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Effect of STCR-IPNS-Based Fertiliser Recommendation on Yield Attributes and Quality of Cotton Seed in The Coastal Karaikal Region

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Abstract

To assess the influence of IPNS on cotton seed quality an experiment was conducted with ten treatments, blanket recommendations, Soil Test Crop Response (STCR_-NPK alone for 3.1, 3.3 and 3.5 Mg ha^{-1} yield targets, STCR-IPNS for 3.1, 3.3 and 3.5 Mg ha^{-1} yield targets, farmers' practice and absolute control in RBD with three replications at farmers' holdings at Varichikudy, Karaikal. The soil of the experimental field was clay in texture, taxonomically *Typic Haplusterts*. The results of the field experiment showed that the application of STCR+IPNS-35 q ha-1 resulted in higher plant height, LAI, monopodia per plant, and sympodia per plant at all crop growth stages, which was comparable to other STCR+IPNS treatments. A higher number of fruiting points per plant (73.47) was recorded in the STCR+IPNS-3.3 Mg ha^{-1}, which was on par with other STCR+IPNS treatments. Higher bolls plant^{-1} (64.32), boll setting percentage (87.66 %), boll weight (4.76 g) and Bartlett's Earliness **Index** (BEI) (0.59) were recorded in STCR+IPNS-3.5 Mg ha^{-1}. The highest seed cotton yield (36.00 q ha^{-1}), stover yield (5930 kg ha^{-1}), ginning per cent (42.52 %), seed index (9.19) and lint index (6.82) were recorded in STCR+IPNS-3.5 Mg ha^{-1} treatment. The highest seed cotton yield in STCR-IPNS 3.5 Mg ha^{-1} was 40.35 % and 34.63 % higher than the seed cotton yield recorded by farmers' practice (2.65 Mg ha^{-1}) and blanket recommendation (2.67 Mg ha^{-1}), respectively, and 114.9 % higher than control (1.67 Mg ha^{-1}). and response ratio (7.10).

Keywords: Cotton, Fertilizer prescription equation, Soil Test Crop Response (STCR), Integrated plant nutrient supply (IPNS)

Introduction

Food crops are those that are grown only to be consumed, whereas non-food or fiber crops are planted for economic gain. In India, the area under cotton cultivation is between 12 and 13.5 million hectares, compared with the world area under cultivation (32.91 million hectares), and accounts for about 24 per cent of world cotton production. India uses about 6.34 million Mg of cotton, compared with the world's use of about 26.09 million Mg (The Cotton Corporation of India Ltd., 2022). To minimize India's current annual negative nutrient balance, increased use of organic resources along with chemical fertilizers would be essential and inevitable. Thus, the only way to prevent further nutrient mining and sustain crop productivity, as well as soil health and crop quality, on a long-term basis is through IPNS. Although the integrated plant nutrient supply (IPNS) is an old concept, its importance was not realised earlier due to low nutrient turnover in the soil-plant system. Now, it has assumed great importance, firstly because of the present negative nutrient balance, and secondly, because neither chemical fertilisers alone nor organic sources exclusively can achieve the sustainability of soil production. Among the various methods of fertiliser recommendations, the one based on yield targeting is unique because it considers not only the soil test-based fertiliser dose but also the yield level the farmer can achieve if good agronomic practices are followed. This targeted yield approach is also scientifically sound as the balanced fertilization is ensured not only among the fertilizer nutrients but also the soil available nutrients (Veeranna and Srijaya, 2017). Fertilizer

Prescription Equations (FPEs) under IPNS was developed for cotton in Thirunallar Soil series (*Typic Haplusterts*) (Sakthi Priyanka, 2021). These equations are to be validated at farmer's holding before adoption. Therefore, the present research work has been undertaken with the objectives of validating the Fertiliser Prescription Equation for cotton in the Thirunallar Soil series and evaluating the effects of varying NPK and IPNS fertiliser doses on growth, yield attributes, and yield of the cotton crop.

