The Pharma Innovation Journal 2022; 11(9): 1986-1990

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 1986-1990

www.thepharmajournal.com
Received: 08-07-2022
Accepted: 19-08-2022

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Influence of STCR based fertilizer recommendations on growth and yield of Paddy in command area of Hosahalli village tank

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Abstract
A field experiment was conducted in the farmers' fields of Hosahalli village tank command area, Hassan district, Karnataka, during the *kharif* season of 2021, at different organic carbon levels to assess the performance of paddy under different STCR based fertilizer recommendations. The experiment was laid out in split plot design with three replications. Main plot consisted of 3 organic carbon levels *viz*., High (>0.75%), Medium (0.50-0.75%) and Low (<0.50%). The sub plots consisted of 4 fertilizer levels in which 3 STCR based fertilizer recommendations for targeted yields of 40, 50 and 60 q ha^{-1}, compared with farmer's practice. Significantly higher growth parameters *viz.*, plant height, number of tillers and leaf area were recorded with STCR fertilizer recommendations for 60 q ha^{-1} targeted yield followed by 50 q ha^{-1}. The highest grain yield (53.59 q ha^{-1}) and straw yield (80.36 q ha^{-1}) were recorded with STCR fertilizer recommendations for 60 q ha^{-1} targeted yield. Effect of organic levels and their interaction with STCR fertilizer recommendations did not show significant influence on growth and yield of paddy.

Keywords: Paddy, plant height, grain yield, soil test crop response, fertilizer recommendations

Introduction
Rice is the most important food crop, providing one in three people on earth with a daily diet. Rice cultivation is the main single usage of land for food production, and consumes 9 per cent of the earth's arable land space. Rice supplies energy for 21%, calories for 40% of the world's population and 15% of protein per capita (IRRI, 2002) [3]. The slogan "RICE IS LIFE" is most appropriate for India as this crop plays vital role in our national food security and a mean of live hood for millions of rural households. India is the second largest rice producing country in the world after China. The nation needs to raise its food grain production to 450 million tonnes by 2050 to sustain food security. It implies the future of food production will come from improved paddy yield. In India, rice occupies 43 million ha (mha) and generates about 125 million tonnes (mt) with an average productivity of 2.85 t ha^{-1}. Rice alone contributes about 43 per cent to the basket of Indian food grain (Anon., 2016) [2]. West Bengal, Andhra Pradesh, Odisha, Jharkhand and Tamil Nadu are the largest rice-growing regions. The production of rice in India is a significant food safety factor. However, the sustainability of the existing production systems is not very well known, especially systems under minimum practise with triple cropping. The predominant systems in India include rice-based cropping systems. After the Green Revolution, the use of fertilisers is one of the main factors to increase rice production continuously. In order to maximize the profitability of crops, farmers are disproportionately utilizing fertilizers that deteriorate soil quality and reduce benefit cost ratio. Blanket usage of the fertiliser contributes to over fertiliser or to an insufficient nutrient balance for their soils, as well as to adverse environmental effects such as nutrient mining or surface and groundwater contamination due to variable indigenous nutrient supply in the different areas (Adhikari *et al.*, 1999) [1]. In addition, the efficiency of fertiliser usage is also lower and output is eventually reduced. The efficiency of fertilisers with nitrogen in Asia is only 20-30 per cent, and in the rest of the world only 45 per cent and 20-30 per cent with potassium- and phosphorous usage efficiencies. A proper nutrient management will achieve 75-80 percent of potential yield (Witt *et al.*, 1999) [16]. Management of nutrients helps to lower fertiliser losses and to increase production and rice productivity (Singh *et al.*, 2008) [15].
So nutrient's balanced application is one of the most important factors for efficient crop growth and increasing the quality of the product.

Soil and plant test based fertilizers application is now being promoted all over the world. Soil monitoring allows one to know the state of nutrients and their imbalances in the soil and to resolve the nutrients imbalances (Rao and Srivastava, 2000) [9]. In soil research, the fertilizer recommendation is generally provided for specific crops by taking into account only the usable soil nutrient level, through categorizing soil into small, medium and high fertility groups. Within fertility class there is a very broad range of variation of specific nutrients, farmers overlooking large variations in their actual volume in the soil, so the soil test and STCR equation gives the idea about application of accurate amount of nutrients. The STCR-based fertilizer recommendations also known as "Prescription Based Fertilizer Recommendations" take into account standard of nutrient present in soil to achieve targeted crop yields under a particular agro-climatic situation. Thus, the application of soil test-based nutrients not only helps in improving crop productivity but also increases the benefit cost ratio.

