Fertilizer Prescriptions under STCR-IPNS for Rice-Rice Cropping Sequence on An Inceptisol (Typic Ustropept)

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ABSTRACT

To develop fertilizer prescription equations based on soil test crop response (STCR) approach for rice-rice cropping sequence, trials were conducted at farmer’s field in Karikalampakkam village, U.T. of Puducherry, during 2015-16. Soil test data, yield and nutrient uptake by successive crops were recorded to calculate four basic parameters viz. nutrient required to produce one quintal of rice, contribution of nutrients from fertilizers, contribution of nutrients from soil and contribution of nutrients from FYM used in developing STCR based fertilizer prescription equations. The per cent nutrient contribution of nutrients from soil (CS), fertilizer (CF) and FYM (CFYFM) were found to be 19.15, 45.90 and 23.27 for N, 12.13, 40.46 and 34.26 for P\textsubscript{2}O\textsubscript{5} and 13.76, 79.64 and 41.07 for K\textsubscript{2}O respectively for rice cv. White ponni. The same for the rice cv. ADT 45 were 13.48, 40.46 and 34.26 for N, 15.81, 44.64 and 19.89 for P\textsubscript{2}O\textsubscript{5} and 10.48, 58.64 and 41.51 for K\textsubscript{2}O respectively. Based on fertilizer prescription equations and nomograms formulated for a range of soil test values and desired yield target for the cropping sequence. It was revealed that under the treatment NPK + FYM @ 12.5 t ha\textsuperscript{-1}, nutrient use efficiency has gone down from 16 kg food grain produced per kg NPK applied during 1970’s to 8 kg food grain produced per kg NPK applied during 1990’s and around 6 kg now due to increasing deficiency of secondary and micronutrient (Tiwari et al., 2013). Although the largest area under rice crop in the world (44 m ha\textsuperscript{-1}) is in India, average productivity is lesser than that of China and Japan.

The annual consumption of fertilizers (N, P\textsubscript{2}O\textsubscript{5} and K\textsubscript{2}O) has increased from 0.07 million tons in 1951-52 to more than 28 million tons in 2010-11 and per hectare consumption has increased from less than 1.0 kg in 1951-52 to the level of 135.0 kg in 2010-11 (Karsangla and Gohain, 2013). The nutrient use efficiency has gone down from 0.87, 2.24 and 1.55 tons ha\textsuperscript{-1}, respectively (Tiwari et al., 2013). Although the largest area under rice crop in the world (44 m ha\textsuperscript{-1}) is in India, average productivity is lesser than that of China and Japan. The nutrient use efficiency has gone down from 0.87, 2.24 and 1.55 tons ha\textsuperscript{-1}, respectively (Tiwari et al., 2013). Although the largest area under rice crop in the world (44 m ha\textsuperscript{-1}) is in India, average productivity is lesser than that of China and Japan. 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The current fertilization practices do not put back in equal measure the nutrient to the soil as have been removed by crops, resulting in continuous depletion of soil fertility. This can be offset only by adopting soil testing and applying integrated plant nutrient supply (IPNS) as has been

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enunciated as “The Law of Optimum”, which has been demonstrated and validated in numerous farmer’s field for obtaining targeted yield of crops under the All India Coordinated Research Project on Soil Test Crop Response (AICRP-STCR) project annual reports (Ramamoorthy and Velayutham, 2011, Tandan 2014 and Velayutham et al., 2016). The targeted yield approach where in Ramamoorthy et al. (1967) established the theoretical basis and experimental proof for the fact that Liebig’s law of minimum operates equally well for N, P and K. In Union Territory of Puducherry, this type of work has not yet been initiated. Hence, the present work was carried out to develop STCR relationship for prescribing fertilizer recommendations under IPNS for desired yield targets for rice-rice cropping sequence on an Inceptisol of Puducherry.

