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Evaluation of yield and yield attributing parameters of rice (*Oryza sativa* L.) using different fertilizer recommendations methods

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Abstract
Rice is life is most appropriate for Indians as this crop plays a vital role in our national food security and is a means of livelihood for millions of rural households. Adequate and balanced supply is a pre-requisite to optimum plant growth and realizing potential crop yield. An experiment was conducted to evaluate yield and yield attributing parameters of rice using different fertilizer recommendations methods. The experiment consists of three replications and fourteen treatments *viz.,* farmer's practice, Blanket, STL, IARI and STCR methods of fertilizer recommendation through inorganic and organic combinations and also through solely inorganic in randomized block design (RBD). The results reveals the yield parameters, the highest grain and straw yields and the highest gross returns and net returns were found higher with the combination of STCR method through inorganic and organic for 8 t ha^{-1}. The B:C ratio was the highest in the targeted yield of 8 t ha^{-1} through inorganic alone. It is concluded that STCR method of fertilizer recommendations inveterated their supremacy on the higher productivity of rice and profitability to farmers.

Keywords: farmer's practice, blanket, STL, IARI and STCR

1. Introduction

In India rice (*Oryza sativa*) is the staple food crop for more than two thirds of the population. Rice fulfills 43 per cent of calories requirement of more than 70 per cent of the Indian population and the slogan "RICE is life" is most appropriate for India as this crop plays a vital role in our national food security and is a means of livelihood for millions of rural households. This signifies the contribution of rice in meeting food requirements to alleviate the hunger of the country. One of the reasons for lower production of rice is imbalanced fertilization of N, P and K nutrients (Reddy and Ahmed, 2000) [12].

Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection (Kimetu *et al.,* 2004) [8]. Declining soil fertility and mismanagement of plant nutrients have made this task more difficult. Balanced NPK fertilization has received considerable attention in India (Gosh *et al.,* 2004; Hegde and Babu, 2004 and Prasad *et al.,* 2004) [3, 5, 10]. Well-managed fertilizer use can create a "Win- Win" situation by increasing food production and reducing soil degradation in nutrient poor fragile soils. Today the major goal of sustainable agriculture is to maintain production at levels necessary to meet the increasing aspiration of an expanding country population without degrading the environment. Adequate and balanced supply is a pre-requisite to optimum plant growth and realizing potential crop yield.

Soil testing helps the farmers to use fertilizers according to needs of crop. Fertilizer use for targeted yield (Ramamoorthy *et al.,* 1967) [11] is an approach, which takes in to account the crop needs and nutrients present in the soil. Subsequently in India, the quantitative refinements in the fertilizer recommendations based on the soil and plant analysis were made (1967- 68) through the All India Coordinated Research Project for investigation on soil test crop response correlation (STCR). The ICAR project on soil test crop response correlation used the targeted yield approach to develop relationship between crop yields on the one hand and soil test values and fertilizer inputs on the other.

Starting from the first phase of soil analysis correlation work carried out at IARI based on low, medium and high status of major nutrients, many concepts and approaches of fertilizer recommendation have been evolved at different periods and situations by researchers viz., critical level approach, agronomic approach, nutrient mobility concept, deductive approach, inductive approach, targeted yield approach and still progress over soil test crop response correlations and studies. After analysing the merits and demerits of these important fertilizer recommendation methods and their adoption in different situations by farmers, soil testing laboratories and researchers, the present investigation is programmed to evaluate their yield and yield attributing parameters of rice.

