

Original Research Article

Soil Test based Targeted yield equations for blackgram (*Vigna mungo*) through Integrated Plant Nutrition System on Alfisol

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ABSTRACT

Using Ramamoorthy's inductive methodology for assessing the soil test based crop requirement by adopting an Integrated Plant Nutrition System to create Fertilizer Prescription Equations (FPEs) for blackgram with the prime objective of attaining the targeted yield by the farmers. A field experiment was conducted out on red non-calcareous sandy loam soil belonging to the Palaviduthi soil series (*TypicRhodustalf*) during rabi 2021-22. The experiment comprised of eleven treatments viz., STCR – NPK alone and STCR – IPNS for yield targets 1.0, 1.2, and 1.4 t ha⁻¹, Blanket (25:50:25) @ 100% with and without FYM (12.5 t ha⁻¹), FYM alone @ 6.25 and 12.5 t ha⁻¹ and absolute control in randomized block design with three replications. From the experimental data, basic parameters viz., nutrient requirement (NR), per cent contribution from soil (Cs), per cent contribution from fertilizers (Cf), and per cent contribution from FYM (Cfym) were computed. The quantity of fertilizers contributed by the application of Farmyard manure was assessed. It has been found that the nutrient requirement for producing one quintal grain of blackgram was 4.77 kg of N, 4.50 kg of P₂O₅, and 5.05 kg of K₂O. The per cent contribution from soil (Cs) was 15.61, 29.91, and 8.12 for N, P, and K respectively and the percent contribution from fertilizers (Cf) and FYM (Cfym) was 48.61 and 37.19 for N, 44.78, and 14.63 for P₂O₅ and 55.72 and 31.71 for K₂O. FPEs for blackgram were generated using these basic parameters through a Soil Test Crop Response based Integrated Plant Nutrition System (STCR – IPNS). FPEs created in this mode were used to create nomograms for a range of soil test values and yield targets. Thus the Inductive cum Targeted Yield Model used to develop fertilizer prescription equations provides a strong basis for soil fertility maintenance consistent with high productivity and efficient nutrient management in farming for sustainable and enduring agriculture.

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Keywords: (Blackgram, Farmyard manure, Soil test crop response, Fertilizer Prescription Equations (FPEs)).

1. INTRODUCTION

Blackgram (*Vigna mungo*) is a highly lucrative legume crop that was introduced from India and is now cultivated throughout Southern Asia. In a poor man's diet, it is the cheapest source of plant protein. Blackgram, which comprises nearly 24% protein, 60% carbohydrates, fat, minerals, and amino acids like methionine and cysteine, ~~and~~ is thought to be of great importance in terms of food, energy, and nutritional security. It produces 10% of the country's ~~total~~ pulse output [5]. ~~to~~ To increase the output of blackgram, proper fertilization is required.

Fertilizer is one of the most expensive agricultural inputs, and getting the appropriate amount is critical for farm profitability and environmental protection [8]. The low productivity in this crop is attributed to its narrow genetic base, poor plant type, vulnerability to abiotic and biotic stresses and cultivation in marginal and harsh environment [2] and inadequate use of micronutrients. ~~is an important factor responsible for lower yield of blackgram~~ [16][13]. It serves also as cover crop and improves soil fertility by fixing atmospheric nitrogen. For increased ~~productivity~~, a well-balanced diet is essential. Simultaneously, in order to meet rising nutrient demand, there is an urgent need to explore alternative nutrient sources, such as organic manures and bio-fertilizers for long-term productivity and more ecologically friendly nutrient management methods. In this context, neither do the organic manures fulfill the crop nutrient requirement nor do the chemical fertilizers maintain and restore the physical, chemical and biological health of the soils for sustainable agriculture. Therefore, there is a need for standardizing the mixed use of organic and inorganic sources of nutrients to increase the productivity of crops and improve the soil health [21].

Soil test based fertilizer application is a useful tool and it is presumed that a fertilizer prescription equation is a unique technology to optimize need-based fertilizer application. The concept of fertilizer prescription equations for desired yield target was first given by [26]. Later on [15] established theoretical basis and experimental technique to suit Indian soil and climatic conditions showing the linear relationship between yield and nutrient uptake. For a given quantity of yield of any crop, fertilizer requirement can be estimated considering efficiency of soil and fertilizer nutrients.

The desire for higher yield had driven the farmers to ~~get resorted to~~ apply excessive ~~quantity~~ ~~quantities~~ of fertilizers by ignoring the soil nutrient status and crop nutritional requirements ~~thathaving—had~~ a negative impact on soil health. On the other hand, blanket recommendations pose some limitations due to variation in inherent soil fertility in varying locations which may result in either inadequacy or toxicity of nutrients ~~and also newhile the~~ desired yield ~~will not be achieved~~. To preserve soil from the negative impacts, the Soil Test

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Comment [A7]: Are you referring to productivity of the crop or of the people who consume the crop? Not clear in this sentence.

