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Spatial Fertilizer Recommendation at Rythu Bharosa Kendra (RBK) level using Geographic Information System

M Indhuja, M Madhan Mohan, M Sunil Kumar and M Sreenivasa Chari

S. V. Agricultural College, Tirupati-517 502

ABSTRACT

The spatial recommendation of chemical fertilizers based on soil test values is pivotal in achieving the targeted yields by improving nutrient use efficiency and soil nutrient balance. The major crops of Bandarupalli RBK are rice and groundnut with an area of 416 ha. Based on application of Soil Test Crop Response (STCR) equations targeted yields in rice and groundnut were calculated for study area based on analytical results of the soil samples collected from 120 locations. The spatial fertilizer recommendation maps were prepared using *Arc*GIS tools for nitrogen, phosphorous and potassium fertilizers to rice and groundnut. The spatial fertilizer recommendation for targeted yields revealed that 13.3, 40.8, 35.0, 10.8 per cent, 47.5, 25.8, 17.8, 7.5, 1.4 per cent and 12.5, 18.3, 12.5, 55.8, 0.83 per cent study area was recommended with <100, 100 – 130, 130 – 160, 160 -190 kg ha^{-1}, <0, 0- 20, 20 – 40, 40 – 60, 60 – 80 kg ha^{-1} and <0, 0 - 30, 30 - 60, 60 - 90, 90 - 120 kg ha^{-1} of N, P_2O_5 and K_2O fertilizers respectively to rice crop for getting targeted yield of 4500 kg ha^{-1}. For groundnut, 15.0, 36.6, 35.0, 13.3 percent, 40.8, 21.6, 27.5, 10.0 per cent and 6.6, 20.0, 55.8, 17.5 per cent study area was recommended with <40, 40 - 60, 60 - 80, 80 - 100 kg ha^{-1}, <0, 0 - 10, 10 - 20, 20 - 30 kg ha^{-1}, <0, 0 - 30, 30 - 60, 60 - 90 kg ha^{-1} of N, P_2O_5, K_2O, respectively for getting targeted yield of 3000 kg ha^{-1} in study area.

The need for environmentally benign and socially acceptable development has put a heavy demand on the capabilities of land use planners because, planning and execution of development programmes require more accurate, reliable and timely information and better tools for the management of such information. The computer system has made it possible to store, process and analyze statistical information. The application of fertilizers by the farmers without prior knowledge of soil fertility status might result in adverse effects on the soil as well as crops in terms of nutrient deficiency and toxicity either by the inadequate or overdose of fertilizer application. In the past, the plant and soil tests were used as a criteria to delineate the deficient regions by random sampling methods without geo referencing the soil samples. In recent years, with the invention of modern technologies of remote sensing, Geo Information Systems and Geo Positioning System, it is possible to monitor the changes in fertility status in spatial and temporal manner. The fertilizer recommendation maps are used for the site-specific nutrient management. GIS is a tool in producing a soil fertility map of an area, which will help in formulating site specific balanced fertilizer recommendation to the crops and to understand the status of soil fertility spatially and temporally. Using this background, spatial recommendation maps were prepared to give optimum recommendation to the major crops of the study area *viz*., rice and groundnut based on soil test crop response (STCR) equations.

MATERIAL AND METHODS

The present study area *i.e.,* Bandarupalli RBK is located in Yerpedu Mandal, Tirupati District of Andhra Pradesh. Its geographic limits range from 13° 36' to 13° 40' North latitude and 79° 18' to 79° 28' East longitude and 89 m above the mean sea level. Bandarupalli RBK is one of the RBK's of the mandal. It falls under southern agro- climatic zone of Andhra Pradesh. Latitude and Longitude were recorded by GPS instrument from soil sampling places and the soils were collected by quartering process the soil quantity