MATERIALS AND METHODS

The experiments were conducted at farmer’s field of Karikalampakkam village in Nettapakkam commune of U.T.of Puducherry. The study area comes under coastal alluvial plain classified as fine, mixed isohyperthermic, Typic Ustropept with an area of 12.72%. According to agro climatic zonal classification, Puducherry is located at 11°56’ North latitude and 79°66’ East longitude. The soils of experimental field was slightly alkaline (pH 8.4), non-saline in reaction and sandy clay loam in texture. The P and K fixing capacities of the soil were 15 and 100 kg ha⁻¹, respectively. The fertility status was low, high and medium with respect to available N (170.8 kg ha⁻¹), P (65.4 kg ha⁻¹) and K (236.0 kg ha⁻¹). Following the inductive methodology of Ramamoorthy et al. (1967), the experiment was conducted in two phases. In the first phase, fertility gradient experiment was conducted by raising rice cv. kulla ponni as an exhaust crop during 2015. For this, the field was divided into three equal which were fertilized with N₃P³K₃ (strip-I), N₃P₅K₅ (strip-II) and N₅P₅K₂ (strip-III) levels to create fertility gradient. Subsequently, in the second phase, after the harvest of the exhaust crop, rice cv. White ponni was transplanted as test crop on 9th of November, 2015 and harvested on 11th of March, 2016. After the harvest of rice cv. White ponni, rice cv. ADT 45 was transplanted on 1st April, 2016 and harvested on 22nd of June, 2016. Each of the fertility strips was subdivided into 24 subplots resulting in 72 plots. There were 24 treatments consists of four levels of N (0, 50, 100 and 150 kg ha⁻¹), P₂O₅ (0, 25, 50 and 75 kg ha⁻¹), K₂O (0, 25, 50 and 75 kg ha⁻¹) and FYM (0.625 and 12.5 t ha⁻¹). The moisture and N, P₂O₅ and K₂O contents of FYM were 28, 0.52, 0.32 and 0.38%, respectively. Pre-sowing soil samples were collected from each plot for each crop and analysed for available N (alkaline permanganate method-Subbiah and Asija, 1956), available P (extraction with 0.5 M NaHCO₃-Olsen et al., 1954) and available K (ammonium acetate method – Stanford and English, 1949). Grain and straw yields of both rice crops were recorded and these samples were analysed for N (Humphries, 1956), P and K contents (Jackson, 1973) and uptake values were computed. Using the data on crop yield, nutrient uptake, pre-sowing soil available nutrient status and fertilizer doses applied, the basic parameters used in developing STCR based fertilizer prescription equation viz. nutrient (NR), contribution of nutrients from soil (CS), fertilizer (CF) and FYM (CFYM) were calculated as per procedure described by Ramamoorthy et al.(1967) and Santhi et al.(2002). Fertilizer doses and the soil test based fertilizer recommendations were formulated in the form of a ready reckoner for desired yield target of rice-rice under NPK alone as well as NPK+FYM.

RESULTS AND DISCUSSION

Soil available nutrients: Strip-wise range and mean soil test values of pre-sowing stage for available nutrients are given in Table 1. The average levels of available nutrients were found to increase with increasing fertility strips and the highest content was recorded in strip III. The average soil available nutrients status was low, high and medium with respect to available N (150.6 kg ha⁻¹), P (54.7 kg ha⁻¹) and K (56.2 kg ha⁻¹). The fertilizer doses and the soil test based fertilizer recommendations were formulated in the form of ready reckoner for desired yield target of rice-rice under NPK alone as well as NPK+FYM.

Table 1: Pre-sowing soil available NPK (kg ha⁻¹) in various strips.

| Strip | Available N Range | Mean | Available P₂O₅ Range | Mean | Available K₂O Range | Mean |
|--------|------------------|------|----------------------|------|---------------------|------|
| Rice cv. White ponni | | | | | | |
| Strip-I | 142.8 – 156.8 | 150.6 | 42.2-49.8 | 46.2 | 200-212 | 208 |
| Strip-II | 198.8-220.2 | 205.8 | 50.4-59.6 | 54.7 | 216-242 | 229 |
| Strip-III | 218.6-235.2 | 228.7 | 51.6-61.9 | 56.2 | 260-283 | 270 |
| Rice cv. ADT 45 | | | | | | |
| Strip-I | 120.4-170.8 | 151.6 | 37.3-55.8 | 45.4 | 182-210 | 203.4 |
| Strip-II | 165.2-221.2 | 205.3 | 42.9-59.2 | 51.3 | 205-240 | 226.9 |
| Strip-III | 170.8-243.8 | 211.2 | 47.4-61.3 | 53.6 | 232-286 | 263.8 |
Grain yield and nutrient uptake: Range and mean values of grain yield and nutrient uptake under different strips are presented in Table 2. Maximum yield both rice crops was obtained in strip III followed by strip II and I. It is stated that a crop which is grown under favourable environment is bound to produce better yields, provided the nutrient supply is matching with nutrient accumulation that occurs in the crop. The strip-wise average nutrient uptake was in the order III > II > I for both the crops. The result indicated that a wide variability existed in the soil test values, grain yield and nutrient uptake which is a pre-requisite for calculating the basic parameters and fertilizer prescription equations for calibrating the fertilizer doses for specific yield targets (Santhi et al., 2002).

Basic Parameters for Fertilizer Prescription Equations:
The basic parameters for developing fertilizer prescription equation for rice-rice sequence viz. i) nutrient requirement in kg q⁻¹ of rice (NR), ii) per cent contribution from soil available nutrient (Cs), iii) per cent contribution from fertilizer (CF) and iv) per cent contribution from FYM (CFYM). The nutrient requirement for the production of one quintal of rice cv White ponni and cv ADT 45 were computed as 1.44, 0.58 and 1.37 and 1.25, 0.73 and 1.01 kg of N, P₂O₅ and K₂O, respectively (Table 3). The per cent contribution of nutrients from the fertilizer sources revealed that among the three nutrients contribution was more in the case of K compared to N and P. The higher value of K could be due to interaction effect of higher doses of N and P coupled with priming effect of K doses, which might have caused the release of soil K, resulting in the higher uptake in the native soil sources by the crop (Ray et al., 2000).

