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Short communication

EFFECT OF SOIL TEST CROP RESPONSE (STCR) FERTILIZER PRESCRIPTIONS COMBINED WITH INTEGRATED PLANT NUTRIENT SUPPLY (IPNS) ON PERFORMANCE OF NORMAL AND LATE SOWN TORIA

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An On Farm Trial (OFT) was conducted at farmers' field of Dokhin Kulabali Village of Lakhimpur district of Assam, India during *rabi* 2015-16 under All India Coordinated Research Project on Soil Test Crop Response (STCR) to find out the effect of STCR equation based fertilizer prescriptions and STCR prescriptions combined with Integrated Plant Nutrient Supply (IPNS) on yield performance of normal and late sown toria varieties *viz*.TS-38 and Jeuti (JT-90-1), respectively with the following treatments viz. T_1: Farmers' practice (100% Recommended Dose of Chemical Fertilizers (RDF) and manures), T_2: STCR-Inorganic and T_3: STCR-IPNS. Area under each treatment was 0.07 ha with five replications having one replication per farmer for each variety arranged in Randomized Block Design. A total of 10 farmers were involved in the study covering an area of 2.1 ha. Initial soil properties and organic manures were analyzed for calculating the fertilizer prescriptions for STCR and STCR-IPNS. Fields of the adjacent farmers were selected for the OFT to minimize the soil fertility differences within replications. Variety TS-38 was sown on 14th Nov, 2015 while variety JT-90-1 was sown on 25thNov, 2015. In both the varieties, STCR-IPNS gave significantly higher yield over STCR-inorganic and farmers' practice and only STCR-IPNS could achieve the targeted yield in and around of 12 q ha^{-1} with highest B:C ratios. Conversely, STCR-inorganic and farmers' practice could not produce the targeted yield and found statistically at par. However, B:C ratio in STCR-Inorganic was higher than farmers' practice because Farm Yard Manure (FYM) @ 2 t ha^{-1} was also applied in farmers' practice along with RDF unlike STCR-Inorganic applications. The study reveals that STCR prescriptions coupled with IPNS is the best for achieving the targeted yield with higher benefit: cost ratios in both normal and late sown toria.

Food security without compromising the soil health and environmental quality is the major challenge of 21st century. On the other hand, the horizontal expansion of fertile arable healthy farm land is virtually impossible. Conversely, the population rate of our country is escalating beyond control. Under such circumstances, Indian agriculture has to face very redoubtable mission of accomplishing sound growth rate in coming years. Without considering the health management aspects of soil resources it will not be possible to feed the ever increasing population in near future. A lot of research had already been carried out in India till date to relate soil fertility and fertilizer uses (Zhang *et al*. 2009). First scientific attempt in India to relate the soil database with injudicious use of fertilizers was made by Stewart, (1947) while, massive soil testing programme was launched in India during 1955-56 under the "Indo-Us Operational Agreement for Determination of Soil Fertility and Fertilizer Use". Muhr *et al*. (1965) first described the critical values that characterized the estimates as low, medium and high status of soil nutrients. However, the background research for fixing critical values considered only few pot experiments of paddy and wheat carried out at the department of Soil Science & Agricultural Chemistry at Indian Agricultural Research Institute, New Delhi ignoring the soil type variations. Again, the general recommendations of fertilizers were thought to be applicable to the medium category of soil testing estimates with an adjustment of 25-50 per cent for high and low categories of soil test estimates. Liebig's law of minimum states that the growth of plants is limited by the nutrient element present in the smallest amount, all others being in sufficient quantities. Ramamoorthy *et al*. (1967) established that Liebig's law of the minimum holds good for all the primary nutrients. Therefore, Ramamoorthy and Velayutham (1971) suggested that soil test calibration that was expected to establish a correlation between the levels of soil nutrients quantified in the laboratory and crop response to fertilizers in the experiment fields permit balanced fertilization and that should be the basis of fertilizer application. A fertilizer recommendation on yield target is typical in a sense that this method not only signifies soil test based fertilizer recommendations but also the level of yield the farmer expects to achieve if good agronomic practices are practiced. The targeted yield concept maintains equilibrium between 'feeding the plant' and 'feeding the soil'. The method provides a logical basis for judicious use of chemical fertilizers and balance between soil available nutrients and applied nutrients from external sources.