Comment [A8]: Whichever style you use, you cannot refer to a number, for no number can give you anything. You refer to the person: ... was first given by Troug [26]. Later on Ramamoorthy and his co-authors [15] established...

Crop Response approach ~~sounds to be better~~ is a more sustainable approach, not only by providing balanced fertilizer recommendations but also ~~aids by aiding~~ farmers in achieving their targeted yield. Hence an attempt was made to develop fertilizer prescription equations for blackgram through STCR – IPNS approach for desired yield in red non-calcareous soil (Palaviduthi series).

2. MATERIAL AND METHODS

2.1 Soil characteristics and experimental description

A field experimental study was conducted in Thondamuthur Block, Coimbatore during the ~~rain~~ season of 2021-2022. ~~With, using~~ the experimental crop Blackgram (VBN8), ~~the~~ The soil belongs to the Palaviduthi soil series (~~Red-red~~ non-calcareous). The experimental field's surface soil (0-15 cm) was red non-calcareous, sandy loam texture with slightly alkaline pH (7.91), ~~non-~~ saline (electrical conductivity (EC)) of 0.12 dSm⁻¹, low organic carbon (0.42 %), low available N (220 kg ha⁻¹), high available P (62 kg ha⁻¹), and available K (332 kg ha⁻¹) respectively; and sufficient in ~~the following available~~ micronutrients Cu, Mn, Fe, and ~~Zn~~. On a plot size of 5 x 4 m², the experiment was laid out in ~~Randomized-randomized Block-block~~ Design ~~design~~ (RBD) with eleven treatment combinations and three replications. Hand-dibbled blackgram seeds were placed 30 x 10 cm apart and covered with soil. As a basal treatment, the crop received a full dose of N, P₂O₅, and K₂O - Urea (46% N), single super phosphate (SSP, 16% P₂O₅), and muriate of potash (MOP, 60% K₂O) were used as nitrogen, phosphorus, and potassium sources, ~~respectively~~.

2.2 Treatments

The treatments were, T₁-Absolute ~~control~~, T₂- FYM alone @6.25 t ha⁻¹, T₃- FYM alone @12.5 t ha⁻¹, T₄- STCR-NPK alone – 1.0 t ha⁻¹, T₅- STCR-NPK alone – 1.2 t ha⁻¹, T₆- STCR-NPK alone – 1.4 t ha⁻¹, T₇-STCR-IPNS -1.0 t ha⁻¹, T₈- STCR-IPNS -1.2 t ha⁻¹, T₉- STCR-IPNS -1.4 t ha⁻¹, T₁₀-Blanket @ 100% ~~RDF~~ and T₁₁ - Blanket + FYM @12.5 t ha⁻¹. By using these eleven treatments and three replications, the study was set up in ~~Randomized randomized Block-block~~ Design ~~design~~. The entire amount of Urea, SSP and MOP was given basally along with FYM as organic source for the particulate treatments [4].

2.3 Soil and plant analysis

The soil samples were collected antecedent to fertilizer and manure application and analyzed for alkaline KMnO₄-N [25], Olsen-P [12] and NH₄OAc-K [24]. The ~~Grain-grain~~ and ~~Haulm-haulm~~ yields were noted for different treatments and samples were collected and analyzed for total N [6], total P ~~and~~ K [7]. The total N, P and K uptake for different treatments were calculated by taking into account the dry matter yield and N, P and K content in the grain and haulm of blackgram. The impact of the treatments imposed on yield and uptake

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was investigated using statistical analysis of the experimental data using SPSS statistical software [11].

2.4 Trial methodology

The required parameters for formulating fertilizer prescription equations for targeted yield were experimentally obtained for a given soil type-crop-agroclimatic condition. All of the practices were followed according to the TNAU Crop Production Guide [2020]. In addition to the calculated fertilizer doses from the existing FPEs, for STCR – IPNS, FYM alone and blanket + FYM @12.5 t ha⁻¹ treatments, FYM (with 24% moisture 0.54% N, 0.26% P and 0.51% K) was applied as per the treatment schedule. Before commencing the field experiment, the soil samples were taken from each plot. Chemical characteristics and available macronutrients were examined in initial soil samples and the crop was harvested. From the experimental data on grain and haulm yields, nutrient uptake, initial soil available N, P and K and fertilizer dose added (Table 1) were reported. By use of this data fertilizer prescription equations were developed for blackgram by refinement of existing FPEs.