Materials and Methods

The field experiment was conducted with cotton hybrid (RCH 659) with ten treatments, blanket recommendations, FYM alone, STCR-NPK alone for 3.1, 3.3 and 3.5 Mg ha^{-1} yield targets, STCR-IPNS for 3.1, 3.3 and 3.5 Mg ha^{-1} yield targets, farmers practice and absolute control in RBD with three replications at farmers' holding at Varichikudy, Karaikal. The study area comes under coastal alluvial plain (PC1) classified as fine, smectitic isohyperthermic, *Typic Haplusterts* with an area of 26.14 per cent. The soil was found to be non-saline 0.48 dSm^{-1}) and neutral (pH-7.20). The CEC of soil was 21.9 cmol (p$^+$) kg^{-1}. The fertility status of the soil was low in $KMnO_4$-N (200.48 kg ha^{-1}) and medium in organic carbon (0.58 per cent) and high in Olsen-P (69.4 kg ha^{-1}) and NH_4OAc-K (348 kg ha^{-1}). For STCR treatments, the fertilizer doses were computed using the fertilizer prescription equations developed under NPK alone and IPNS. For STCR-IPNS treatments, FYM was applied @ 12.5 Mg ha^{-1} basally. The applied FYM had 30% moisture, 0.53%, 0.27%, and 0.51% NPK, respectively. The quantities of N, P and K contributed through FYM were subtracted from the inorganic fertilizer doses applied for STCR-IPNS treatments (Table 1). Soil test crop response (STCR) recommendation based on initial soil test values of available N, P and K kg ha^{-1}. The application of nitrogen as urea was taken up in three splits, i.e., 50 per cent as basal and the remaining dose of N was applied at 45 and 65 DAS. Phosphorus and potassium were applied as basal in the form of single super phosphate and muriate of potash, respectively as per the treatments.

Fertilizer Prescription Equations for Cotton

STCR-IPNS

FN = 7.29 T – 0.23 SN-0.80 ON

FP_2O_5 = 3.47 T – 0.47 SP – 0.71OP

The yield parameters were calculated by using the following formula

$$\text{Boll setting percent} = \frac{\text{Number of bolls harvested plant}^{-1}}{\text{Number of fruiting points plant}^{-1}} \times 100$$

Ginning per cent (Santhanam, 1976)

$$\text{Ginning (\%)} = \frac{\text{Weight of the lint (g)}}{\text{Weight of the seed cotton (g)}} \times 100$$

Lint index (Khan *et al.,* 2010)

$$\text{Lint index} = \frac{\text{seed index x Ginning \%}}{100 - \text{Ginning \%}}$$

Earliness in seed cotton harvested under various treatments was calculated by means of

Table 1. Fertilizer rate for Cotton under various treatments

S.No.	Treatment details	N (kg)	P_2O_5 (kg)	K_2O (kg)	FYM (Mg ha^{-1})
1	T_1- Control	0	0	0	0
2	T_2- FYM (12.5 Mg ha^{-1}) alone	-	-	-	12.5
3	T_3- Farmers' practice	100	50	50	0
4	T_4- Blanket Recommendation	120	60	60	0
5	T_5- STCR-NPK alone – 3.1 Mg ha^{-1}	181	80	83	0
6	T_6- STCR-NPK alone – 3.3 Mg ha^{-1}	196	88	92	0
7	T_7- STCR-NPK alone – 3.5 Mg ha^{-1}	210	95	100	0
8	T_8- STCR+IPNS – 3.1 Mg ha^{-1}	133	56	38	12.5
9	T_9- STCR+IPNS – 3.3 Mg ha^{-1}	148	63	46	12.5
10	T_{10}- STCR+IPNS – 3.5 Mg ha^{-1}	163	71	54	12.5

assessing the Bartllet's Earliness Index (Bartllet, 1947).

$$BEI = \frac{P_1+(P_1+P_2)+\cdots+(P_1+P_2+\cdots+P_n)}{(P_1+P_2+\cdots+P_n)\ x\ n}$$

Where, P_1, $P_2 \ldots P_n$ are the seed cotton yield in kg for each picking and n is the number of pickings.

Response Ratio (RR- kg kg^{-1})

Response (kg ha^{-1}) / Quantities of N, P_2O_5 and K_2O applied (kg ha^{-1}).