It is assumed that there is a linear relationship between crop yield and nutrient uptake in Targeted Yield

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approach (Singh,2016). A definite amount of nutrients are taken up by the crop to achieve a particular yield. Once for a targeted yield, the nutrient requirement is known; the fertilizer requirement can be easily calculated by taking into consideration the contribution of nutrients from soils and required contribution from fertilizer sources. Contributions of nutrients from Farm Yard Manures are to be considered IPNS prescriptions and accordingly amount of chemical fertilizers are substituted in the fertilizer prescriptions for targeted yields.

Considering all these an On Farm Trial (OFT) was carried out with the following objectives:

1. To establish a relationship amongst soil test values and crop response to fertilizers, so as to provide a calibration for fertilizer prescriptions based on soil testing.

2. To acquire a basis for making fertilizer prescriptions for targeted yields.

The experiment was conducted as the OFT programme in the project AICRP on STCR under the Department of Soil Science, Assam Agricultural University, Jorhat in association with the Regional Agricultural Research Station, AAU, North Lakhimpur. For this purpose, 10 farmers were selected covering 5 villages (Table 2) in North Lakhimpur district of Assam and executed the programme with the treatments as given in table 1. All the treatments were replicated thrice. Before application of fertilizers, soil samples were collected and analyzed in order to obtain the soil test values (STV) for NPK and used to calculate the fertilizer doses required for a particular target and soil type. Both normal sown (15th Oct to 15th Nov) and late sown (after 15th Nov) rapeseed variety *viz.*, TS-38 and Jeuti were sown between 14th and 25th November 2015, respectively and were harvested between 20th February and 2nd March, 2016 respectively. The pertinent data were analyzed with standard statistical methods.

The essential basic data required for formulating fertilizer prescriptions for targeted yield were

(i) Nutrient requirement in kg q^{-1} of produce, grain or other economic produce

(ii) The per cent contribution of soil available nutrients

(iii) The per cent contribution of nutrients from the applied fertilizers

The above mentioned parameters were calculated as follows:

Nutrient Requirement of N, P and K for grain production:

$$\textbf{kg of nutrient } q^{-1} \textbf{ of grain} = \frac{\text{total uptake of nutrient in kg}}{\text{grain yield (q)}}$$

$$\textbf{Contribution of nutrient from soil} = \frac{\text{total uptake in control plot (kg ha}^{-1}\text{)}}{\text{Soil test value of nutrient in control plot (kg ha}^{-1}\text{)}} \text{ x100}$$

Contribution of nutrient from fertilizer: Contribution from fertilizer (CF) = Total uptake of nutrients in treated plots – (Soil test value of nutrients in fertilizer treated plots × CS)

$$\textbf{\% Contribution from fertilizer} = \frac{\text{CF}}{\text{Fertilizer dose}} \text{ x } 100$$

Calculation of fertilizer dose: The above mentioned data were transformed into targeted yield equations as follows:

$$\textbf{Fertilizer dose} = \frac{\text{Nutrient requirement in kg ha}^{-1} \text{ of grain}}{\%\text{CF}} \times 100 \times \text{T} - \frac{\%\text{ CS} \times \text{soil test value}}{\%\text{CF}} =$$

$$\text{a constant} \times \text{yield target (q ha}^{-1}\text{)} - \text{b constant} \times \text{soil test value (kg ha}^{-1}\text{)}$$

The multiple regression equation approach was used to establish a relationship between crop yield on the one hand, and soil test estimates and fertilizer inputs, on the other. Developed STCR and STCR-IPNS equations are presented in table with treatment details are presented in table 1.

