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Development of Integrated Fertilizer Prescription Based on STCR- IPNS for Cotton through Inductive Cum Targeted Yield Model in Thirunallar Soil Series of Karaikal, Puducherry, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Soil Test Crop Response (STCR) approach within the Integrated Plant Nutrient System (IPNS) is a targeted yield-based strategy that balances immediate crop nutrient needs with long-term soil health, aiming to optimize yield, fertilizer efficiency, and sustainability. Field trials on Typic *Haplusterts* soils in Karaikal used an inductive cum targeted yield model to develop fertilizer prescription equations (FPE) based on the nutrient requirement (NR) of crops and the contributions from soil (Cs), fertilizers (Cf), and farmyard manure (Cfym). For cotton, desired yield targets of 31, 33, and 35 q ha^{-1} were set, and nomograms were created to determine precise fertilizer applications based on soil test values. When FYM was applied at 12.5 t ha^{-1}, it contributed 52 kg of nitrogen (N), 30 kg of phosphorus (P_2O_5), and 48 kg of potassium (K_2O), which complemented the calculated NPK fertilizer needs. These values allowed for precise adjustments of nutrient inputs, aligning with both crop demands and the soil's nutrient-supplying capacity, and improving efficiency while maintaining soil health. This approach provides a practical framework for farmers, enhancing yields and profitability while promoting the sustainable use of resources by balancing "fertilizing the crop" with "fertilizing the soil."

Keywords: STCR; IPNS; targeted yield model; FPE; soil test value.

1. INTRODUCTION

The agricultural system in India faces challenges such as a growing population, limited arable land, and soil health concerns. One of the greatest challenges in agriculture is producing enough food, fibre, and fuel.

"Fiber crops like cotton are significant in this context, as they provide essential raw materials for industries. Cotton 'the king of apparel fibers' is an important fiber and cash crop and it supplies a major share of raw material for the textile industry and playing a key role in the economic and social affairs of the world" (Vora *et al*., 2015). "It plays vital role in the economy of the farmer as well as the country, thus it is popularly known as White gold" (Parmar *et al*., 2018).

India grows all four cotton species and hybrids. Cotton by-products, like cottonseed oil, meal, hulls, and linters, are used in food, animal feed, and industrial products such as plastics and paper, showcasing its broad economic importance.

Cotton farming in India relies heavily on chemical fertilizers, which, despite being cost-effective, degrade soil health over time. Continuous use of fertilizers depletes soil fertility, so a balanced approach combining organic and inorganic fertilizers is recommended to maintain soil productivity and ensure long-term sustainability.

At this point, the Inductive-cum-Targeted Yield Model, modified by Ramamoorthy, ensures a balance between "fertilizing the crop" and "fertilizing the soil." It provides a scientific method for applying nutrients based on soil availability, optimizing crop yield while maintaining soil health for sustainable agriculture.

2. MATERIALS AND METHODS

The present study consisted of two field experiments in two phases viz., fertility gradient experiment with rice variety (ADT 45) (Phase I) and followed by test crop experiment with Rasi Hybrid Cotton (RCH 659 BG II) (Phase II) at farmer's field in thirunallar soil series of Karaikal district.

The study area comes under coastal alluvial plain (PC1) classified as fine, smectitic isohyperthermic, *Typic Haplusterts* with an area of 26.14 per cent. According to agro climatic zonal classification, the study area is located at10°98' North latitude and 79°82'East longitude.

The surface soil (0-15 cm deep) of the experimental field is Clay in texture. The pH, electrical conductivity and cation exchange capacity of the soil were 7.40, 0.46 dS and 21.5 cmol kg, respectively. The initial soil available alkaline potassium permanganate nitrogen (N), Olsen phosphorus (P) and ammonium acetate potassium (K) were 268.4 kg, 48.5 kg and 351 kg, respectively. The P and K fixing capacities of the soil were150 and100 kg respectively.

The objective of this investigation was to create a broad range of soil fertility conditions in the experimental field by adjusting the levels of a controllable variable, fertilizer dosage, across varying levels of the uncontrollable variable, soil fertility. Since these variations are not typically present at a single location, a preliminary gradient crop experiment was conducted before the main test crop experiment. This approach aimed to identify fertility differences within the field, helping to minimize heterogeneity in soil populations, standardize the methods used, and account for prevailing climatic conditions.