2. Materials and Methods

A field experiment was conducted with a test crop of Improved white ponni rice variety in the sandyloam soil (isohyperthermic typic ustropept) of a farmer's field representing Saniyasikuppam series in Puducherry, during rabi season 2017-18 to evaluate yield and yield attributing parameters of rice using the different methods of fertilizer recommendations. The experiment was laid out in Randomised Block Design with three replications. There were fourteen numbers of treatments comprising of different fertilizer recommendations

T_1 - Absolute Control
T_2 - Blanket Recommendation through Inorganic
T_3 - Blanket Recommendation through Inorganic + Organic
T_4 - Farmer's Practice
T_5 -IARI Method through Inorganic
T_6 - IARI Method through Inorganic + Organic
T_7 - STL Method through Inorganic
T_8 - STL Method through Inorganic + Organic
T_9 - STCR Method through Inorganic for 6 t/ha
T_{10} - STCR Method through Inorganic + Organic for 6 t/ha
T_{11} - STCR Method through Inorganic for 7 t/ha
T_{12} - STCR Method through Inorganic + Organic for 7 t/ha
T_{13} - STCR Method through Inorganic for 8 t/ha
T_{14} - STCR Method through Inorganic + Organic for 8 t/ha

3.1. Observation

3.1.1 Panicle length: At harvest stage, panicle length was measured from the collar to the tip of the panicle in five randomly selected plants and the mean value is expressed in cm.

3.1.2 Panicle weight: The weight of five panicles from selected plants of each plot was recorded. The mean weight per panicle was calculated and expressed in grams.

3.1.3 Number of spikelets per panicle: The numbers of spikelets from five selected plants were counted and the mean value is expressed as number of spikelets per panicle.

3.1.4 Number of filled and unfilled grains per panicle: The numbers of filled and unfilled grains from five selected plants were counted separately and mean value is expressed as number of filled and unfilled grains per panicle.

3.1.5 High density grains per panicle: All the grains of the panicle from the main tiller of the selected plants were removed and immersed in NaCl salt solution of 1.2 specific gravity. Only those grains that were settled at the bottom of the solution were taken as high density grains and were counted as high density grains per panicle. The salt solutions of 1.2 specific gravity to separate high density grains was prepared by dissolving 300 g of NaCl in one litre of distilled water as per the method suggested by Padmaja Rao *et al.* (1985) [9].

3.1.6 Spikelet fertility percentage: It was derived by the following formula:

$$\text{Spikelet fertility} = \frac{No.of\ .filled\ grains\ per\ panicle}{No.of\ .spikelets\ per\ panicle} \times 100$$

3.1.7 Test weight

A sample of 1000 grains from each plot was taken from the filled grains and the weight was recorded in grams.

3.1.8 Grain yield

The crop from net plot area was harvested and thrashed to separate the grains. The grains were sun - dried for optimum moisture. The grain weight was recorded and expressed in kg ha^{-1}.

3.1.9 Straw yield

Straw from net plot area after thrashing the grain was sun - dried for optimum moisture, weighed and recorded as kg ha^{-1}. The biometric observations plant samples were subjected to statistical scrutiny as per the statistical procedures suggested by Sukhatme and Amble (1985) [16].

4. Results and Discussion

The yield parameters viz., panicle length, panicle weight, number of spikelets per panicle and number of filled grains per panicle are presented in table 1. and the yield attributes viz., spikelet fertility, high density grains per panicle and test weight are given in table 2.

4.1 Panicle length: The STCR recommendation of 8 t ha^{-1} through inorganic and organic had higher panicle length (23.23 cm) conspicuously over other fertilizer recommendations. However, it was comparable with the same recommendation through inorganic alone. The length was lesser in blanket recommendation and the least (19.23 cm) was recorded in control. The panicle length increased with the increase of nitrogen rate. Nitrogen nutrient took part in panicle formation as well as elongation. This panicle length increased with increased N – fertilization, that too with organic and inorganic combination. The similar results were reported by Idris and Matin (1990); Vijayakumar and Singh (2006) [6, 17].

4.2 Panicle weight: The treatment STCR recommendation through inorganic and organic for 8 t ha^{-1} recorded higher panicle weight of 03.25 g. The lowest panicle weight (01.85 g) was recorded by control. This treatment was comparable to the same treatment through inorganic alone and also equivalent to other treatments sequentially. This kind of results might be presumably due to the efficiencies of each and every treatment and treatment combinations except control in the release of nutrients at all the critical stages, contributing the formation of panicle evenly at later stages of crop growth and finds support from Fahad *et al.* (2016) [2].