Per cent achievement (%)

$$\text{Per cent achievement} = \frac{\text{Yield obtained in STCR treatment (q ha}^{-1})}{\text{Yield target (q ha}^{-1})} \times 100$$

Results and Discussion

Growth parameters of cotton

The results of field experiment shown that application of STCR+IPNS-3.5 Mg ha^{-1} recorded higher plant height at 30 DAS (46.44cm), 60 DAS (62.52cm), 120 DAS (89.07cm) and 150 DAS (99.45cm) (Table 2). Application of STCR+IPNS-3.5 Mg ha^{-1} registered the highest LAI of 0.56 and was comparable with STCR+IPNS- 3.3 Mg ha^{-1} which in turn comparable with STCR+IPNS- 3.1 Mg ha^{-1}. The number of monopodia plant^{-1} (2.89) and sympodia plant^{-1} (14.00), was the highest in the STCR+IPNS treatments which was on par with all other treatments except control and FYM alone (Table 3). It could also be due to influence of organic manure/FYM combined with soil test-

Table 2. Effect of different fertilizer doses of STCR-NPK alone and STCR - IPNS on plant height (cm)

Treatments	30 DAS	60 DAS	120 DAS	150 DAS
T_1-Control	22.33	39.52	64.19	72.23
T_2-FYM (12.5 Mg ha^{-1}) alone	24.83	44.84	68.33	76.75
T_3-Farmer's Practice	27.40	46.17	70.40	80.50
T_4-Blanket Recommendation	33.13	53.56	76.33	81.22
T_5-STCR-NPK alone-3.1 Mg ha^{-1}	35.70	55.16	78.23	85.56
T_6-STCR-NPK alone-3.3 Mg ha^{-1}	37.82	57.36	80.20	88.14
T_7-STCR-NPK alone-3.5 Mg ha^{-1}	39.93	59.93	82.93	90.62
T_8-STCR+IPNS-3.1 Mg ha^{-1}	40.39	60.00	83.33	93.70
T_9-STCR+IPNS-3.3 Mg ha^{-1}	42.03	61.50	85.12	96.30
T_{10}-STCR+IPNS-3.5 Mg ha^{-1}	46.44	62.52	89.07	99.45
S.Ed±	1.42	2.17	3.10	3.44
LSD (p=0.05)	2.98	4.56	6.50	7.21

Table 3. Effect of different fertilizer doses of STCR-NPK alone and STCR – IPNS on Leaf Area Index, Monopodia plant^{-1} and Sympodia plant^{-1}

Treatments	LAI			Monopodia plant^{-1}		Sympodia plant^{-1}	
	30 DAS	60 DAS	120 DAS	120 DAS	150 DAS	120 DAS	150 DAS
T_1-Control	0.26	0.42	0.64	1.33	2.44	9.33	11.89
T_2-FYM (12.5 Mg ha^{-1}) alone	0.32	0.50	0.74	1.56	2.56	11.44	12.11
T_3-Farmer's Practice	0.33	0.60	0.78	1.56	2.67	11.56	12.11
T_4-Blanket Recommendation	0.35	0.63	0.79	1.56	2.67	11.56	13.00
T_5-STCR-NPK alone-3.1 Mg ha^{-1}	0.40	0.68	0.88	1.67	2.78	12.33	13.11
T_6-STCR-NPK alone-3.3 Mg ha^{-1}	0.42	0.69	0.90	1.67	2.78	12.44	13.56
T_7-STCR-NPK alone-3.5 Mg ha^{-1}	0.45	0.70	0.91	1.89	2.78	13.44	13.89
T_8-STCR+IPNS-3.1 Mg ha^{-1}	0.52	0.92	1.00	2.00	2.89	13.89	14.11
T_9-STCR+IPNS-3.3 Mg ha^{-1}	0.54	0.95	1.07	2.11	2.89	13.89	14.67
T_{10}-STCR+IPNS-3.5 Mg ha^{-1}	0.56	0.99	1.10	2.22	2.89	14.00	14.89
S.Ed ±	0.01	0.03	0.04	*0.07*	*0.11*	*0.49*	*0.53*
LSD (p=0.05)	0.03	0.06	0.07	0.14	0.22	1.03	1.11

based fertilizer recommendation, which stimulated better plant and root growth by providing hormones, vitamins and other organic acids produced during decomposition of FYM and balanced fertilizer application. The organic acids could have solubilized the native and applied nutrients present in the soil which increased the growth and yield parameters of cotton. Rajakumar (2014), Sreenadha Reddy (2014), and Mageshen (2019) have also reported similar trends in crop Bhindi.