In gradient experiments, the variation in soil fertility was created by adopting the Inductive Methodology developed by Ramamoorthy. The experimental field was split into three equal strips for this purpose; a gradient crop of rice (ADT 45) was grown in the first strip, which got no fertilizer, while the second and third strips received one and two times the usual dose of N, P, and K, respectively (Table 1). A total of 24 soil samples were taken from each fertility strip before and after harvest, and their alkalinity was assessed.

After the harvest of rice, each strip was divided into 24 plots, and pre sowing soil samples were collected from each plot and analyzed for alkaline N, P and K. The treatment consisted of four levels of N (0, 60, 120 and 180 kg ha^{-1}), P (0, 30, 60 and 90 kg ha^{-1}) and K (0, 30, 60 and 90 kg ha^{-1}) and three levels of FYM (0, 6.25 and 12.5 t ha^{-1}) (Table 2).

The Integrated Plant Nutrition System (IPNS) treatment, which consisted of three treatments: NPK alone (OM I), NPK+ Farm yard manure @ 6.25 t ha^{-1} (OM II) and NPK + Farm yard manure @12.5 t ha^{-1} (OM III) were super imposed across the strips following the Fractional Factorial design. This allowed for the randomization of 21 fertilizer treatments and three controls, with each treatment being present in all three strips in either direction (Table 3).

"The treatment structure is given in the test crop Cotton was planted with a spacing of 60 cm x 45 cm. After planting Routine cultural operations were followed periodically. The crop was grown to maturity, harvested and plot wise yields were recorded. The seed cotton weight, plant and post-harvest soil samples were collected from each plot and processed and analyzed for N, P and K contents, and NPK uptake by Cotton was computed using the dry matter yield" (Ramamoorthy et al., 1967).

"The basic parameters, namely nutrient requirements (NR), contribution of nutrients from soil (Cs), fertilizer (Cf), and farmyard manure (Cfym), were computed using the data on the yield of cotton, total uptake of N, P_2O_5, and K_2O, initial soil test values for available N, P_2O_5, and K_2O, and doses of fertilizers of N, P_2O_5, and K_2Oapplied. These computations were made using the methodology" (Ramamoorthy et al.,1967)

Table 1. Fertilizer doses applied to the gradient crop rice

Strip	Levels of Nutrients			Fertilizer doses (kg ha^{-1})		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
I	N_0	P_0	K_0	0	0	0
II	N_1^*	P_1^{**}	K_1^{**}	150	343	121
III	N_2	P_2	K_2	300	686	242

**: As per Blanket recommendation*
***: As per P and K fixing capacities of the soil*

Table 2. Levels of fertilizer nutrients and FYM for cotton

Level	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	FYM (t ha^{-1})
0	0	0	0	0
1	60	30	30	6.25
2	120	60	60	12.5
3	180	90	90	-

1. Nutrient requirement (NR) kg q^{-1}

$$\text{kg of N/ } P_2O_5\text{/ } K_2O \text{ required per quintal of seed cotton production} = \frac{\text{Total uptake of N/ } P_2O_5\text{/ } K_2O \text{ (kg ha}^{-1})}{\text{seed cotton (q ha}^{-1})}$$

Table 3. Treatment structure of test crop experiment on cotton

Sl. No.	Treatment Combinations			Levels of Nutrients (kg ha^{-1})		
	N	**P**	**K**	**N**	**P_2O_5**	**K_2O**
1.	0	0	0	0	0	0
2.	0	0	0	0	0	0
3.	0	0	0	0	0	0
4.	0	2	2	0	60	60
5.	1	1	1	60	30	30
6.	1	2	1	60	60	30
7.	1	1	2	60	30	60
8.	1	2	2	60	60	60
9.	2	1	1	120	30	30
10.	2	0	2	120	0	60
11.	2	1	2	120	30	60
12.	2	2	2	120	60	60
13.	2	2	1	120	60	30
14.	2	2	0	120	60	0
15.	2	2	3	120	60	90
16.	2	3	2	120	90	60
17.	2	3	3	120	90	90
18.	3	1	1	180	30	30
19.	3	2	1	180	60	30
20.	3	2	2	180	60	60
21.	3	3	1	180	90	30
22.	3	3	2	180	90	60
23.	3	2	3	180	60	90
24.	3	3	3	180	90	90