4.3 Number of spikelets per panicle: The STCR recommendation of 8 t ha^{-1} through inorganic and organic (172.3) and through inorganic alone (162.3) registered higher number of spikelets per panicle than the other fertilizer recommendations significantly. The control registered the lowest number of spikelets (107.2) per panicle. It was majorly due to greater translocation of photosynthates from source to sink, thereby resulted in higher yield contributing characters of rice (Hasanuzzaman *et al.*, 2010) [4]. The results are in confirmity with the results of Jayakumar *et al.* (2014) and Wijitkosum and Kallayasiri (2015) [7, 18].

4.4 Number of filled grains per panicle: The maximum number of filled grains per panicle was observed in STCR method through inorganic and organic for 8 t ha^{-1} (165.3), which was followed by the same treatment but without the application of organic manure (154.1). The minimum number of filled grains per panicle (083.3) was noticed in control. The increase in dose regulates the nitrogen movement in plants, when it is found lagging. The results revealed that poor dose of nutrition reduces photomorphogenesis and resulted to lowering down the amount of photosynthetate to be translocated to sink which decides the filled grains.

4.5 Spikelet fertility: The higher percentages of spikelet fertility i.e. 95.98, 95.00 and 94.44 were registered by STCR recommendation of 8 t ha^{-1} through inorganic and organic, through inorganic alone and 7 t ha^{-1} through inorganic and organic respectively. The treatments of various recommendations excelled in their performances than blanket recommendation through inorganic (81.37%), whereas this treatment performed better than control significantly (77.81%). The application and supply of nitrogen at proper and suitable proportion matched the demand of crop in critical growth stages leads to the better spikelet fertility in the crop.

4.6 High density grains per panicle: Marked variations were observed due to the effect of treatments imposed for different fertilizer recommendations. High density grain per panicle was the highest in the case of STCR method through inorganic and organic for 8 t ha^{-1} (151.3). This was followed by the same treatment without organics (132.7). The poor performance of blanket recommendation through inorganic (56.13) was even comparable with control, which had the least number of high density grains (36.93) per panicle. The complementary effects of integration of manures and fertilizers which satisfies the immediate nutrient requirement from inorganic sources during initial stages of crop growth and from slow release through organic sources for subsequent requirements by steady supply of nutrients would have imparted more filled grains per panicle and more high density grains per panicle (Roy *et al.*, 2001) [14]. This was also confirmed by Reddy (2015) [13].

4.7 Test weight: Test weight did not show any significant variations among treatments and treatment combinations of various fertilizer recommendations. However, the test weight was numerically higher (18.27 g) in STCR method through inorganic and organic for 8 t ha^{-1}. The lower test weight (16.85 g) was recorded in control. The thousand grain weight of a rice variety is mostly an intrinsic character and hereby these treatments and treatment combinations could not show their influences on this character.

4.8 Grain yield: The grain yield was significantly influenced by various treatments and treatment combinations of different fertilizer recommendations (Fig 1.). The influence was so evident with the highest yield of 8121 kg ha^{-1} by STCR method through inorganic and organic for 8 t ha^{-1}. This treatment combination was closely followed by STCR method through inorganic for 8 t ha^{-1} (7840 kg ha^{-1}). The grain yields were recorded lower in control (2630 kg ha^{-1}). The increase in grain yield owing to STCR approach might be due to balanced application of nutrients which is based on soil analysis, which takes account the amount of nutrient removed by crops, initial levels of soil fertility, efficiency of nutrients present in the soil and added through fertilizers. These factors might have provided the optimum time for better uptake and ultimately resulted in dry matter production and yield. This kind of result was witnessed Satalagaon *et al.* (2014) [15] in onion crop.

4.9 Straw yield: Similar to grain yield, the highest straw yield was noticed in STCR method through inorganic and organic for 8 t ha^{-1} (9702 kg ha^{-1}), which was followed by the same treatment through inorganic (9425 kg ha^{-1}). These treatments were found on par with each other, but superior in enhancing the straw yield over other fertilizer recommendations. The lowest yield of 4538 kg ha^{-1} was recorded in control. It is inputed that the addition of organic manure will directly help in enhancing the activity of microorganisms and release of nutrients into soil pool, which in turn helps in better growth and production of crop. This was explained through the findings of Basavaraja *et al.* (2016) [1].