was reduced up to 1 kg. A total of a 120 numbers of GPS based soil samples from two villages (Bandarupalli and Mannasamudram) were collected. The soil samples were brought to the laboratory and air dried under shade and then pounded with a wooden pestle. The samples were sieved through a 2mm sieve and the pebbles, stones and roots were separated. About 0.5 to 1kg of air-dried sieved soil sample was kept in the plastic sample bag, labelled and stacked on the open sample racks for analysis. The analysis of soil samples was done by using standard methods *i.e*., pH (1:2.5) (Jackson, 1973), EC (1:2.5) (Jackson, 1973) organic carbon (Walkley and Black method) (Jackson, 1973), available nitrogen (Alkaline Permanganate method) (Subbiah and Asija, 1956), available phosphorus (Olsen's method) (Olsen *et al*., 1954), available potassium (Ammonium acetate method) (Jackson, 1973). The base map of the study area was digitized and geo referenced. Polygons were superimposed on the geo-referred map. The latitude, longitude and analysis data were entered into attributed table and linked to *Arc*GIS software for making thematic soil fertility maps for the study area.

The objective of spatial fertilizer recommendation is to ensure the supply of nutrients by considering *in-situ* soil fertility status in optimum quantity and right proportions to meet the crop requirement. In most of the soils, available nutrients are seldom present in optimum amount and in right proportions. The required balance of nutrients in soil can be supplied by soil test- based fertilizer recommendations to ensure higher efficiency of fertilizer use. The fertilizer recommendations developed using fertilizer adjustment equations from STCR can be displayed in the form of spatial fertilizer recommendation map by linking the information with soil fertility maps. The fertilizer recommendation maps for different management zones in terms of nitrogen, phosphorus and potassium were derived by kringing interpolation method in GIS environment.

RESULTS AND DISCUSSION

The available nitrogen ranged from low to medium (50.16 to 304.6 kg ha^{-1}). Similar range was given by Sashikala *et al*. (2021) in Ananthapuramu district of Andhra Pradesh. The available phosphorous ranged from low to high (13.4 to 89.6 kg ha^{-1}) with the mean, SD and CV of 51.4 kg ha^{-1}, 20.6 and 40.1 percent, respectively. Similar range was reported by Mohan *et al.* (2021) in rice growing soils of Tirupati revenue division. The available potassium varied from low to high (69 to 925 kg ha^{-1}) with mean, SD and CV as 276.4 kg ha^{-1}, 182.1 and 65.9 per cent, respectively (Table.1). Similar range for potassium was noticed by Sreenivas *et al.* (2007) in Godavari Western Delta. Some of the soils had high status in available potassium which might be attributed to the prevalence of potassium rich minerals like Illite and Feldspar and similar results were also reported by Shivanna *et al.* (2014) in soils of Tiptur district of Karnataka. Similarly, Mohan *et al,* 2013. prepared thematic maps of available nitrogen, phosphorous and potassium for spatial fertilizer recommendations for soils of Hanumankoppa micro-watershed of Hanagal taluk, Karnataka.

STCR equations adopted for rice

FN = 4.53 T- 0.51 SN

FP_2O_5 = 2.12 T- 2.06 SP

FK_2O = 2.35 T-0.12 SK

T= Targeted yield (4500 kg ha^{-1})
SN= Soil nitrogen
SP= Soil phosphorous
SK= Soil potassium

STCR equations adopted for groundnut

FN = 3.69 T- 0.36 SN

FP_2O_5 = 1.32 T- 0.71 SP

FK_2O = 2.54 T-0.12 SK

T= Targeted yield (3000 kg ha^{-1})
SN= Soil nitrogen
SP= Soil phosphorous
SK= Soil potassium

The site-specific nutrient recommendations to rice and groundnut crops were calculated based on STCR equations for study area. The spatial fertilizer recommendations were mapped for effective transfer of soil test-based fertilizer recommendation among the farming community. The soil available nitrogen, phosphorus and potassium spatial variability values generated from the thematic maps of Bandarupalli RBK was used to establish fertilizer recommendations. The area under different ranges of available N, P and K are arrived. The actual N, P and K fertilizer nutrient recommendations were derived using the fertilizer prescription equations based on the targeted yield approach developed by the All India Coordinated Soil Test Crop Response Correlation Project, Hyderabad centre for rice and groundnut crop. Similarly spatial fertilizer recommendation maps for rice, groundnut and sugarcane was prepared by Rajeshwari *et al.* (2019) in Nethakuppam watershed.