Table 1. Treatment details of On Farm Trial with STCR and STCR-IPNS equations

Sr. No.	Treatments	Detail of treatments with STCR and STCR-IPNS equations
1.	**T1**- Farmer's practice **(FP)**	60:30:30 ::N:P_2O_5:K_2O kg ha^{-1}+ 2t FYM ha^{-1}
2.	**T2**-STCR Targeted Yield 12 q ha^{-1}- Inorganic **(STCR-inorg)**	Only N, P and K fertilizer (Urea, SSP and MOP) based on soil test values. **FN** =8.71* T -0.27* STVN **FP** =5.90* T -3.13* STVP **FK** =9.42* T -0.78* STVK where, FN,FP,FK-Fertilizer N,P_2O_5, K_2O; STVN, STVP, STVK-Soil test values for N, P_2O_5, K_2O, T-Targeted yield
3.	**T3**- STCR Targeted Yield 12 q ha^{-1}-IPNS **(STCR-IPNS)**	N, P and K fertilizer (Urea, SSP and MOP) based on soil test values + FYM @ 2t ha^{-1}. Amount of N, P and K fertilizer was adjusted after analysis of initial soil and FYM sample. **FN** =8.71* T -0.27* STVN -0.22* M **FP** =5.90* T -3.13* STVP - 0.08* M **FK** =9.42* T -0.78* STVK -0.18* MWhere, M stands for NPK contribution from organic source

An On Farm Trial (OFT) was conducted at farmers' field of Dokhin Kulabali Village of Lakhimpur district of Assam, India during *rabi* 2015-16 under All India Coordinated Research Project on Soil Test Crop Response (STCR) to find out the effect of STCR equation based fertilizer prescriptions and STCR prescriptions combined with Integrated Plant Nutrient Supply (IPNS) on yield performance of normal and late sown toria varieties *viz.*, TS-38 and Jeuti (JT-90-1) with a target yield of 12 q ha^{-1}. TS-38 was sown in 14th Nov,2015 and JT-90-1 (Jeuti) was sown in 25th Nov,2015. Treatment details are presented in table 1.

Initial soil properties and nutrient composition of farm yard manure were analyzed to calculate fertilizer doses using STCR and STCR-IPNS equations using standard protocols. Details are presented in Table 2 and 3.

Table 2. Initial soil properties

Name of the farmer	GPS	EC (dS m^{-1})	pH	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	OC (%)
Unaram Chinte	27⁰18′53.3″N & 94⁰10′38.2″E	0.06	5.11	281.66	10.89	44.14	0.74
Ajay Basumatary	27⁰18′50.3″N & 94⁰10′37.2″E	0.03	5.22	260.42	10.37	70.07	0.70
Ramchandra Basumatary	27⁰18′45.5″N & 94⁰10′38.3″E	0.06	4.94	256.20	9.85	104.18	0.73
Mohan Basumatary	27⁰18′46.9″N & 94⁰10′38.3″E	0.04	5.03	245.23	14.56	41.36	0.73
Nama Basumatary	27⁰18′50.7″N & 94⁰10′35.6″E	0.11	5.00	268.61	23.46	183.52	0.71
Paniram Basumatary	27⁰18′51.5″N & 94⁰10′43.2 ″E	0.07	5.2	281.36	11.94	131.79	0.70
Ananta Basumatary	27⁰18′51.0″N & 94⁰10′41.8″E	0.06	5.16	255.16	19.27	45.96	0.68
Ananda Basumatary	27⁰18′48.6″N & 94⁰10′41.4 ″E	0.06	5.29	231.58	9.32	104.33	0.59
Bhaitee Goyary	27⁰18′48.2″N & 94⁰10′43.5 ″E	0.04	6.33	300.11	17.18	77.68	0.65
Sulen Basumatary	27⁰18′49.7″N & 94⁰10′43.5″E	0.08	6.10	128.57	10.37	96.11	0.49

Table 3. Nutrient composition of Farm Yard Manure (FYM)