4.10 Economic analysis: The data pertaining to the effect of different fertilizer recommendations on economic parameters of rice is presented in fig.2. The highest gross returns (Rs.153455), net returns (Rs.97861) were registered by the STCR method through inorganic and organic for 8 t ha^{-1}, followed by the yield target of 8 t ha^{-1} through inorganic alone. With respect to benefit drawn per unit rupee invested on input, it was observed that B:C ratio was the highest in STCR method of 8 t ha^{-1} through inorganic alone (2.81), followed by the same treatment with organics (2.76).

Table 1: Effect of fertilizer recommendations on yield parameters of rice

Treatments	Panicle length (cm)	Panicle weight (g)	No. of. spikelets per panicle	No. of. filled grains per panicle
T_1- Control	19.23	01.85	107.2	083.3
T_2 - Blanket Recommendation – Inorganic	20.01	02.04	130.1	096.8
T_3 - Blanket Recommendation - Inorganic + Organic	20.45	02.19	122.0	105.0
T_4 - Farmer’s Practice	21.23	02.37	130.0	115.4
T_5 -IARI – Inorganic	21.44	02.59	134.1	129.0
T_6 - IARI - Inorganic + Organic	21.52	02.65	141.1	130.4
T_7 - STL – Inorganic	20.63	02.23	136.5	110.8
T_8 - STL - Inorganic + Organic	21.36	02.40	132.2	125.7
T_9 – STCR (6 t/ha) - Inorganic	21.89	02.70	141.7	131.9
T_{10} –STCR (6t/ha) - Inorganic + Organic	22.06	02.72	143.1	134.8
T_{11} – STCR (7 t/ha) - Inorganic	22.21	02.79	144.5	135.8
T_{12} - STCR (7 t/ha) - Inorganic + Organic	22.46	02.84	150.2	141.8

T_{13} – STCR (8 t/ha) - Inorganic	22.92		03.05		162.3		154.1	
T_{14} – STCR (8t/ha) - Inorganic+ Organic	23.23		03.25		172.3		165.3	
Mean	21.47		02.55		139.1		125.7	
Source	S.Ed (0.05)	C.D	S.Ed (0.05)	C.D	S.Ed (0.05)	C.D	S.Ed (0.05)	C.D
Treatments	0.28	0.58	0.08	0.17	6.52	13.40	4.84	9.94

Table 2: Effect of fertilizer recommendations on yield attributes of rice

Treatments	Spikelet fertility (%)		High density grains per panicle		Test weight (g)	
T_1- Control	77.81		36.93		16.85	
T_2 - Blanket Recommendation – Inorganic	81.37		56.13		17.59	
T_3 - Blanket Recommendation - Inorganic + Organic	84.17		67.67		17.72	
T_4 - Farmer's Practice	87.88		81.40		17.43	
T_5 -IARI – Inorganic	91.58		99.33		17.40	
T_6 - IARI - Inorganic + Organic	92.76		101.4		17.46	
T_7 - STL – Inorganic	85.30		75.47		17.47	
T_8 - STL - Inorganic + Organic	90.65		94.33		17.62	
T_9 – STCR (6 t/ha) - Inorganic	93.32		104.9		17.89	
T_{10} –STCR (6t/ha) - Inorganic + Organic	93.72		108.1		17.91	
T_{11} – STCR (7 t/ha) - Inorganic	94.06		112.5		17.99	
T_{12} - STCR (7 t/ha) - Inorganic + Organic	94.44		119.1		18.14	
T_{13} – STCR (8 t/ha) - Inorganic	95.00		132.7		18.15	
T_{14} – STCR (8t/ha) - Inorganic+ Organic	95.98		151.3		18.27	
Mean	89.86		95.81		17.71	
Source	S.Ed (0.05)	C.D	S.Ed (0.05)	C.D	S.Ed (0.05)	C.D
Treatments	0.93	1.91	5.76	11.84	0.49	NS