The basic parameters viz., Nutrient requirement (NR), Per cent contribution from soil (Cs), Per cent contribution from fertilizer (Cf) and Per cent contribution from FYM were determined following the procedure reported earlier [19]. The available soil nutrient content is considered while estimating the contribution from soil, fertilizer and FYM. The formulae for computing the basic parameters are furnished below:

1. Nutrient requirement (NR in kg q⁻¹)

i)	Kg N required per quintal of grain production	=	$\frac{\text{Total uptake of N (kg ha}^{-1}\text{)}}{\text{Grain yield (q ha}^{-1}\text{)}}$
ii)	Kg P ₂ O ₅ required per quintal of grain production	=	$\frac{\text{Total uptake of P}_2\text{O}_5 \text{ (kg ha}^{-1}\text{)}}{\text{Grain yield (q ha}^{-1}\text{)}}$
iii)	Kg K ₂ O required per quintal of grain production	=	$\frac{\text{Total uptake of K}_2\text{O (kg ha}^{-1}\text{)}}{\text{Grain yield (q ha}^{-1}\text{)}}$

2. Per cent contribution of nutrients from soil to total nutrient uptake (Cs)

i)	Per cent	$\frac{\text{Total uptake of N in control plot (kg ha}^{-1}\text{)}}{\text{Total uptake of N in treatment plot (kg ha}^{-1}\text{)}}$
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Comment [A20]: I understand the necessity of soil analyses before the crop was planted, but surely you also had it analysed at crop harvest? How else can you calculate what was used? Here you only refer to initial soil samples (which sounds like before the trial).

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$$\text{contribution of N from soil} = \frac{\text{Soil test value for available N in control plot (kg ha}^{-1}\text{)}}{\text{Soil test value for available N in control plot (kg ha}^{-1}\text{)}} \times 100$$

$$\text{ii) Per cent contribution of P}_2\text{O}_5 \text{ from soil} = \frac{\text{Total uptake of P}_2\text{O}_5 \text{ in control plot (kg ha}^{-1}\text{)}}{\text{Soil test value for available P}_2\text{O}_5 \text{ in control plot (kg ha}^{-1}\text{)}} \times 100$$

$$\text{iii) Per cent contribution of K}_2\text{O from soil} = \frac{\text{Total uptake of K}_2\text{O in control plot (kg ha}^{-1}\text{)}}{\text{Soil test value for available K}_2\text{O in control plot (kg ha}^{-1}\text{)}} \times 100$$

3. Per cent contribution of nutrients from fertilizers to total uptake (Cf)

$$\text{i) Per cent contribution of N from fertilizer} = \frac{\text{Total uptake of N in treated plot (kg ha}^{-1}\text{)} - \left(\text{Soil test value for available N in treated plot (kg ha}^{-1}\text{)} \times \text{Average Cs} \right)}{\text{Fertilizer N applied (kg ha}^{-1}\text{)}} \times 100$$

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$$\text{ii) Per cent contribution of P}_2\text{O}_5 \text{ from fertilizer} = \frac{\text{Total uptake of P}_2\text{O}_5 \text{ in treated plot (kg ha}^{-1}\text{)} - \left(\text{Soil test value for available P}_2\text{O}_5 \text{ in treated plot (kg ha}^{-1}\text{)} \times \text{Average Cs} \right)}{\text{Fertilizer P}_2\text{O}_5 \text{ applied (kg ha}^{-1}\text{)}} \times 100$$

$$\text{iii) Per cent contribution of K}_2\text{O from fertilizer} = \frac{\text{Total uptake of K}_2\text{O in treated plot (kg ha}^{-1}\text{)} - \left(\text{Soil test value for available K}_2\text{O in treated plot (kg ha}^{-1}\text{)} \times \text{Average Cs} \right)}{\text{Fertilizer K}_2\text{O applied (kg ha}^{-1}\text{)}} \times 100$$

4. Per cent nutrient contribution of nutrients from organics to total uptake (Co)

i) Per cent contribution from FYM (Cfym)

$$\left(\right)$$

$$C_{fym} = \frac{\left(\frac{\text{Total uptake of N/P/K in FYM treated plot (kg ha}^{-1}\text{)}}{\text{Nutrient N/P/K added through FYM (kg ha}^{-1}\text{)}} - \frac{\text{Soil test value for available N/P/K in FYM treated plot (kg ha}^{-1}\text{)}}{\text{Average Cs}} \right) \times 100$$