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

$$\text{Per cent contribution of N/ } P_2O_5 \text{/ } K_2O \text{ from soil} = \frac{\text{Total uptake of N/ } P_2O_5\text{/ } K_2O \text{ in control plot (kg ha}^{-1}\text{)}}{\text{STV for available N/ } P_2O_5\text{/ } K_2O \text{ in control plot (kg ha}^{-1}\text{)}} \times 100$$

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

$$\text{Per cent contribution of N/ } P_2O_5\text{/ } K_2O \text{ from fertilizer} = \frac{\text{Total uptake of N/ } P_2O_5\text{/ } K_2O \text{ in treated plot (kg ha}^{-1}\text{)} - \left(\text{Soil test value for available N/ } P_2O_5\text{/ } K_2O \text{ in treated plot (kg ha}^{-1}\text{)} \times \text{Average Cs}\right)}{\text{Fertilizer N/ } P_2O_5\text{/ } K_2O \text{ applied (kg ha}^{-1}\text{)}} \times 100$$

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

$$\text{Cfym} = \frac{\text{Total uptake of N/ } P_2O_5\text{/ } K_2O \text{ in FYM treated plot (kg ha}^{-1}\text{)} - \left(\text{STV for available N/ } P_2O_5\text{/ } K_2O \text{ in FYM treated plot (kg ha}^{-1}\text{)} \times \text{Average Cs}\right)}{\text{Nutrient N/ } P_2O_5\text{/ } K_2O \text{ added through FYM (kg ha}^{-1}\text{)}} \times 100$$

With the use of these parameters, fertilizer prescription equations were created to determine the fertilizer doses. The soil test-based fertilizer recommendations were provided in the form of a ready table for the intended yield target of cotton under both IPNS and NPK alone.

2.1 Targeted Yield equations

Making use of the four basic parameters, the fertilizer prescription equations were developed under NPK alone and STCR-IPNS for cotton as furnished below:

i) Fertilizer nitrogen (FN)

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

$$FN = \frac{NR}{Cf/100} \; T - \frac{Cs}{Cf} \; SN - \frac{Cfym}{Cf} \; ON$$

ii) Fertilizer phosphorus (FP_2O_5)

$$FP_2O_5 = \frac{NR}{Cf/100} \; T - \frac{Cs}{Cf} \; x\, 2.29 \; x\, SP$$

$$FP_2O_5 = \frac{NR}{Cf/100} \; T - \frac{Cs}{Cf} \; x\, 2.29 \; x\, SP - \frac{Cfym}{Cf} \; x\, 2.29 \; Xop$$

iii) Fertilizer potassium (FK_2O)

$$FK_2O = \frac{NR}{Cf/100} \; T - \frac{Cs}{Cf} \; x\, 1.21 \; x\, SK$$

$$FK_2O = \frac{NR}{Cf/100} \; T - \frac{Cs}{Cf} \; x\, 1.21 \; x\, SK - \frac{Cfym}{Cf} \; x\, 1.21 \; x\, OK$$

where,

T is the yield target in q ha^{-1}, NR is Nutrient requirement of N or P_2O_5 or K_2O (kg ha^{-1}), FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O (kg ha^{-1}), Cs is Per cent contribution of nutrient from soil, Cf is Per cent contribution of nutrient from fertilizer; ON, OP and OK are the quantities of N, P and K supplied through FYM in kg ha^{-1} and SN, SP and SK respectively are Soil test value for available alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1}.

Based on the afore mentioned formulae, fertilizer doses for different soil available nutrient levels can be predicted for particular seed cotton yield targets (T).

3. RESULTS AND DISCUSSION

The range and mean of soil test values and yield of three strips are presented in Table 4. Maximum mean yield (27.49 q ha^{-1}) was obtained in strip III and the lowest in the strip I (16.80 q ha^{-1}) (Fig. 1).