Material and Methods

The investigation was conducted in *kharif* season of 2021 in farmer's field in command area of Hosahalli village tank, Hassan district, Karnataka to assess performance of paddy as influenced by STCR based fertilizer recommendations. The local variety "Tunga" was grown with different treatments based on STCR equation for present investigation. Initial soil samples were collected and analyzed for pH, EC, organic carbon, available nitrogen, Phosphorus and Potassium (Table 1). Based on these soil test values and target yield (40, 50 and 60 q ha^{-1}) the fertilizers were calculated using STCR equation and added to the different treatments. The study was consisting of 3 main plot treatments of different organic carbon levels and 4 sub plot treatments in which 3 STCR based fertilizer recommendations for targeted yields of 40, 50 and 60 q ha^{-1}, compared with farmer's practice which were replicated three times in a split plot design.

STCR based fertilizer recommendations

Fertilizer adjustment equations for the study area for paddy (for target yield of 40, 50 and 60 q ha^{-1})

FN= 5.343807 T–0.690865 SN ($KMnO_4$-N)–0.00125 OM

FP_2O_5= 1.89835 T–0.660225 SP_2O5 (Brays P_2O_5)–0.0017 OM

FK_2O= 4.055729 T–1.023547 SK_2O (NH_4OAc K_2O)–0.00328 OM

Where,

FN= Fertilizer N (kg ha^{-1}), SN = Soil N (kg ha^{-1}), OM= Organic matter (%), FP_2O_5 = Fertilizer P_2O_5 (kg ha^{-1}), SP_2O_5 = Soil P_2O_5 (kg ha^{-1}), FK_2O = Fertilizer K_2O (kg ha^{-1}), SK_2O = Soil K_2O ((kg ha^{-1}) and T = Targeted yield (q ha^{-1}).

Treatments details

Main plot: Fertility status of Farmer's fields based on organic carbon level

C_1: High (>0.75%)

C_2: Medium (0.50-0.75%)

C_3: Low (<0.50%)

Sub plot: Fertilizer recommendation based on STCR approach for targeted yield of,

T_1: 40 q/ha

T_2: 50 q/ha

T_3: 60 q /ha

T_4: Farmer's practice

Farmer's practice of fertilizer application varied from individual to individual. The farmer's followed fertilizer doses were 92:48:30, 94:54:30, 92:48:30, 135:71:30 and 90:42:30 N: P_2O_5: K_2O kg ha^{-1} and the sources were Urea, Di-ammonium phosphate (DAP), Muriate of potash (MOP) and complex fertilizers like 20:20:0:13 N: P_2O_5: K_2O:S kg ha^{-1}. Whereas, the fertilizer sources used for STCR approach were urea, single-super phosphate (SSP) and muriate of potash (MOP).

Table 1: Fertility status of selected farmer's fields for validation of fertilizer recommendations at different organic carbon levels

Farmer's name	Survey number	pH	EC (dS m^{-1})	Organic Carbon (%)	Available nitrogen (kg ha^{-1})	Available phosphorous (kg ha^{-1})	Available potassium (kg ha^{-1})
High organic carbon level							
Devaraj	85*	5.80	0.30	0.99	451.58	43.09	270.00
Manjunath	14**	4.70	0.15	1.02	338.69	7.82	166.20
Mohan Kumar	87*	4.50	0.20	0.81	326.14	5.90	268.44
Medium organic carbon level							
Manjunath	14**	4.60	0.12	0.66	376.32	8.85	147.84
Suresh	80*	4.10	0.26	0.54	426.50	11.16	230.76
Dharmayya	8**	5.12	0.18	0.66	275.97	2.18	222.72
Low organic carbon level							
Suresh	80*	4.50	0.05	0.39	313.60	11.29	364.56
Umesh	11**	5.65	0.08	0.42	439.04	2.18	151.56
Bhairayya	9**	4.82	0.13	0.48	639.74	10.13	228.48

*Survey numbers under Palya village, Hassan district, Karnataka

** Survey numbers under Hosahalli village, Hassan district, Karnataka

Results and Discussion

Effect of organic carbon levels and their interaction with STCR fertilizer recommendations recorded statistically on par plant height, no. of tillers $hill^{-1}$, leaf area, grain yield and straw yield. Whereas, significant difference was recorded in fertilizer recommendations for targeted yield in all growth stages and at harvest.

