All STCR - IPNS treatments exceeded STCR - NPK alone treatments in terms of yield for the same yield target. The results demonstrated that both STCR - IPNS and STCR - NPK alone treatments improved the yield in alignment with progressing yield targets. The yield increase in STCR-IPNS treatments varied between 35.39 to 112.02 percent over absolute control, 13.90 to 78.37 percent over vermicompost @ 5 t ha^{-1}, 25.74 to 96.90 percent over farmers practice 5.32 to 64.93 percent above the blanket (100 percent RDF), respectively. The treatments under the STCR - NPK alone had a percent yield increase of 25.71 to 92.49 over the absolute control. All STCR treatments performed better than the blanket except STCR treatments with a lower yield target. The yields from the farmer's practices, and absolute control were noticeably lower when compared to fertilized treatments. The absolute control reported a relatively lower grain yield (599 kg ha^{-1}) and there was 64.94, 138.60, 96.90, and 112.02 percent increase of the yield recorded by STCR IPNS-1.2 t ha^{-1} over the blanket (100% RDF alone), blanket + FYM @ 12.5 t ha^{-1}, farmer's practice and absolute control. For validating the fertiliser prescription equations, the per cent achievement should be within ± 10 per cent variation from targeted yield. The per cent achievement recorded by STCR treatments was within the range of ± 10 per cent variation. The highest per cent achievement and response ratio was registered with lowest yield target level under both STCR-IPNS and STCR-NPK alone treatments. The increase in response ratio due to STCR - IPNS 1.2 t ha^{-1} over blanket (100% RDF alone), blanket plus FYM @ 12.5 t ha^{-1} and farmer's practice was 1.01 kg kg^{-1}, 0.82 kg kg^{-1} and 1.16 kg kg^{-1}.Among the same yield targets, the STCR-IPNS treatments reported higher response ratio values than corresponding STCR-NPK alone treatments and with increase in yield targets, there was a corresponding increase in the values of response ratio.

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