The data on initial soil test values with range and mean value revealed that alkaline $KMnO_4$-N ranged from 261.6 to 282.8 kg ha^{-1} with a mean value of 275.8 kg ha^{-1} in strip I and from 282.6 to 305.2 kg ha^{-1} with a mean values of 297.6 kg ha^{-1} in strip II and from 292.3 to 322.0 kg ha^{-1} with a mean value of 313.7 kg ha^{-1} in strip III. The Olsen-P ranged from 48.8 to 61.8, 55.6 to 77.8 and 60.2 to 83.8 kg ha^{-1}, respectively in strip I, II and III. The mean values of Olsen-P were 57.8, 70.1 and 74.6 kg ha^{-1} in strip I, II and III, respectively. The range of NH_4OAc-K varied between 348 and 390 with mean values of 376 kg ha^{-1} in strip I, 350 and 418 with the mean value of 408 kg ha^{-1} in strip II and 367 and 439 with a mean value of 428 kg ha^{-1} in strip III (Fig. 2).

The N uptake in strip I, II and III, ranged, respectively from 28.2 to 97.5, 30.1 to 136.8 and 32.2 to 148.5 with the mean values of 67.0, 87.9 and 94.3 kg ha^{-1}. The P uptake ranged from 6.8 to 29.1 kg ha^{-1} with a mean of 19.9 kg ha^{-1} in strip I, from 7.9 to 41.2 kg ha^{-1} with a mean of 25.6 kg ha^{-1} in strip II and from 8.4 to 42.2 kg ha^{-1} with a mean of 26.9 kg ha^{-1} in strip III. The K uptake ranged from 33.6 to 94.1, 36.9 to 107.2 and 41.2 to 112.4 kg ha^{-1} in strip I, II and III, respectively. The mean K uptake values were 69.3, 83.6 and 87.7 kg ha^{-1}, respectively in strip I, II and III (Fig. 3).

The above-mentioned findings demonstrated the significant diversity in the soil test results, seed cotton production, and nutrient uptake all of which are necessary to compute the basic parameters and fertilizer prescription equations needed to calibrate fertilizer doses for particular yield targets.

Table 4. Pre-sowing soil available NPK, yield and NPK uptake by cotton in various strips (kg ha^{-1})

Parameters (kg ha^{-1})	Strip I		Strip II		Strip III		Overall			
							Treated (NPK)		Control (NPK)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
$KMnO_4$ -N	261.6 - 282.8	275.8	282.6 - 305.2	297.6	292.3 - 322.0	313.7	268.8 - 322.0	297.9	261.6 - 301.6	282.8
Olsen–P	48.8 - 61.8	57.8	55.6 - 77.8	70.1	60.2 - 83.8	74.6	54.8 - 83.8	68.8	48.8 - 66.4	59.6
NH_4OAc-K	348 - 390	376	350 – 418	408	367 - 439	428	367 - 439	409	348 - 412	379
Seed cotton yield (q ha^{-1})	8.12 - 33.00	21.04	9.20 - 34.65	23.20	10.90 - 36.65	26.10	11.15 - 36.65	24.98	8.12 - 17.95	13.40
N uptake	28.2 - 97.5	67.0	30.1 - 136.8	87.9	32.2 - 148.5	94.3	40.6 - 148.5	89.8	28.2 - 49.6	40.1
P uptake	6.8 - 29.1	19.9	7.9 - 41.2	25.6	8.4 - 42.2	26.9	13.3 - 42.0	26.1	6.8 - 16.2	11.4
K uptake	33.6 - 94.1	69.3	36.9 - 107.2	83.6	41.2 - 112.4	87.7	56.8 - 112.4	85.8	33.6 - 56.8	46.5

Table 5. Nutrient requirement, per cent contribution of nutrients from soil, fertilizer and FYM for cotton.