At 30 DAT, among fertilizer recommendations, targeted yield of 60 q ha^{-1} recorded higher plant height (30.16 cm), no. of tillers $hill^{-1}$ (3.60) and leaf area (357.17 cm^2 $hill^{-1}$) followed by 50 q ha^{-1} (29.54 cm, 3.42 and 345.12 cm^2 $hill^{-1}$, respectively), which were significantly higher compared to 40 q ha^{-1} (27.93 cm, 3.24 and 300.86 cm^2 $hill^{-1}$, respectively) and farmer's practice (27.51 cm, 3.07 and 293.81 cm^2 $hill^{-1}$, respectively). At 60 DAT, significantly higher plant height (60.24 cm), no. of tillers $hill^{-1}$ (12.60) and leaf area (696.48

cm^2 hill^{-1}) were recorded in targeted yield of 60 q ha^{-1} followed by 50 q ha^{-1} (58.78 cm, 11.07 and 672.98 cm^2 hill^{-1}, respectively) when compared to 40 q ha^{-1} (56.90 cm, 9.98 and 586.67 cm^2 hill^{-1}, respectively) and farmer's practice (55.66 cm, 9.76 and 572.93 cm^2 hill^{-1}, respectively).

At 90 DAT targeted yield of 60 q ha^{-1} recorded higher plant height (88.01 cm), no. of tillers hill^{-1} (16.33) and leaf area (982.04 cm^2 hill^{-1}) followed by 50 q ha^{-1} (85.83 cm, 14.93 and 948.90 cm^2 hill^{-1}, respectively) and was significantly superior over 40 q ha^{-1} (83.09 cm, 13.64 and 827.20 cm^2 hill^{-1}, respectively) and farmer's practice (81.30 cm, 12.13 and 807.83 cm^2 hill^{-1}, respectively). However, at harvest targeted yield of 60 q ha^{-1} recorded higher plant height (86.52 cm), no. of tillers hill^{-1} (14.67) and leaf area (795.45 cm^2 hill^{-1}) which was closely followed by 50 q ha^{-1} (84.39 cm, 13.58 and 768.61 cm^2 hill^{-1}, respectively) and significantly superior over 40 q ha^{-1} (81.70 cm, 12.44 and 670.03 cm^2 hill^{-1}, respectively) and farmer's practice (79.90 cm, 11.18 and 654.35 cm^2 hill^{-1}, respectively). The plant's height quickly increased as a result of increasing fertility levels for increased targeted yields till 90 DAT (Table 2). The reduced rate of subsequent elongations, notably between 90 DAT and harvest, was primarily brought about by a greater need for photosynthates to support reproduction following the reduction division stage. Higher nutrient recommendations led to more nutrient availability in the soil for plant nutriment. Additionally, increased nutrient availability improved cell division, elongation, as well as numerous metabolic processes, which ultimately increased the plant height. The outcomes are in close agreement with those of Mahajan *et al.* (2009) [8], Kumar *et al.* (2007) [7] and Sathiya *et al.* (2008) [10]. The number of tillers hill^{-1} steadily increased up until 90 DAT, after which it started to fall as harvest approached (Table 2). Ageing and senescence, which caused tillers to die later in life, were to blame for the decline in tiller numbers beyond 90 DAT. The plant's habit of tillering has typically been seen as a crucial aspect of development from a physiological standpoint. In rice, tillering begins at the third leaf stage, and secondary roots start to appear at the fourth to fifth leaf stage. The present study indicates that increasing fertility levels due to increased targeted yields from 40 to 60 q ha^{-1} increased the tillers and the maximum tillers hill^{-1} was recorded at targeted yield of 60 q ha^{-1}. This may be explained by the fact that higher nutrient doses led to greater nutrient availability in the soil for plant nutrition. Furthermore, continuous availability of nutrients enhanced cell division and elongation as well as various metabolic processes, which ultimately increased the plant's tillers and source capacity. Increased plant height also helps in better photosynthesis in plant, which in turn helped in formation of new tillers. The same outcomes were also attained by Jha *et al.* (2006) [6] and Singh *et al.* (2006) [12].