N	P	K
	%	
0.51	0.44	0.62

Yield and yield attributes are presented in table 4. Perusal of data of normal sown toria variety TS-38 reveals that no significant differences in branches plant^{-1} and plant height were observed amongst the treatments. However, significant differences were observed in siliqua plant^{-1}, seed siliqua^{-1} and seed yield plant^{-1}. Siliqua plant^{-1} was found to be significantly highest in STCR-IPNS (192 siliqua plant^{-1}) while same for FP and STCR-Inorg was at par. Seeds siliqua^{-1} was significantly higher in STCR-IPNS as compared to control while it was at par with STCR-inorg. Yield of STCR-inorg was recorded to be at par with farmers' practice, while STCR-IPNS recorded significantly higher yield as compared to other treatments. On the other hand, in late sown toria (JT-90-1), branchch plant and siliqua FP while non significant amongst the treatments (Table 4). Branches plant $^{-1}$, siliqua plant^{-1} and yield ha^{-1} were recorded to at par within FP and STCR-inorg in var JT-90-1 . In both the varieties, STCR-IPNS gave significantly higher yield over STCR-inorganic and farmers' practice and only STCR-IPNS could achieve the targeted yield in and around of 12 q ha^{-1} with highest B:C ratios. Conversely, STCR-inorganic and farmers' practice could not produce the targeted yield and found statistically at par.

Table 4. Yield and yield attributes of toria

Treatments	Branches plant^{-1}	Height (cm)	Siliqua plant^{-1}	Seeds siliqua^{-1}	Yield q ha^{-1}
Variety : TS-38 (DESIGN: RBD) DOS 14th November, 2015					
FP	7.2	99.8	132.24 b	13.8 b	11.1b
STCR-Inorg	5.6	100.6	119.20 b	14.4 ab	10.8 b
STCR-IPNS	7.6	108.3	192.00 a	15.6 a	12.1a
SE(m)±	1.34	4.47	12.70	0.59	0.23
CD at 5%	-	-	29.33	1.36	0.547
CV	20.88	10.065	13.6	6.37	4.38
JT-90-1 (DESIGN: RBD) DOS 25th November , 2015					
FP	5.6 b	105.1	108.8 b	13.2	10.16 b
STCR-Inorg	5.0 b	104.6	102.8 b	12.8	9.80 b
STCR-IPNS	7.6 a	111.4	197.6 a	14.8	11.98 a
SE(m)±	0.55	4.18	6.0	1.25	0.30
CD at 5%	1.27	-	13.86	-	0.69
CV	14.44	6.18	6.96	14.59	4.41

Data regarding economics of toria cultivation are presented in table 5. Perusal of data reveals that, B:C ratio in STCR-Inorganic was higher than farmers' practice for both the varieties. This is because Farm Yard Manure (FYM) @ 2 t ha^{-1} was also applied in farmers' practice along with RDF unlike STCR-Inorganic applications which increased the gross cost of FP. The study reveals that STCR prescriptions coupled with IPNS is the best for achieving the targeted yield with higher benefit: cost ratios in both normal and late sown toria.

Table 5. Economics of toria cultivation

Parameters (TS-38)	FP	STCR-inorg	STCR-IPNS
Yield (q ha^{-1})	11.1	10.8	12.1
Gross cost (Rs ha^{-1})	15738	14686	14454
Gross return (Rs ha^{-1})	38850	37800	42350
Net return (Rs ha^{-1})	23113	23116	27896
B:C	2.47	2.57	2.93
Parameters (Jeuti)			
Yield (q ha^{-1})	10.2	9.8	11.98
Gross cost	16769	15238	14988
Gross return	35700	34300	41930
Net return	18931	19062	26942
B:C	2.12	2.25	2.80

Ready reckoner can be developed using the targeted yield equations for different achievable yield targets and for the certain available soil nutrient range. With available soil test data and the targeted yields, one can obtain fertilizer prescriptions specifically suited for a particular type of soil and agronomic conditions. Using STCR based equations, optimum quantity of fertilizer nutrients are to be applied in soils while STCR-IPNS maintain the soil health and system productivity and sustainability with integration of organic manure and reducing the amount chemical fertilizer without compromising the yield target. Consequently, these fertilizer target yield equations shall take care of fertilizer use efficiency, soil use efficiency, and farmers' available resources which are not possible with other conventional methods of fertilizer applications.

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