### Table 3: Values of basic parameters used for developing STCR based fertilizer prescription equations.

| Parameter                      | Rice cv.White ponni | Rice cv. ADT 45 |
|--------------------------------|---------------------|-----------------|
| Nutrient requirement (kg q⁻¹)  | 1.44                | 1.44            |
| Per cent contribution from soil (CS) | 19.15              | 19.15           |
| Per cent contribution from fertilizer (CF) | 45.90              | 45.90           |
| Per cent contribution from FYM (CFYM) | 23.27              | 23.27           |

### Table 4: Soil test based fertilizer prescription equations for targeted yield of rice-rice sequence.

| Particular                  | Rice cv.White ponni | Rice cv. ADT 45 |
|-----------------------------|---------------------|-----------------|
| Fertilizer alone            |                     |                 |
| FN (Fertilizer N-kg ha⁻¹)   | 3.13 T -0.42 SN    | 3.13 T -0.42 SN-0.51 ON |
| F P₀ (Fertilizer P₀ - kg ha⁻¹) | 1.45 T -0.69 SP  | 1.45 T -0.69 SP -1.54 OP |
| F K₀ (Fertilizer K₀ - kg ha⁻¹) | 1.72 T -0.21 SK  | 1.72 T -0.21 SK -0.62 OK |
| Fertilizer with FYM         |                     |                 |
| FN (Fertilizer N-kg ha⁻¹)   | 3.06 T – 0.33 SN   | 3.06 T – 0.33 SN – 0.85 ON |
| F P₀ (Fertilizer P₀ - kg ha⁻¹) | 1.63 T – 0.81 SP  | 1.63 T – 0.81 SP –1.02 OP |
| F K₀ (Fertilizer K₀ - kg ha⁻¹) | 1.70 T -0.22 SK  | 1.70 T -0.22 SK -0.85 OK |

T-yield target in q ha⁻¹; SN,SP and SK-soil available N,P and K; ON,OP and OK-N,P and K applied through FYM.
Table 5: Fertilizer recommendation (kg ha\(^{-1}\)) for targeted yield rice- rice sequence under NPK and NPK+FYM.

| Soil test values N: P\(_{2}\O\) : K\(_{2}\O\) (kg ha\(^{-1}\)) | NPK alone | NPK + FYM (12.5 t ha\(^{-1}\)) |
|---------------------------------|-----------|--------------------------------|
| **Rice cv. White ponni** | | |
| 200: 12: 120 | 60 q ha\(^{-1}\) | 204: 79: 78 | 104: 93: 95 | 58: 50: 44 | 89: 64: 61 |
| 240: 16: 160 | 70 q ha\(^{-1}\) | 119: 91: 87 | 41: 47: 36 | 72: 62: 53 |
| 280: 20: 200 | 80 q ha\(^{-1}\) | 102: 88: 79 | 38: 44: 27 | 56: 59: 45 |

The per cent contribution of N, P\(_{2}\O\), and K\(_{2}\O\) from FYM was 23.27, 26.98 and 41.07, respectively for rice cv. White ponni and 34.26, 19.89 and 41.51 for rice cv. ADT 45 (Table 3). In both the cases higher contribution was recorded in the case of K, which might be due to the good supply of carbon which act as the source of energy for the buildup of bacterial population which inturn would have enhanced the release of K from organic and native sources. The findings are in close conformity with those of Natesan et al. (2007).

**Fertilizer Prescription equations for desired yield targets:**

Based on the basic parameters, fertilizer prescription equations for targeted yield of both rice varieties under NPK alone as well as NPK + FYM were formulated and are furnished in Table 4. On the basis of these equations, a ready reckoner was prepared for making fertilizer recommendations for different soil test values to meet specified yield targets of rice under NPK alone and NPK + FYM (Table 5).

Based on the fertilizer prescription equations for rice cv. White ponni for NPK alone, fertilizer N recommendation was found in the range from 102 - 136, fertilizer P\(_{2}\O\) from 88 - 93 and fertilizer K\(_{2}\O\) from 79 - 95 kg ha\(^{-1}\) for attaining a yield target of 70 q ha\(^{-1}\) (Table 5). When FYM was applied along with NPK fertilizers, fertilizer requirement of N, P\(_{2}\O\), and K\(_{2}\O\) was found in the range of 56 to 89, 59 to 64 and 45 kg ha\(^{-1}\), respectively at the same level of soil test values. Similar trend also observed in rice cv. ADT 45. Under NPK + FYM @12.5 t ha\(^{-1}\), 47, 29, 34 and 41, 22 and 27 kg ha\(^{-1}\) of fertilizer N, P\(_{2}\O\), and K\(_{2}\O\), respectively could be saved for attaining target yield of 70 q ha\(^{-1}\) for rice cv. White ponni and cv. ADT 45 as compared to NPK fertilizers alone. Similar results were also reported by Anjali Basumatty et al. (2015). Use of FYM resulted in saving of fertilizer nutrients in rice-rice cropping sequence. Practice of fertilizing rice crop using fertilizer prescription equations developed would help in achieving higher productivity, nutrient use efficiency and profitability.

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