Yield components of cotton

The treatment which received fertilizer plus FYM (12.5 Mg ha^{-1}) with a target yield of 3.3 Mg ha^{-1} recorded higher number of fruiting points plant^{-1} (73.59) (Table 4). The soil that received STCR+IPNS-3.5 Mg ha^{-1} recorded a higher number of bolls (64.32), which was on par with STCR+IPNS-3.3 Mg ha^{-1}, which in turn was comparable with STCR+IPNS-3.1 Mg ha^{-1} and STCR-NPK alone-3.5 Mg ha^{-1} treatments. The STCR+IPNS-3.5 Mg ha^{-1} treatment recorded a higher boll setting percentage (87.66%), which was comparable to other STCR+IPNS and all STCR-NPK-alone treatments. The plot, which received the STCR+IPNS-3.5 Mg ha^{-1} treatment, recorded a higher boll weight (4.76 g) and was on par with other STCR+IPNS and all STCR-NPK-alone treatments. The BEI (Bartlett's Earliness Index) ranged from 0.51 in the control to 0.59 in the STCR+IPNS-3.5 Mg ha^{-1} treatment. The addition of organic manure, along with balanced nutrient addition to the soil, increased microbial activity, which might have produced growth regulators, leading to activation of cell division, cell elongation, and formation of more tissues, resulting in good vegetative growth and other yield parameters.

Yield of cotton

The higher cotton yield was recorded in STCR+IPNS- 3.5 Mg ha^{-1} (36.00 q ha^{-1}) which was comparable with STCR+IPNS- 3.3 Mg ha^{-1} treatment and significantly different from other treatments. The higher stover yield of 5930 kg ha^{-1} was found with STCR+IPNS-3.5 Mg ha^{-1} which did not differ significantly with other STCR-IPNS treatments and STCR-NPK alone-3.3 Mg ha^{-1} which in turn recorded comparable stover yield of 5.30 Mg ha^{-1}and 5.25 Mg ha^{-1} with STCR-NPK alone-3.5 Mg ha^{-1} and STCR-NPK alone-3.1 Mg ha^{-1}, respectively (Table 5). Increase in yield may be due to an increase in LAI, leading to higher photosynthesis and accumulation of a high number of metabolites in the plant system. The increase in yield due to the integration of organic and inorganic is quite expected. The positive and favourable influence of organic manure application on the physical, chemical, physico-chemical and biological properties needs no further emphasis as it is well established. The efficacy of inorganic fertilizers was much pronounced when they were combined with organic manure (Fritz and Wonneberger, 1973). The better physical environment provided by

Table 4. Effect of different fertilizer doses of STCR-NPK alone and STCR - IPNS on yield components

Treatments	Fruiting Points plant^{-1}	Bolls plant^{-1}	Boll setting (%)	Boll weight (g)	BEI
T_1-Control	44.86	23.31	52.06	3.89	0.51
T_2-FYM (12.5 Mg ha^{-1}) alone	50.23	30.26	60.21	3.98	0.53
T_3-Farmer's Practice	62.26	44.87	72.18	3.99	0.54
T_4-Blanket Recommendation	65.69	47.40	72.23	4.14	0.54
T_5-STCR-NPK alone-3.1 Mg ha^{-1}	66.68	56.52	84.84	4.53	0.55
T_6-STCR-NPK alone-3.3 Mg ha^{-1}	69.01	58.48	85.03	4.56	0.56
T_7-STCR-NPK alone-3.5 Mg ha^{-1}	70.45	60.29	85.73	4.58	0.56
T_8-STCR+IPNS-3.1 Mg ha^{-1}	70.43	60.33	85.78	4.70	0.57
T_9-STCR+IPNS-3.3 Mg ha^{-1}	73.59	63.21	85.94	4.71	0.58
T_{10}-STCR+IPNS-3.5 Mg ha^{-1}	73.47	64.32	87.66	4.76	0.59
S.Ed ±	1.59	1.40	3.60	0.21	0.01
LSD (p=0.05)	3.33	2.94	7.54	0.43	0.02