Among targeted yields**,** 60 q ha^{-1} recorded higher grain yield (53.59 q ha^{-1}) and straw yield (80.36 q ha^{-1}) which was significantly superior over 50 q ha^{-1} (46.74 and 72.14 q ha^{-1}, respectively), 40 q ha^{-1} (38.50 and 62.41 q ha^{-1}, respectively) and farmer's practice (31.89 and 54.12 q ha^{-1}, respectively) (Table 3 and Fig. 1). Biradar *et al.* (2012) [4] confirmed that there was rise in grain yield of paddy due to SSNM over RDF and FFP of about 12 and 24 per cent, respectively. The higher yield of paddy (8.34 t ha^{-1}) in SSNM compared to Farmers practice (7.47 q ha^{-1}). Basavaraja *et al.* (2017) [3] obtained higher yield (41.60 q ha^{-1}) in paddy under STCR targeted yield approach of fertilizer prescription compared to package of practice (39 q ha^{-1}). The balanced application and required quantity of nutrients as per crop need/uptake have increased the growth and development of the crops which ultimately enhanced the yield under SSNM. Khurana *et al.* (2008) applied field specific macro nutrients which increased the yields of rice and wheat crops by 12 and 17 per cent and profitability by 14 and 13 per cent, respectively in the *on-farm* trials conducted at different locations in Punjab. Singh *et al.* (2011) [13] reported increased productivity and profit in rice, wheat and Bengal gram crops under SSNM over FFP in the field studies conducted in the western Indo-Gangetic plain region. Singh *et al.* (2009) [14] conducted multilocation trials to assess the economic viability of SSNM in rice crop across India, which revealed that SSNM increased the rice productivity and net returns by 25 per cent.

Significantly higher harvest index (0.40) was recorded with a targeted yield of 60 q ha^{-1} followed by 50 q ha^{-1} (0.39) and was superior over 40 q ha^{-1} (0.38) and farmer's practice (0.37). This might be due to the higher grain yield obtained by the former treatments. Similar result was reported by Shantappa (2014) [11].

Table 2: Plant height, number of tillers hill^{-1} and leaf area at different growth stages of paddy as influenced by organic carbon levels and STCR based fertilizer recommendations for different targeted yields

Treatments	Plant height (cm)				Number of tillers hill^{-1}				Leaf area (cm^2 hill^{-1})			
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
Organic carbon levels (C)												
C_1: High	29.23	58.88	85.98	84.53	3.47	11.02	14.52	13.30	331.02	645.49	910.14	737.21
C_2: Medium	28.80	57.78	84.38	82.95	3.32	10.85	14.20	12.87	324.00	631.80	890.84	721.58
C_3: Low	28.33	57.03	83.32	81.90	3.22	10.68	14.07	12.73	317.69	619.50	873.50	707.53
S. Em ±	0.19	0.46	0.66	0.65	0.05	0.12	0.18	0.14	3.69	7.19	10.14	8.22
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer recommendations for targeted yield (T)												
T_1: 40 q ha^{-1}	27.93	56.90	83.09	81.70	3.24	9.98	13.64	12.44	300.86	586.67	827.20	670.03
T_2: 50 q ha^{-1}	29.54	58.78	85.83	84.39	3.42	11.07	14.93	13.58	345.12	672.98	948.90	768.61
T_3: 60 q ha^{-1}	30.16	60.24	88.01	86.52	3.60	12.60	16.33	14.67	357.17	696.48	982.04	795.45
T_4: Farmer's practice	27.51	55.66	81.30	79.90	3.07	9.76	12.13	11.18	293.81	572.93	807.83	654.35
S. Em ±	0.16	0.59	0.85	0.83	0.09	0.15	0.19	0.17	5.33	10.40	14.66	11.87
CD (p=0.05)	0.49	1.75	2.52	2.46	0.25	0.45	0.57	0.51	15.84	30.89	43.55	35.27
Interaction (C × T)												
S. Em ±	0.31	0.99	1.43	1.40	0.14	0.26	0.34	0.29	8.81	17.17	24.21	19.61
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS: Non-significant, DAT: Days after transplanting