The nitrogen recommendation for rice crop in the traditional approach for the study area is 80 kg ha^{-1} considering the entire southern zone as a homogeneous unit. Similarly, phosphorus and potassium requirement for rice to this area is 60 and 40 kg ha^{-1}, respectively. The given recommended dose throughout the study area may lead to under utilization or over utilization of fertilizers for getting higher yields due to the spatial variability of the nutrients within the field. The blanket recommendation to the soils not only reduces the fertilizer use efficiency, soil quality but also increases input cost. Hence, judicial site-specific application of fertilizer needs to be followed as a step for achieving targeted yields. This could be achieved by applying variable rates of fertilizers across the field to match the variation in soil fertility (Wollenhaupt *et al.,* 1994). NPK fertilizer recommendations for rice grown in various delineated zones of N, P and K were given based on the application of STCR equations. These equations consider the nutrient requirement for targeted yield of rice by condensing the nutrient status of fertilizer resources and residual soil fertility. The spatial fertilizer recommendation for available nitrogen, phosphorus and potassium for rice crop were presented in Figure 1, 2 and 3 and Table 2.

The spatial fertilizer recommendation map for nitrogen indicated that 55.3, 169.9, 145.8 and 44.9 ha of area representing 13.3, 40.8, 35, 10.8 per cent of study area was recommended with <100, 100-130, 130-160 and 160-190 kg ha^{-1} of nitrogen, respectively. For phosphorous recommendation map indicated that 197.6, 107.3, 74, 31.2 and 5.8 ha of area (416 ha) representing 47.5, 25.8, 17.8, 7.5 and 1.4 per cent area was recommended with <0, 0-20, 20-40, 40-60, 60-80 kg ha^{-1}, respectively. The spatial fertilizer recommendation map indicated that 52.2, 76.1, 52.2, 232.1 and 3.4 ha of area (416 ha) representing 12.5, 18.3, 12.5, 55.8 and 0.83 per cent area was recommended with <0, 0-30, 30-60, 60-90 and 90-120 kg ha^{-1} of potassium, respectively for getting targeted yield of 4500 kg ha^{-1} based on STCR equation.

The nitrogen recommendation for groundnut crop in the traditional approach for the study area is 20 kg ha^{-1} considering the entire zone as a homogeneous unit. Similarly, phosphorus and potassium requirements were 40 and 50 kg ha^{-1} respectively. The spatial fertilizer recommendation maps for groundnut crops were prepared based on STCR equation and presented in Fig. 4, 5 and 6 and Table.3. The spatial nitrogen recommendation map indicated that 62.4, 152.2, 145.6 and 55.8 ha of area (416 ha) representing 15, 36.6, 35 and 13.3 per cent of the study area was recommended with < 40, 40-60, 60-80 and 80-100 kg ha^{-1}, respectively. The spatial phosphorous recommendation map presented that 169.9, 89.8, 114.6 and 41.6 ha of area (416 ha) representing 40.8, 21.6, 27.5 and 10 per cent area was recommended with <0, 0-10, 10-20 and 20-30 kg ha^{-1}, respectively. The spatial potassium fertilizer recommendation map of indicated that 27.4, 83.4, 232.2 and 72.8 ha of area representing 6.6, 20, 55.8 and 17.5 per cent of area was recommended with <0, 0-30, 30-60 and 60-90 kg ha^{-1}, respectively for getting targeted yield of 3000 kg ha^{-1} based on STCR equation.