Table 5. Effect of different fertilizer doses of STCR-NPK alone and STCR - IPNS on yield and Quality of cotton

Treatments	Seed cotton yield (Mg ha^{-1})	Stover yield (Mg ha^{-1})	Ginning per cent	Seed Index	Lint Index
T_1-Control	1.68	4.27	31.79	7.79	3.64
T_2-FYM (12.5 Mg ha^{-1}) alone	2.23	4.59	36.39	8.38	4.80
T_3-Farmer's Practice	2.57	5.04	34.78	7.76	4.15
T_4-Blanket Recommendation	2.67	5.17	35.75	7.55	4.22
T_5-STCR-NPK alone-3.1 Mg ha^{-1}	3.11	5.25	35.90	8.05	4.52
T_6-STCR-NPK alone-3.3 Mg ha^{-1}	3.21	5.36	35.97	8.20	4.64
T_7-STCR-NPK alone-3.5 Mg ha^{-1}	3.24	5.31	36.93	8.35	4.91
T_8-STCR+IPNS-3.1 Mg ha^{-1}	3.29	5.75	38.50	8.69	5.46
T_9-STCR+IPNS-3.3 Mg ha^{-1}	3.46	5.85	41.54	8.99	6.42
T_{10}-STCR+IPNS-3.5 Mg ha^{-1}	3.60	5.93	42.52	9.19	6.82
S.Ed ±	0.12	2.93	1.46	0.33	0.50
LSD (p=0.05)	0.25	6.18	3.07	0.68	1.05

organics favours good root growth, which facilitates efficient utilisation of applied nutrients, thus resulting in higher yield. Similar observations were also reported by Lalithakumari *et al.* (2010) in cotton.

The perusal of the results revealed that, with increase in yield targets, there was a proportionate increase in yield levels. The highest seed cotton yield of 3.6 Mg ha^{-1} was recorded in STCR-IPNS 3.5 Mg ha^{-1}, which was 40.35 % and 34.63 % higher than the seed cotton yield recorded by farmer's practice (2.56 Mg ha^{-1}) and blanket recommendation (2.67 Mg ha^{-1}), respectively and 114.9 % higher than control (1.68 Mg ha^{-1}). The seed cotton and stover yield reductions in farmers' practices and blanket recommendations relative to STCR-IPNS treatments might be due to a mismatch between nutrient supply and crop requirements, without accounting for the initial soil nutrient status.

The results of the present investigation also revealed that under STCR-NPK alone and IPNS treatments, there was a concomitant increase in seed cotton and stover yields with increase in yield target, which could be ascribed to the application of increased doses of nutrients to achieve higher yield targets. Among the same yield targets, the STCR-IPNS treatments recorded relatively higher seed cotton and stover yields than those under STCR-NPK alone treatments due to the cumulative effect of FYM and inorganic fertilisers on increased growth and yield parameters, nutrient availability and uptake, which have resulted in higher yield. Under IPNS, FYM can maintain plant nutrients in available forms for longer period due to improved soil organic matter (SOM) and soil physico-chemical and biological characteristics. Inorganic fertilizers on the other hand, supply nutrients which are readily soluble in soil solution and thereby make nutrients instantly available to plants was also reported by Aziz *et al*. (2010), Bodruzzaman *et al*. (2010) and Tilahun Tadesse *et al*. (2013). Maragatham *et al*. (2012) and Velayutham and Santhi (2013) have also reported the results of a long-term STCR-IPNS demonstration in increasing the yield as compared to blanket recommendation.

Quality characters of cotton

The ginning per cent was found to be the highest in plot which received STCR+IPNS-3.5 Mg ha^{-1} treatment (42.52 %) and was comparable with STCR+IPNS-3.3 Mg ha^{-1} treatment which in turn was comparable with STCR+IPNS-3.1 Mg ha^{-1} (Table 5). The treatment that received STCR+IPNS at 3.5 Mg ha^{-1} was the best among the treatments tested and was comparable to other STCR+IPNS treatments. The lint index ranged from 3.64 in the control to 6.82 in STCR+IPNS-3.5 Mg ha^{-1}. The present investigation clearly revealed that all these quality parameters were significantly influenced by different fertilizer STCR-IPNS treatments. It is also true that there is ample evidence that the addition of organic manure can improve cotton quality. From the