Table 3: Grain yield, straw yield and harvest Index of paddy as influenced by organic carbon levels and STCR based fertilizer recommendations for different targeted yields

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index
Organic carbon levels (C)			
C_1: High	44.07	69.27	0.39
C_2: Medium	42.39	68.31	0.38
C_3: Low	41.59	64.18	0.39
S. Em ±	0.81	1.75	0.00
CD (p=0.05)	NS	NS	NS
Fertilizer recommendations for targeted yield (T)			
T_1: 40 q ha^{-1}	38.50	62.41	0.38
T_2: 50 q ha^{-1}	46.74	72.14	0.39
T_3: 60 q ha^{-1}	53.59	80.36	0.40
T_4: Farmer's practice	31.89	54.12	0.37
S. Em ±	0.80	1.91	0.00
CD (p=0.05)	2.36	5.66	0.01
Interaction (C × T)			
S. Em ±	1.44	3.35	0.01
CD (p=0.05)	NS	NS	NS

NS: Non-significant

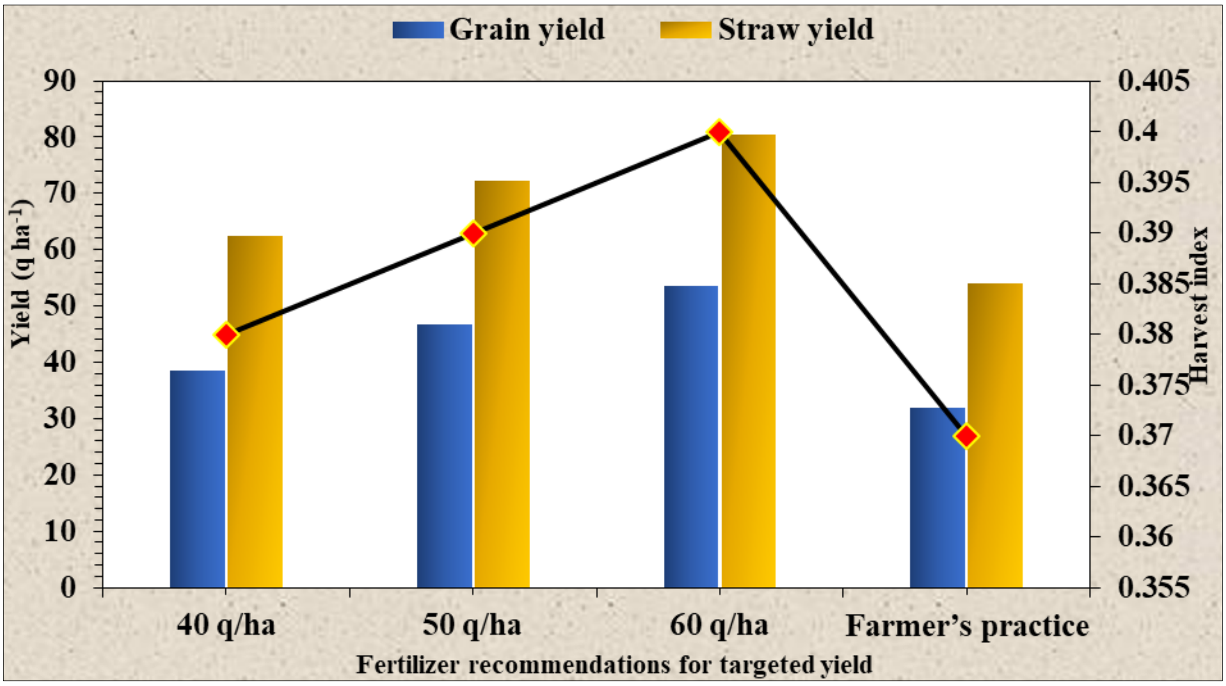

Fig 1: Grain yield, straw yield and harvest Index of paddy as influenced by organic carbon levels and STCR based fertilizer recommendations for different targeted yields

Conclusion

STCR equation and target yield based application of fertilizers would help to provide the appropriate amount of nutrient for the crop. It not only helps to enhance crop yield but fetch higher net return also. If the nutrient availability in soil and requirement for a targeted yield is known, the fertilizer requirement can be calculated from the scientific equations. STCR technology is very useful to improve farmer's knowledge about the amount of soil nutrients that are present in the soil and nutrient requirement of the crop which will enhance productivity of the crop.

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