Fertiliser Fertilizer prescription equation

Making use of these basic parameters, the FPEs will be developed as follows:

i) Fertilizer nitrogen (FN)

$$FN = \frac{NR}{C_f / 100} T - \frac{Cs}{C_f} SN$$

$$FN = \frac{NR}{C_f / 100} T - \frac{Cs}{C_f} SN - \frac{C_{fym}}{C_f} ON$$

ii) Fertilizer phosphorus (FP₂O₅)

$$FP_{2O_5} = \frac{NR}{C_f / 100} T - \frac{Cs}{C_f} \times 2.29 \times SP$$

$$FP_{2O_5} = \frac{NR}{C_f / 100} T - \frac{Cs}{C_f} \times 2.29 \times SP - \frac{C_{fym}}{C_f} \times 2.29 \times OP$$

iii) Fertilizer potassium (FK₂O)

$$FK_2O = \frac{NR}{C_f / 100} T - \frac{Cs}{C_f} \times 1.21 \times SK$$

$$FK_2O = \frac{NR}{C_f / 100} T - \frac{Cs}{C_f} \times 1.21 \times SK - \frac{C_{fym}}{C_f} \times 1.21 \times OK$$

Where, FN: Fertilizer N (kg ha⁻¹); FP₂O₅: Fertilizer P₂O₅ (kg ha⁻¹); FK₂O: Fertilizer K₂O (kg ha⁻¹); NR: Nutrient requirement of N or P₂O₅ or K₂O (kg q⁻¹); Cs: Per cent contribution of nutrients from soil; Cf: Per cent contribution of nutrients from fertilizer; SN: Soil test value for available N (kg ha⁻¹); SP: Soil test value for available P (kg ha⁻¹); SK: Soil test value for

available K (kg ha^{-1}); Cfym: Per cent contribution of nutrients from FYM; ON: Quantity of N applied through FYM (kg ha^{-1}); OP: Quantity of P applied through FYM (kg ha^{-1}); OK: Quantity of K applied through FYM (kg ha^{-1}).

The above equations serve as a basis for prescribing fertilizer doses for specific yield targets of Blackgram under IPNS for varied soil available nutrient levels.

3. RESULTS AND DISCUSSION

3.1 Grain yield

The grain yields recorded as a result of various treatments ranged from 762 to 1348 kg ha^{-1} (Table 1). The highest grain yield of 1347 kg ha^{-1} was recorded in T_9 (STCR-IPNS – 1.4 t ha^{-1}) which was on par with the grain yield 1290 kg ha^{-1} recorded in T_6 - STCR-NPK alone – 1.4 t ha^{-1} . Following treatments T_9 and T_6 , T_8 - STCR-IPNS – 1.2 t ha^{-1} recorded grain yield of 1252 kg ha^{-1} , comparable to the grain yield of T_5 - STCR-NPK alone – 1.2 t ha^{-1} (1182 kg ha^{-1}) and T_{11} - Blanket + FYM 12.5 t ha^{-1} (1162 kg ha^{-1}). These treatments were superior to T_7 - STCR-IPNS – 1.0 t ha^{-1} , T_4 - STCR-NPK alone – 1.0 t ha^{-1} and T_{10} - Blanket (100 % RDF) which recorded grain yields of 1094, 1042 and 1020 kg ha^{-1} respectively. All the fertilized treatments were superior to T_2 - FYM alone @ 6.25 t ha^{-1} and T_3 - FYM alone @ 12.5 t ha^{-1} which recorded grain yields of 834 and 894 kg ha^{-1} respectively. With a yield of 762 kg ha^{-1} , absolute control (T_1) had the lowest yield. The high targeted yield (1.4 t ha^{-1}) treatments of STCR – NPK and STCR – NPK + FYM @ 12.5 t ha^{-1} exhibited 9.9 and 13.7 percent increase in yield respectively over T_{11} – Blanket recommendation + FYM @ 12.5 t ha^{-1} . Application of NPK fertilizers combined with FYM might have created a favourable soil condition for root development, enhanced crop growth, yield and nutrient uptake. Among the same yield targets, yield of maize under STCR-IPNS treatments was numerically higher than those under STCR-NPK alone [23]. The yield is analogous to integrated nutrient management and formulation of targeted yield equations for blackgram in Inceptisols of Odisha [19]. Such increase in yields might be due to the improvement in physical and chemical environment of soil as residual effect of addition of farmyard manure. Integration of inorganic fertilizers and biofertilizers resulted in better growth, yield and nutrient uptakes in blackgram [9].