Table 1. Spatial variability of available N, P and K in soils of Bandarupalli RBK

S No.	Parameter	Class	Area (ha)	% Area
1	Available nitrogen	Medium (0.5-0.75%)	31.6	7.6
		Low (280 kg ha^{-1})	398.5	95.8
		Medium (280-560 kg ha^{-1})	17.4	4.1
2	Available phosphorous	Low (<22.4 kg ha^{-1})	41.9	10
		Medium (22.4-56 kg ha^{-1})	235.4	56.6
		High (>56 kg ha^{-1})	138.5	33.3
3	Available potassium	Low (<168 kg ha^{-1})	176.3	42.4
		Medium (168-336 kg ha^{-1})	89.4	21.5
		High (>336 kg ha^{-1})	150.1	36.1

Table 2. Spatial fertilizer recommendations for paddy in soils of Bandarupalli RBK

Area (ha)	Area (%)	Recommended N (kg ha^{-1})	Area (ha)	Area (%)	Recommended P_2O_5 (kg ha^{-1})	Area (ha)	Area (%)	Recommended K_2O (kg ha^{-1})
55.3	13.3	< 100	198	47.5	<0	52.2	12.5	<0
170	40.8	100-130	107	25.8	0-20	76.1	18.3	0-30
146	35	130-160	74	17.8	20-40	52.2	12.5	30-60
44.9	10.8	160-190	31.2	7.5	40-60	232	55.8	60-90
			5.8	1.4	60-80	3.4	0.83	90-120

Table 3. Spatial fertilizer recommendations for groundnut in soils of Bandarupalli RBK

Area (ha)	Area (%)	Recommended N (kg ha^{-1})	Area (ha)	Area (%)	Recommended P_2O_5 (kg ha^{-1})	Area (ha)	Area (%)	Recommended K_2O (kg ha^{-1})
62.4	15	<40	170	40.8	<0	22.7	6.6	<0
152	36.6	40-60	89.8	21.6	0-10	83.4	20	0-30
146	35	60-80	115	27.5	20-Oct	232.2	55.8	30-60
55.8	13.3	80-100	41.6	10	20-30	72.8	17.5	60-90