Parameters	Basic Data			Response yard stick (kg kg^{-1})
	N	P_2O_5	K_2O	
Nutrient requirement (kg q^{-1})	3.49	2.37	4.22	6.64
Per cent contribution from soil (Cs)	10.82	14.03	10.88	
Per cent contribution from fertilizers (Cf)	47.90	68.35	98.20	
Per cent contribution from FYM (Cfym)	38.45	21.25	26.04	

Table 6. Soil test-based fertilizer prescription under IPNS for yield target of 35 q ha^{-1} for cotton (kg ha^{-1})

IPNS							
Parameter	NPK alone (kg ha^{-1})	NPK + FYM 6.25 t ha^{-1} (kg ha^{-1})	Fertilizer saving (kg ha^{-1})	Per cent reduction over NPK	NPK + FYM 12.5 t ha^{-1} (kg ha^{-1})	Fertilizer saving (kg ha^{-1})	Per cent reduction over NPK
$KMnO_4$-N (kg ha^{-1})							
280	177	151	26	14.7	125	52	29.3
300	173	147	26	15.0	121	52	30.0
320	168	142	26	15.5	116	52	30.9
340	164	138	26	15.9	112	52	31.7
360	159	133	26	16.4	107	52	32.7
380	155	129	26	16.8	103	52	33.5
400	150	124	26	17.3	98	52	34.7
Olsen – P (kg ha^{-1})							
10	110	95	15	13.6	80	30	27.3
12	109	94	15	13.8	79	30	27.5
14	108	93	15	13.9	78	30	27.8
16	107	92	15	14.0	77	30	28.0
18	106	91	15	14.2	76	30	28.3
20	105	90	15	14.3	75	30	28.5
22	104	89	15	14.4	74	30	28.8
NH_4OAc-K (kg ha^{-1})							
100	129	105	24	18.6	81	48	37.2
120	126	102	24	19.0	79	47	37.3
140	123	100	23	18.7	76	47	38.2
160	121	97	24	19.8	73	48	39.7
180	118	94	24	20.3	71	47	39.8
200	115	92	23	20.0	68	47	40.9
220	113	89	24	21.2	65	48	42.5

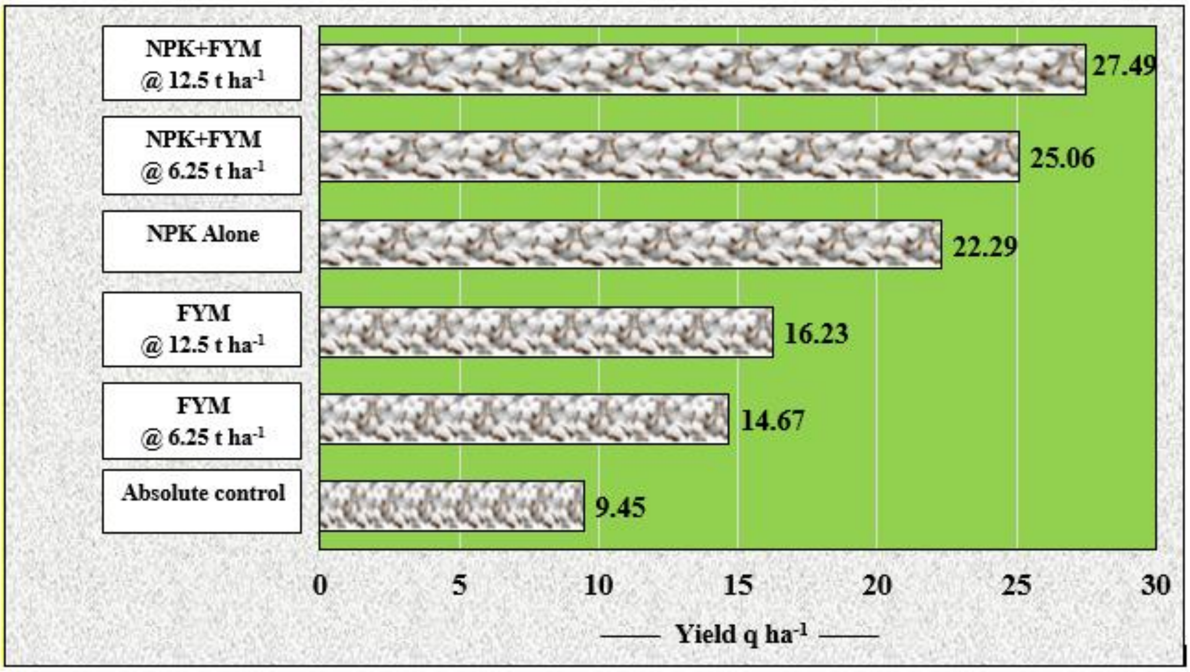

Fig. 1. Effect of IPNS on mean seed cotton yield (q ha^{-1})