3.2 Nutrient uptake

The nutrient uptake ranged from 35.24 – 58.64 kg ha^{-1} for N, 17.75 – 22.76 kg ha^{-1} for P and 30.52 – 52.38 kg ha^{-1} for K respectively (Table 1). The maximum uptake of nutrients was observed in T_9 (STCR-IPNS – 1.4 t ha^{-1}) which was comparable with T_6 (STCR-NPK alone – 1.4 t ha^{-1}) with N uptake of 58.64 and 57.45 kg ha^{-1} , P uptake of 22.76 and 22.19 kg ha^{-1} and

Comment [A23]: FYM is also fertilizer, just not synthetic.

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Comment [A26]: The rest of your manuscript uses American English, so this should be the American spelling without the 'u'.

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•Use "might" if something is less likely to happen or in a hypothetical situation.

and K uptake 52.38 and 51.42 kg ha⁻¹ respectively. Next to T₉ and T₆, - T₈(STCR-IPNS – 1.2 t ha⁻¹), T₅ (STCR-NPK alone – 1.2 t ha⁻¹) and T₁₁ (Blanket + FYM 12.5 t ha⁻¹) recorded N uptake of 54.42, 53.72 and 53.42 kg ha⁻¹, P uptake of 21.98, 21.52 and 21.37 kg ha⁻¹ and K uptake of 49.78, 48.81 and 48.27 kg ha⁻¹ respectively and were comparable among them.

These treatments recorded significantly higher uptake than T₇ (STCR-IPNS – 1.0 t ha⁻¹), T₄ (STCR-NPK alone – 1.0 t ha⁻¹) and T₁₀ - Blanket (100 % RDF) which recorded an uptake of 52.26, 49.82 and 49.21 kg N ha⁻¹, 21.98, 20.34 and 20.12 kg P ha⁻¹ and 47.60, 45.56 and 44.92 kg K ha⁻¹ respectively. FYM alone - 6.25 t ha⁻¹ and T₃ - FYM alone - 12.5 t ha⁻¹ recorded 46.24 and 48.86 kg N uptake ha⁻¹, 18.81 and 19.98 kg P uptake ha⁻¹ and 36.45 and 40.24 kg K uptake ha⁻¹ respectively. Absolute control recorded the lowest NPK uptake of 35.24, 16.84 and 30.52 kg per ha⁻¹ respectively. IPNS may have accelerated carbohydrate synthesis and increased glucose translocation from sink to source, resulting in higher production. This could be because FYM has better physical, chemical, and biological properties than NPK alone treatments [4]. The energizing impact of STCR-IPNS treatments on uptake was also experienced by other researchers [14] and [1]. The uptake pattern observed among the treatments was similar to those observed in barnyard millet by Saren and co-workers [19]. Blackgram being a leguminous crop may also fix substantial amounts of atmospheric N in soil and make it available to the plants. FYM improves the soil physical environment which may become favourable for microbial growth and hence more nutrients become available in soil solution and consequently enhanced uptake by blackgram.

3.3 Response

The response of fertilizers to grain yield was estimated by finding the difference in grain yield in absolute control and grain yield in different treatments which varied from 72 to 585 kg ha⁻¹ (Table 1). The response was higher in T₉: STCR-NPK + FYM @ 12.5 t ha⁻¹ – 1.4 t ha⁻¹ with 585 kg ha⁻¹ succeeded by T₆: STCR-NPK alone – 1.4 t ha⁻¹ with 528 kg ha⁻¹. The least response was observed in T₂: FYM alone @ 6.24 t ha⁻¹ (72 kg ha⁻¹). The results were similar to the response trend given reported by other researchers [10] on *Typic Rhodustalf* at Coimbatore, Tamil Nadu for hybrid maize. The results revealed that, regardless of whether STCR-NPK alone or STCR-IPNS were used, there was a progressive rise in response from lower to higher targets, with the magnitude of the reaction being higher with STCR-IPNS than with STCR-NPK alone. This alone. This formed the basis to compute the basic parameters and develop the fertilizer prescription equations under IPNS. Similar results were reported for a pearl millet variety [17].

Table.1 Mean and range of grain yield, pre-sowing soil test values, NPK uptake, and response of Blackgram