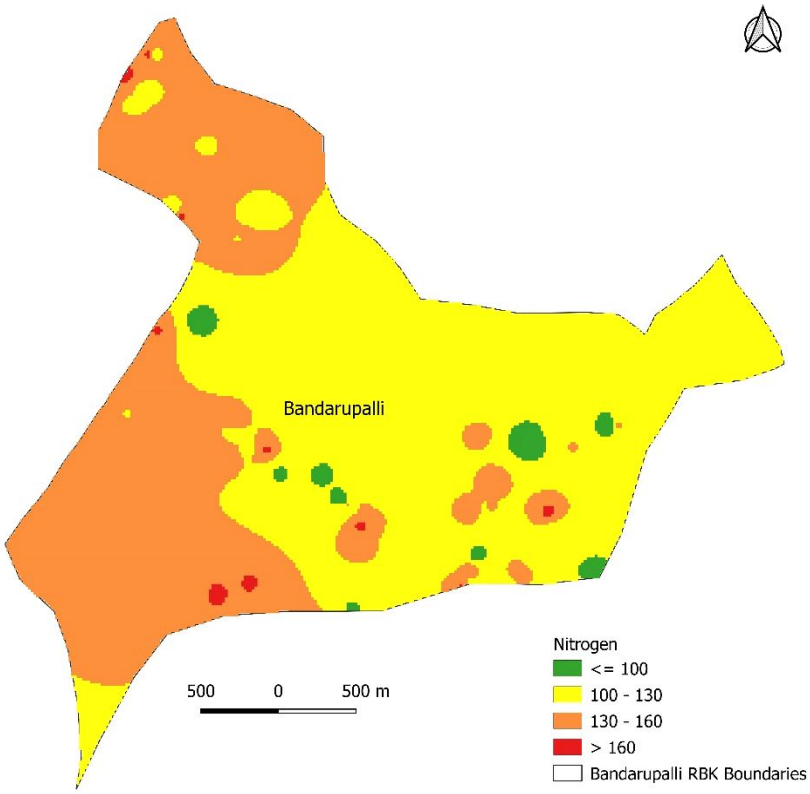


Figure 1. Spatial nitrogen recommendation map for rice

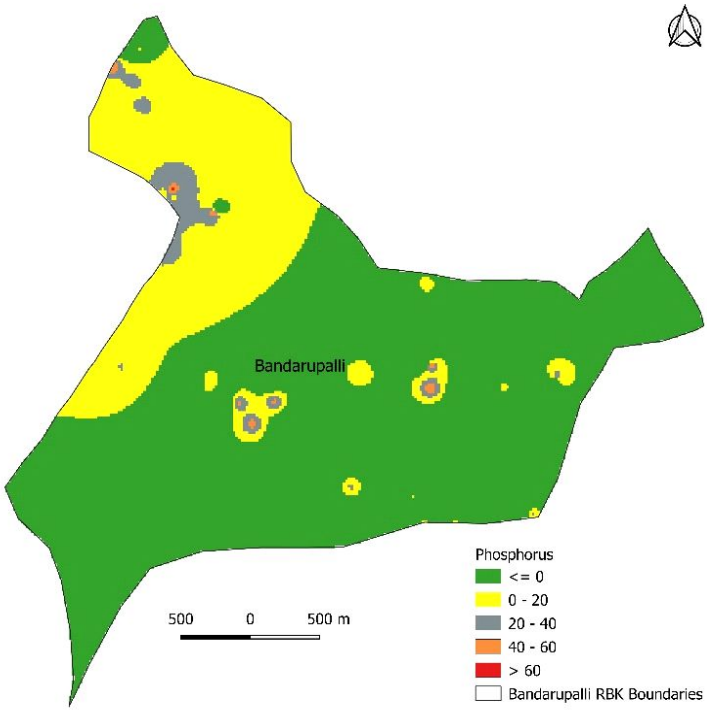


Figure 2. Spatial phosphorous recommendation map for rice

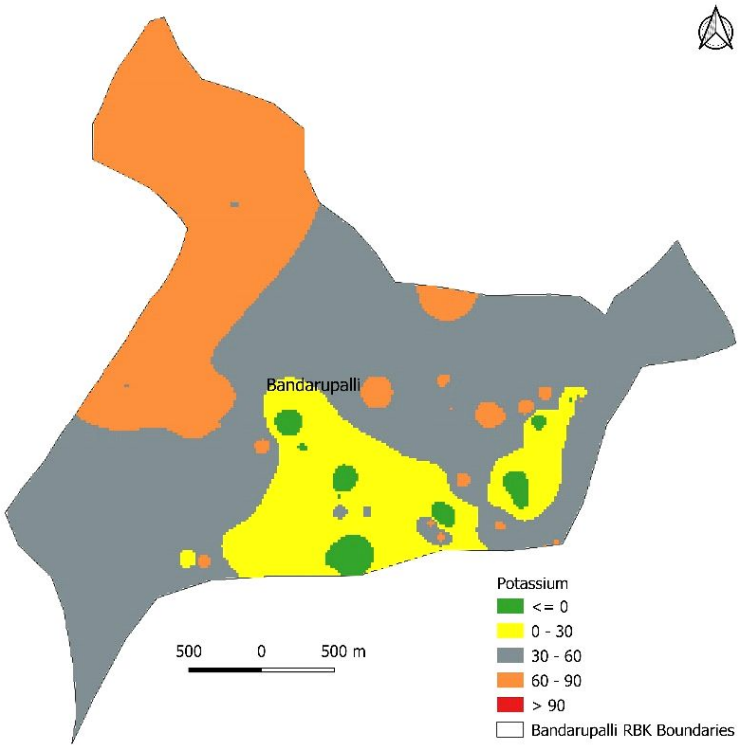