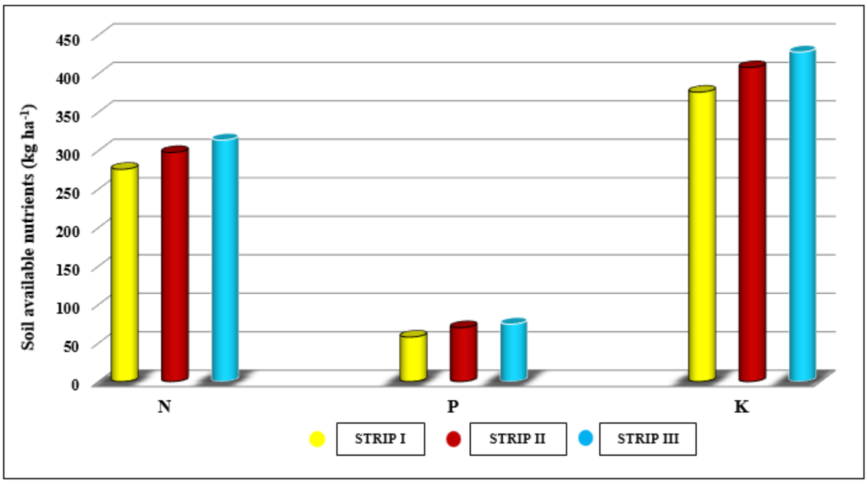

Fig. 2. Initial soil fertility in different strips of test crop (cotton)

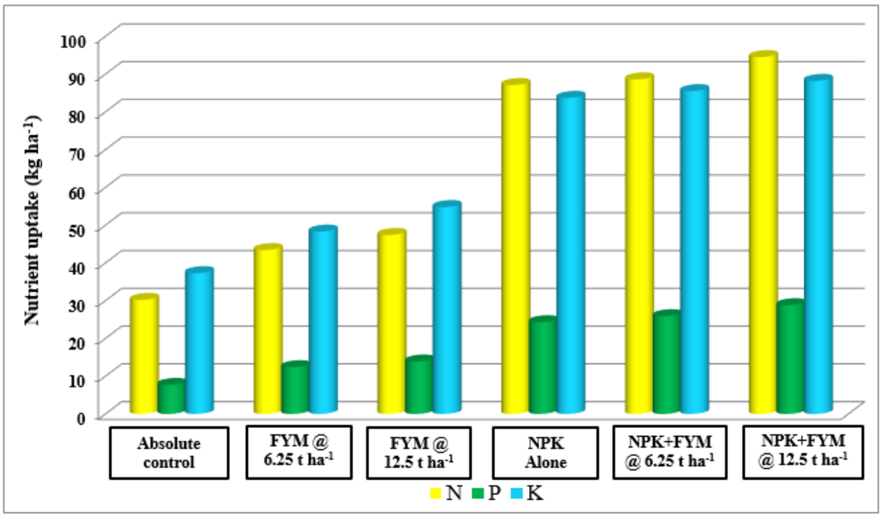

Fig. 3. Effect of IPNS on mean total nutrient uptake by cotton (kg ha^{-1})