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TREATMENT	Grain Yield	UN	UP	UK	SN	SP	SK	FN	FP ₂ O ₅	FK ₂ O	FYM	Response
	(kg ha ⁻¹)										t ha ⁻¹	kg ha ⁻¹
T ₁ -Absolute control	762	35.24	17.75	30.52	224	58	328	0	0	0	0	
T ₂ FYM alone @ 6.25 t ha ⁻¹	834	46.24	18.81	36.45	221	61	331	0	0	0	6.25	72
T ₃ FYM alone @ 12.5 t ha ⁻¹	894	48.86	19.98	40.24	226	59	332	0	0	0	12.5	132
T ₄ STCR - NPK alone - 1.0 t ha ⁻¹	1042	49.82	20.34	45.56	230	57	330	23	10	39	0	280
T ₅ STCR - NPK alone - 1.2 t ha ⁻¹	1182	53.72	21.52	48.81	222	60	328	44	25	49	0	420
T ₆ STCR - NPK alone- 1.4 t ha ⁻¹	1290	57.45	22.19	51.42	224	58	329	66	39	60	0	528
T ₇ STCR-IPNS - 1.0 t ha ⁻¹	1094	52.26	21.26	47.60	228	61	332	23	10	39	12.5	332
T ₈ STCR-IPNS - 1.2 t ha ⁻¹	1252	54.42	21.98	49.78	227	62	326	44	25	49	12.5	489
T ₉ STCR-IPNS - 1.4 t ha ⁻¹	1348	58.64	22.76	52.38	223	59	327	66	39	60	12.5	585
T ₁₀ Blanket (100% RDF)	1020	49.22	20.12	44.92	225	57	331	25	50	25	0	258
T ₁₁ Blanket (100% RDF)+ FYM @12.5 t ha ⁻¹	1162	53.42	21.37	48.27	226	62	332	25	50	25	12.5	400
Range	762-1348	35.24-58.64	17.75-22.76	30.52-52.38	221-230	57-62	326-332					
Mean	1080	50.84	20.73	45.09	225	59	330					
SEd	12.56	0.92	0.28	0.54								
CD (P=0.05)	26.21	1.93	0.59	1.14								

3.4 Basic parameters

Pre-sowing soil available NPK, applied fertilizer dosages, grain yield, and NPK uptake acquired from the experiment are all implemented to compute the basic parameters viz., nutrient requirement (NR), contribution from soil (Cs), fertilizers (Cf) and FYM (Cfym) (Table 2). The results manifest, blackgram requires 4.77, 4.50 and 5.05 kg N, P_2O_5 and K_2O respectively to generate one quintal of grain yield (Fig.1.). Similar results were reported by other researchers [18] in chickpea on Inceptisol. The per cent contribution of soil and fertilizers (Table 2) were (Table 2) 15.61 and 48.61 for N, 29.91 and 44.78 for P_2O_5 and 8.12 and 55.72 for K_2O . The per cent contribution of N, P and K from FYM was 37.19, 14.63 and 31.71 respectively (Fig.2.). The contribution of nutrients from FYM is limited, which could be attributed to the fact that FYM has a lower mineralization rate [22]. However, in the case of P_2O_5 , the contribution was more from soil than from fertilizer. This trend was in synchronoussimilar towith the results of STCR-IPNS based fertilizer prescriptions for Blackgram on Inceptisols of Odisha [19].

Table 2. Basic parameters

	N	P_2O_5	K_2O
NR (kg q ⁻¹)	4.77	4.50	5.05
Cs(%)	15.61	29.91	8.12
Cf(%)	48.61	44.78	55.72
Cfym (%)	37.19	14.63	31.71

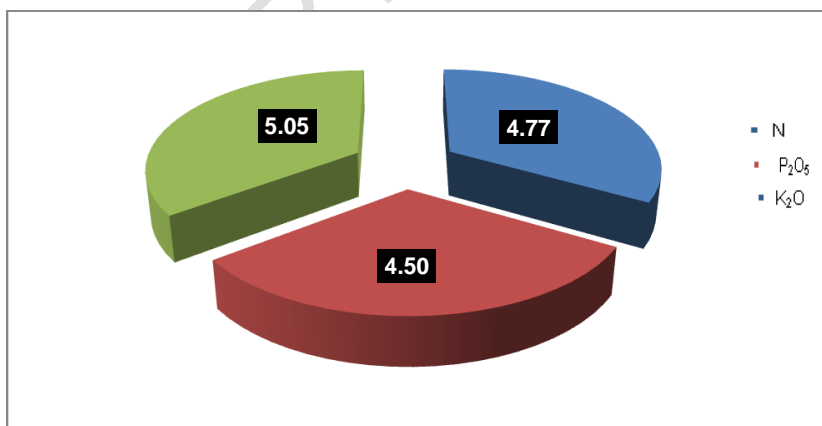


Fig.1. Nutrient Requirement (NR-kg q⁻¹)