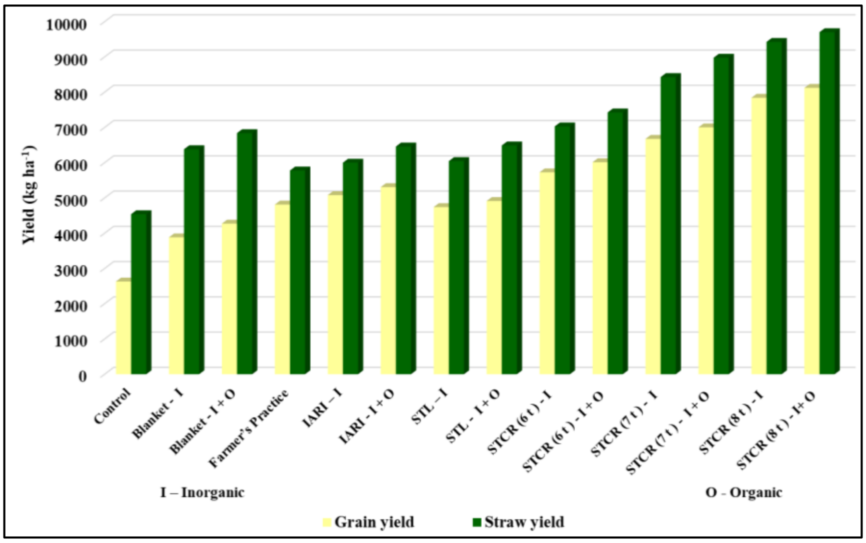

Fig 1: Effect of Different fertilizer recommendation on yields of rice

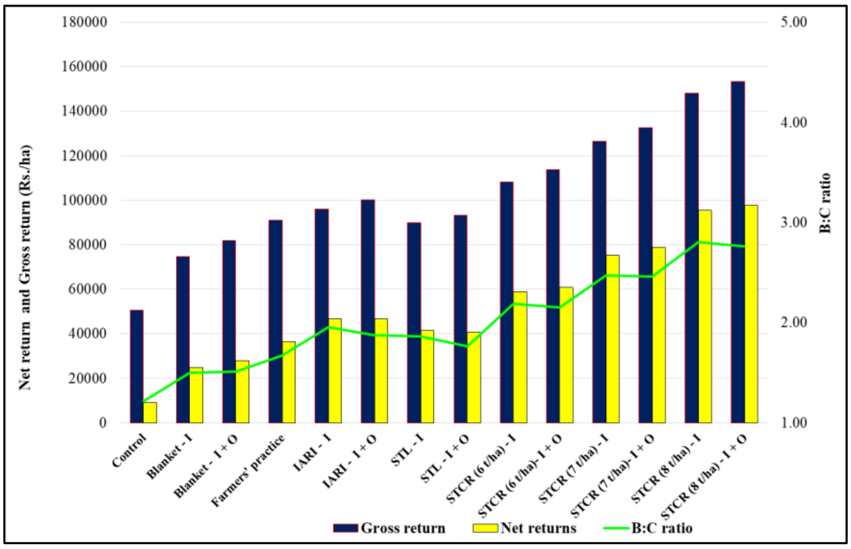

Fig 2: Economic parameters of rice production under different fertilizer recommendations (Rs. ha^{-1})

5. Conclusion

The higher yields realized under the STCR based treatments resulted in the highest gross returns and net returns and that too in the treatment for the yield target of 8 t ha^{-1} through inorganic and organic. With respect to the benefit drawn per rupee invested on input, it was observed that the B:C ratio was the highest in the targeted yield of 8 t ha^{-1} through inorganic alone, but very closely followed by the same treatment with organics, since the cost of organic manure is more nowadays. On the whole, it is concluded that STCR method of fertilizer recommendations inveterated their supremacy on the higher productivity of rice and profitability to farmers. It is further suggested that IARI method of recommendation could be followed, if STCR equations are not developed for specific crop under specific soil series. Wherever, soil testing laboratories still used the ready reckoner may switch over to IARI method in the absence of STCR recommendations.

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