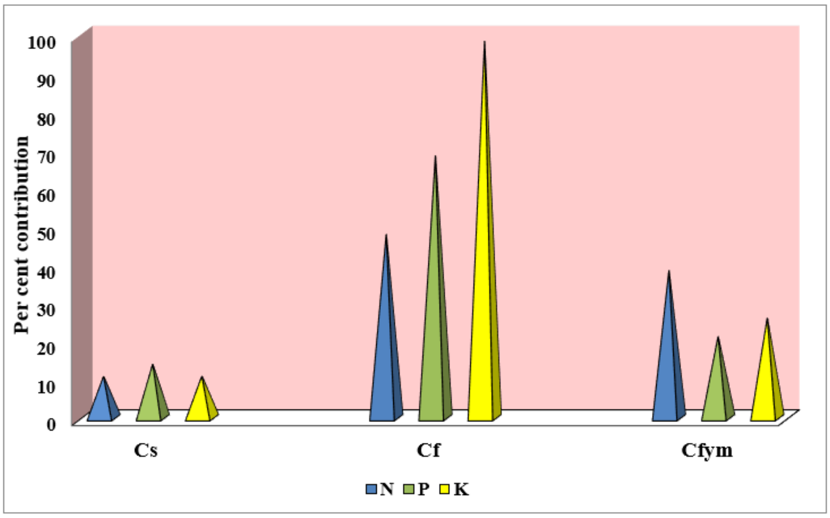

Fig. 4. Per cent contribution of nutrients from soil (Cs), fertilizer (Cf) and FYM (Cfym)

Basic parameters: The three basic parameters nutrient requirement (NR) in kg per quintal of economic produce, percentage contribution from soil available nutrient (Cs), and fertilizer nutrients (Cf) (Table 5) were calculated using the targeted yield model in order to calibrate soil test results and recommend fertilizer dosages for desired seed cotton yield targets (Fig. 4).

Nutrient requirement of seed cotton: The quantity of N, P_2O_5 and K_2O required to produce one quintal (100 kg) of seed cotton were 3.49, 2.37 and 4.22 kg respectively. Among the three nutrients, the requirement of K_2O is the highest followed by N and P_2O_5. The requirement of K_2O was 1.21 times higher than N and 1.78 times higher than P_2O_5. Similar trend of nutrient requirement for N, P_2O_5 and K_2O was reported by Subba Rao and Rathore (2003) for rainfed cotton (var.Narasimha) on vertisol, "The major demand for K by the plant comes at boll set stage and therefore even in soils with high available K, in-season can develop K shortage due to the heavy demand during rapid boll set and fill" (Gormus *et al*., 2002). Jagvir Singh and Blaise (2000) have also reported the affinity of cotton towards potassium.

Per cent contribution of nutrients from soil (Cs) to total nutrient uptake of cotton: The per cent contribution of nutrients from soil (Cs) to the total uptake was computed from the absolute control plots and it expresses the capacity of the crop to extract nutrients from the soil. In the present study, it was observed that the soil has contributed 10.82, 14.03 and 10.88 per cent of available N, P and K towards the total N, P and K uptake by cotton. Among the three nutrients, the per cent contribution from soil was higher for P followed by K and N. Comparatively lower Cs were seen for N and K, which may be because cotton prefers applied N and K2O over native N and K. This is consistent with the findings of Subba Rao and Rathore (2003), Muralidharudu*et al*. (2007) and Popat Kadu *et al*. (2012).

Per cent contribution of nutrients from fertilizer (Cf) to total nutrient uptake of cotton: "From the NPK applied plots, the per cent contribution of nutrients from fertilizers (Cf) to the total uptake was computed. The percentage of nutrients from fertilizers (Cf) that contributed to the overall absorption was calculated from the NPK-applied plots. The contribution of applied fertilizer in the current study was 47.90, 68.35, and 98.20 percent for N, P_2O_5 and K_2O, respectively, and it followed the sequence K_2O > P_2O_5 > N. The response yardstick recorded was 6.64 kg kg^{-1}. The calculated Cf showed that the amount of fertilizer K_2O contributed was 1.44 times that of N and 2.05 times that of P_2O_5. Each of the three nutrients N, P_2O_5, and K_2O had a greater contribution from fertilizers than from soil to cotton's overall uptake" (Subba Rao and Rathore, 2003), Muralidharudu *et al.,* 2007 and Popat Kadu *et al*., 2012).

Fertilizer prescription equation for cotton under IPNS: Using the basic parameters computed (NR, Cs, Cf and Cfym), fertilizer prescription equations were developed under IPNS and are furnished below.