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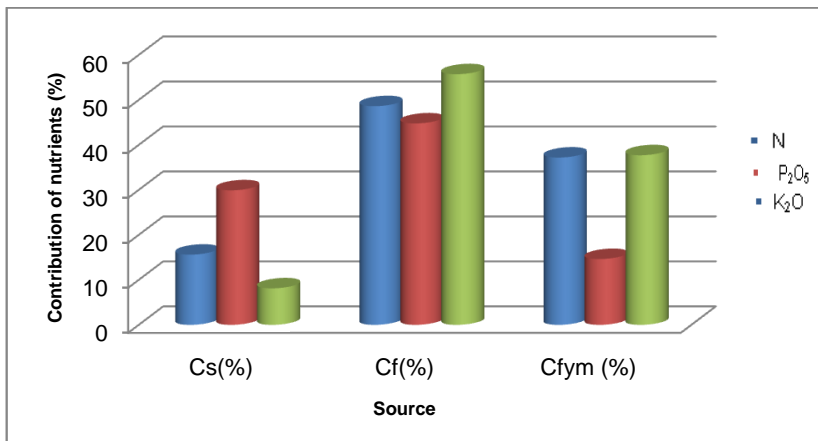


Fig.2. Contribution of nutrients from soil (Cs), fertilizer (Cf), and (Cfym).

3.5 Fertilizer prescription equations for blackgram under *TypicRhodustalf*

Under STCR - NPK alone and STCR - IPNS for blackgram, the basic parameters NR, Cs, Cf, and Cfym were employed to build fertilizer prescription equations.

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STCR-NPK

$$FN = 9.81 T - 0.32 SN$$

$$FP_2O_5 = 10.05 T - 1.53 SP$$

$$FK_2O = 9.06 T - 0.18 SK$$

STCR-NPK +FYM

$$FN = 9.81 T - 0.32 SN - 0.77 ON$$

$$FP_2O_5 = 10.05 T - 1.53 SP - 0.75 OP$$

$$FK_2O = 9.06 T - 0.18 SK - 0.69 OK$$

3.6 Fertilizer prescription for blackgram

For blackgram on *Alfisol*, the FPEs were used to develop ready reckoners for a range of soil test values at desired production targets of 1.0, 1.2 and 1.4 t ha⁻¹. (Tables 3,4,5). It is observed that with soil test values of 220:60:330 kg ha⁻¹ of KMnO₄-N, Olsen-P, NH₄OAc-K to achieve a grain yield of 1.0, 1.2 and 1.4 t ha⁻¹ the calculated fertilizer doses of N, P₂O₅ and K₂O for NPK alone was 28:25:31 and 37.5:29:37.5 and 37.5:49:37.5 respectively. Under STCR-IPNS, when FYM @ 12.5 t ha⁻¹ was applied (24% moisture 0.54% N, 0.26% P and 0.51% K) the 39, 19 and 34 kg of fertilizer N, P₂O₅ and K₂O respectively could be reduced respectively. The Percent reduction due to IPNS over NPK alone was 55.4, 0.59, 9 and 66.7, 13.8, 58.6 and 25.3, 38.8, 10.3 for the yield targets of 1.0, 1.2 and 1.4 t ha⁻¹ respectively. The percent reduction of NPK fertilizers under NPK+FYM increased as soil available N, P, and K increased, whereas it decreased as yield targets increased, which is

Comment [A34]: Though what exactly these numbers are, you will know. Without spaces on the correct places, no one else will know.

consistent with reports by [Sivaranjani et al \[23\]](#) on *VerticUstropept* in Coimbatore[23], [Tamil Nadu for hybrid maize](#), and [Udayakumar and Santhi\[27\]](#) on *TypicUstropept* in Coimbatore, Tamil Nadu [university's Crop Production Guide \[2020\]](#) for [hybrid maize](#) and pearl millet.

Table.3 Ready reckoner of fertilizer doses for STCR-NPK alone, STCR-IPNS (FYM) for desired yield target of 1.0 t ha⁻¹ of Blackgram

Soil Test Value (kg ha ⁻¹)	Treatments		
	STCR –NPK Alone	STCR –IPNS	Percent reduction due to IPNS over STCR-NPK alone
KMnO₄ - N			
180	37.5**	12.5*	66.7
200	34	12.5*	63.2
220	28	12.5*	55.4
240	21	12.5*	40.5
260	15	12.5*	16.7
280	12.5*	12.5*	66.7
Olsen – P			
45	32	25*	22.0
50	25*	25*	0
55	25*	25*	0
60	25*	25*	0
65	25*	25*	0
70	25*	25*	0
NH₄OAc – K			
300	37	12.5*	66.2
320	33	12.5*	62.1
340	29	12.5*	56.9
360	26	12.5*	51.9
380	22	12.5*	43.2
400	19	12.5*	34.2

(NB: **maximum dose; *maintenance dose)

- Blanket dose: 25:50:25 kg ha⁻¹ of [fertiliser-fertilizer](#) N, P₂O₅ [and](#) K₂O respectively for blackgram.
- If the calculated [fertiliser-fertilizer](#) dose tends to fall below 50 per cent of the blanket, a maintenance dose of 50 per cent of the blanket is recommended.
- If the calculated dose exceeds 150 per cent of the blanket, a maximum dose of 150 per cent of the blanket is recommended for N, P₂O₅ [and](#) K₂O respectively.