Table 6. Yield, percent achievement and response ratio in cotton

S.No.	Treatments	Fertilizer dose (kg ha^{-1})			Seed cotton yield (Mg ha^{-1})	Total N/ P_2O_5 / K_2O applied	Percent achievement	Response ratio (kg kg^{-1})
		N	P_2O_5	K_2O				
1	T_1- Control	0	0	0	1.68	0	-	-
2	T_2- FYM (12.5 Mg ha^{-1}) alone	-	-	-	2.23	-	-	-
3	T_3- Farmer's practice	100	50	50	2.57	200	-	4.45
4	T_4- Blanket Recommendation	120	60	60	2.67	240	-	4.16
5	T_5- STCR-NPK alone - 3.1 Mg ha^{-1}	181	80	83	3.11	344	100.4	4.18
6	T_6- STCR-NPK alone – 3.3 Mg ha^{-1}	196	88	92	3.21	376	98.3	4.08
7	T_7- STCR-NPK alone – 3.5 Mg ha^{-1}	210	95	100	3.24	405	92.7	3.87
8	T_8- STCR+IPNS – 3.1 Mg ha^{-1}	133	56	38	3.29	227	106.1	7.11
9	T_9- STCR+IPNS – 3.3 Mg ha^{-1}	148	63	46	3.46	257	104.8	6.93
10	T_{10}- STCR+IPNS – 3.5 Mg ha^{-1}	163	71	54	3.60	288	102.9	6.68

results, it was observed that the application of organic sources like FYM enhanced seed cotton and lint yields, which could be attributed to the sustained availability of nutrients by FYM throughout the crop-growing period. Similar results have been reported by Gwarazimba (2009) for lint and seed index, Tewolde *et al.* (2007) and Beedy *et al*. (2010) for lint yield, and Abdel Aal *et al*. (2011) for seed index.

Validation of existing fertilizer prescription equations

Per cent achievement of yield targets

The per cent achievement of yield targets ranged from 92.68 under STCR -NPK alone – 3.5 Mg ha^{-1} to 106.1 under STCR+IPNS-3.1 Mg ha^{-1} (Table 6). As per the guidelines followed in AICRP-STCR, the percentage achievement of yield targets should be within ± 10 per cent variation, proving the validity of Fertiliser Prescription Equations.

In this regard, the data clearly revealed that the highest achievement of yield target was recorded with STCR+IPNS-3.1 Mg ha^{-1} (106.1 per cent) followed by STCR+IPNS-3.3 Mg ha^{-1} (104.8 per cent) and STCR+IPNS-3.5 Mg ha^{-1} (102.9 per cent). The results clearly revealed that the percentage achievement was within ±10 per cent across all yield target levels, thereby proving the validity of the Fertiliser Prescription Equations. In general, the yield targeting under IPNS recorded a relatively higher per cent achievement than that achieved under their respective STCR-NPK-alone treatments.

Response Ratio (RR)

The response ratio recorded for various treatments ranged from 3.87 kg kg^{-1} in STCR-NPK alone – 3.5 Mg ha^{-1} to 7.10 kg kg^{-1} in STCR-IPNS- 3.1Mg ha^{-1} (Table 6). Next to STCR-IPNS 3.1 Mg ha^{-1}, the highest RR was recorded under STCR-IPNS-3.3 Mg ha^{-1} (6.94 kg kg^{-1}). Among the STCR treatments, STCR-IPNS recorded a relatively higher RR than its corresponding NPK-alone treatment. However, all the STCR-IPNS treatments recorded relatively higher RR as compared to farmer's practice (4.45 kg kg^{-1}).

Conclusions

From the results of the present study, it is concluded that the highest seed cotton yield (3.6 Mg ha^{-1}), stover yield (5.93 Mg ha^{-1}) and ginning per cent of 42.52 %, seed index of 9.19 and lint index of 6.82. were significantly influenced by STCR+ IPNS at 3.5 Mg ha^{-1}. The nutrients released from STCR-NPK alone, blanket recommendation and farmers' practice were lower compared to STCR-IPNS treatments.

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