NPK alone

$$FN = 7.29\ T - 0.23\ SN$$
$$FP_2O_5 = 3.47\ T - 0.47\ SP$$
$$FK_2O = 4.30\ T - 0.13\ SK$$

NPK with FYM

$$FN = 7.29\ T - 0.23\ SN - 0.80\ ON$$
$$FP_2O_5 = 3.47\ T - 0.47\ SP - 0.71\ OP$$
$$FK_2O = 4.30\ T - 0.13\ SK - 0.32\ OK$$

where, T is the yield target in q ha^{-1}; SN, SP and SK respectively are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1}; ON, OP and OK are the quantities of N, P and K supplied through FYM in kg ha^{-1} and FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1} respectively.

Fertilizer prescription under IPNS for desired yield target of cotton

Ready reckoners (nomograms) were formulated for a range of soil test values and for desired yield targets (Table 6). An average soil available N, P and K of 280, 20 and 200 kg ha^{-1} respectively was considered to compare the fertilizer recommendation. The results showed that for achieving 33 q ha^{-1} of cotton, the doses of fertilizer N, P_2O_5 and K_2O required would be 177, 105 and 115 kg ha^{-1}, respectively for NPK alone, 151, 90 and 92 kg ha^{-1}, respectively for NPK + FYM @ 6.25 t ha^{-1} and 125, 75 and 68 kg ha^{-1}, respectively for NPK + FYM @ 12.5 t ha^{-1}.

The per cent reduction in NPK fertilizers under IPNS increased with increasing soil fertility levels (i.e. increasing FYM application) with reference to NPK and decreased with increasing yield targets. The results of the above finding are in line with the results of Balamurugan (2009) in wheat, Coumaravel (2012) in maize and tomato and Bagavathi Ammal and Sankar (2012) in rice, Santhi *et al.* (2017) and Karuna prabhu (2018) in bhendi.

The data clearly indicated that fertilizers rate decreased with increasing soil test values and FYM alone. This was due to contribution of nutrients from soil as well as FYM to fulfill the nutrient requirement of crops. This fact has also been established by Velayutham*et al*. (1985) and Jyoti Pande and Soabaran Singh (2016).

Using the fertilizer prescription equations under IPNS, the magnitude of saving of inorganic fertilizers for cotton was calculated. Application of FYM @ 6.25 t ha^{-1} with 26 per cent moisture and 0.56, 0.32 and 0.51 per cent N, P and K, respectively the savings were 26, 15 and 24 kg ha^{-1} of fertilizer N, P_2O_5 and K_2O, respectively. If FYM @ 12.5 t ha^{-1} was applied with above quality, the saving of fertilizer N, P_2O_5 and K_2O would be 52, 30 and 48 kg ha^{-1}, respectively.

The findings indicate that using an integrated nutrient application approach combining organic manure with inorganic fertilizers is more effective than using inorganic fertilizers alone for achieving higher yield and nutrient uptake in cotton. "Integrated Plant Nutrient System (IPNS) enhances soil fertility, supporting sustained cotton yields while reducing environmental pollution. Additionally, fertilizer recommendations based on Soil Test Crop Response (STCR) provide guidance on achievable yield targets through sound agronomic practices. This approach not only boosts yield but also increases profitability by lowering cultivation costs through efficient fertilizer use. The developed fertilizer prescription equation can therefore be applied to recommend fertilizers for targeted cotton yields in the Thirunallar soil series of Karaikal" (Balamurugan, 2009; Bagavathi et al., 2020).

4. CONCLUSIONS

The study concluded that integrating organic manure with inorganic fertilizers through integrated nutrient management (INM) is more effective than using inorganic fertilizers alone. This approach resulted in higher seed cotton yields and improved nutrient uptake. The Integrated Plant Nutrient System (IPNS) enhances soil fertility, supports sustainable crop productivity, and reduces environmental pollution. Moreover, fertilizer recommendations based on Soil Test Crop Response (STCR) enable precise yield targeting by adopting suitable agronomic practices, leading to increased profitability through higher yields and lower fertilizer costs. The fertilizer prescription equations developed in this research provide practical solutions for achieving targeted seed cotton production in the Thirunallar soil series of Karaikal.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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