Table.4 Ready reckoner of fertilizer doses for STCR-NPK alone, STCR-IPNS (FYM) for desired yield target of 1.2 t ha⁻¹ of Blackgram

Soil Test Value (kg ha ⁻¹)	Treatments
-------------------------------------------	------------

	STCR –NPK Alone	STCR –IPNS	Percent reduction due to IPNS over STCR-NPK alone
KMnO₄ - N			
180	37.5**	21	44.0
200	37.5**	14	62.7
220	37.5**	12.5*	66.7
240	37.5**	12.5*	66.7
260	35	12.5*	64.3
280	28	12.5*	55.4
Olsen – P			
45	52	33	36.5
50	44	25	43.2
55	36	25*	30.6
60	29	25*	13.8
65	25*	25*	0
70	25*	25*	0
NH₄OAc – K			
300	37.5**	21	44.0
320	37.5**	17	54.7
340	37.5**	14	62.7
360	37.5**	12.5*	66.7
380	37.5**	12.5*	66.7
400	37	12.5*	66.2

(NB: **maximum dose; *maintenance dose)

- Blanket dose: 25:50:25 kg ha⁻¹ of ~~fertiliser~~ fertilizer N, P₂O₅ and K₂O respectively for blackgram.
- If the calculated ~~fertiliser~~ fertilizer dose tends to fall below 50 per cent of the blanket, a maintenance dose of 50 per cent of the blanket is recommended.
- If the calculated dose exceeds 150 per cent of the blanket, a maximum dose of 150 per cent of the blanket is recommended for N, P₂O₅ and K₂O respectively.

Table.5 Ready reckoner of fertilizer doses for STCR-NPK alone, STCR-IPNS (FYM) for desired yield target of 1.4 t ha⁻¹ of Blackgram

Soil Test Value (kg ha ⁻¹)	Treatments		
	STCR –NPK Alone	STCR –IPNS	Percent reduction of fertilizer due to IPNS over STCR- NPK alone
KMnO₄ - N			
180	37.5**	37.5**	0
200	37.5**	34	9.3
220	37.5**	28	25.3
240	37.5**	21	44.0
260	37.5**	15	60.0
280	37.5**	12.5*	66.7
Olsen – P			
45	72	53	26.4

50	64	45	29.7
55	57	38	33.3
60	49	30	38.8
65	41	25*	39.0
70	34	25*	26.5
NH₄OAc – K			
300	37.5**	37.5**	0
320	37.5**	35	6.7
340	37.5**	32	14.7
360	37.5**	28	25.3
380	37.5**	25	33.3
400	37.5**	21	44.0

(NB: **maximum dose; *maintenance dose)

- Blanket dose: 25:50:25 kg ha⁻¹ of ~~fertiliser-fertilizer~~ N, P₂O₅ & K₂O respectively for blackgram.
- If the calculated ~~fertiliser-fertilizer~~ dose tends to fall below 50 per cent of the blanket, a maintenance dose of 50 per cent of the blanket is recommended.
- If the calculated dose exceeds 150 per cent of the blanket, a maximum dose of 150 per cent of the blanket is recommended for N, P₂O₅ & K₂O respectively.

4. CONCLUSION

The results of this experiment revealed that the fertilizer prescription equations for blackgram on *TypicRhodustalf* (red, non-calcareous, Palaviduthi soil series) have been ~~evolved~~ developed. According to the findings, combining organic manures and inorganic fertilizers resulted in higher nutrient uptake than using ~~only-either~~ organic or inorganic fertilizers ~~alone~~ or using no fertilizers at all. This could be because the balanced and combined use of various plant nutrient sources results in proper absorption, translocation, and assimilation of those nutrients, resulting in increased dry-matter accumulation and nutrient contents of the plant, and thus more uptake of nutrients, which has a direct impact on increased agricultural production. Hence, this study provides a dual benefit to farmers where they can aim for desired yield targets based on their resource availability which would result in sustained soil ~~fertility~~.

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Comment [A35]: I miss the economic aspects. Yes, the combined option delivers the best results, but is it economically viable? Is the extra expenditure really worth while? Or are you paying more than what the yield will increase with? We don't know.

Comment [A36]: The format of your reference list will have to be in line with the requirements of the journal, but that will be ONE format throughout. Journal names will be written out in full, or abbreviated, but not both. It will either be in italics or not, but not both. Year after authors or after title, not both

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first, then initials. Not Christian names.

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