Figure 3. Spatial potassium recommendation map for rice

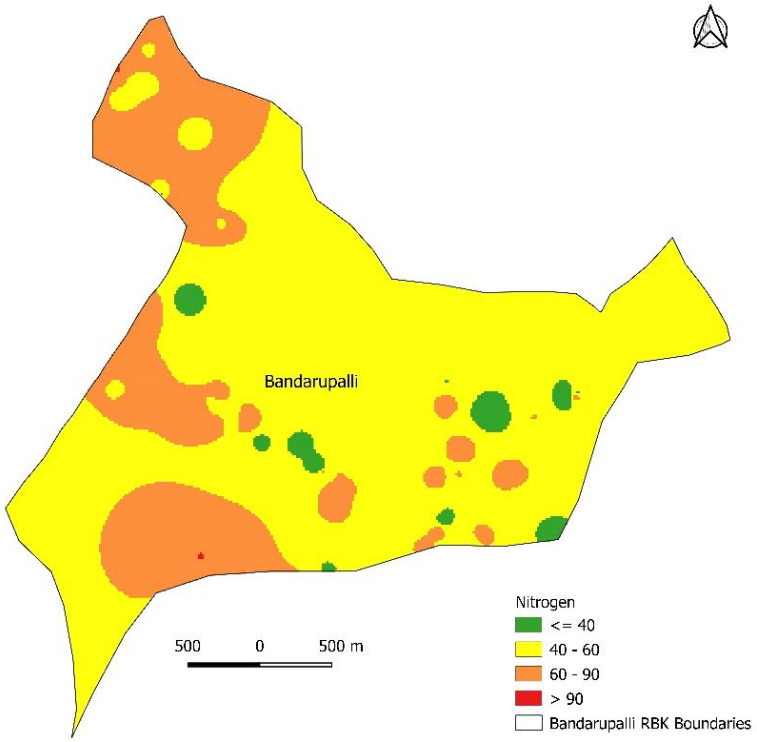


Figure 4. Spatial nitrogen recommendation map for groundnut

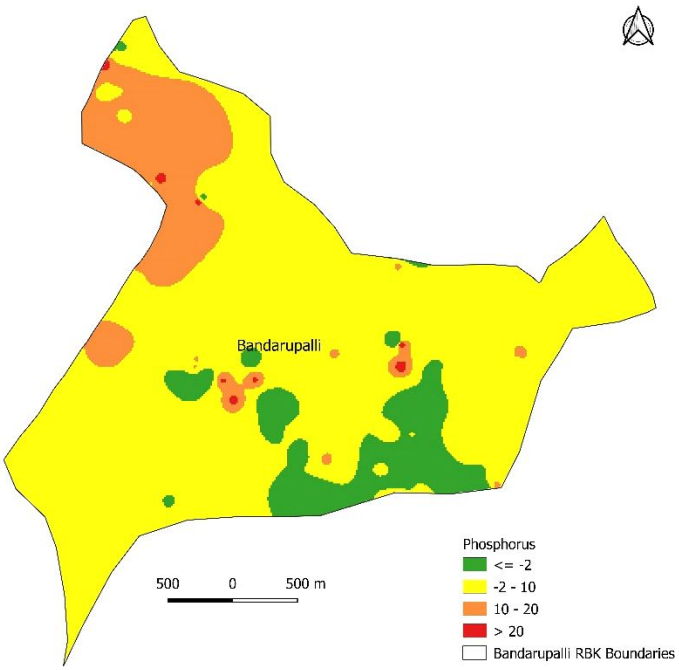
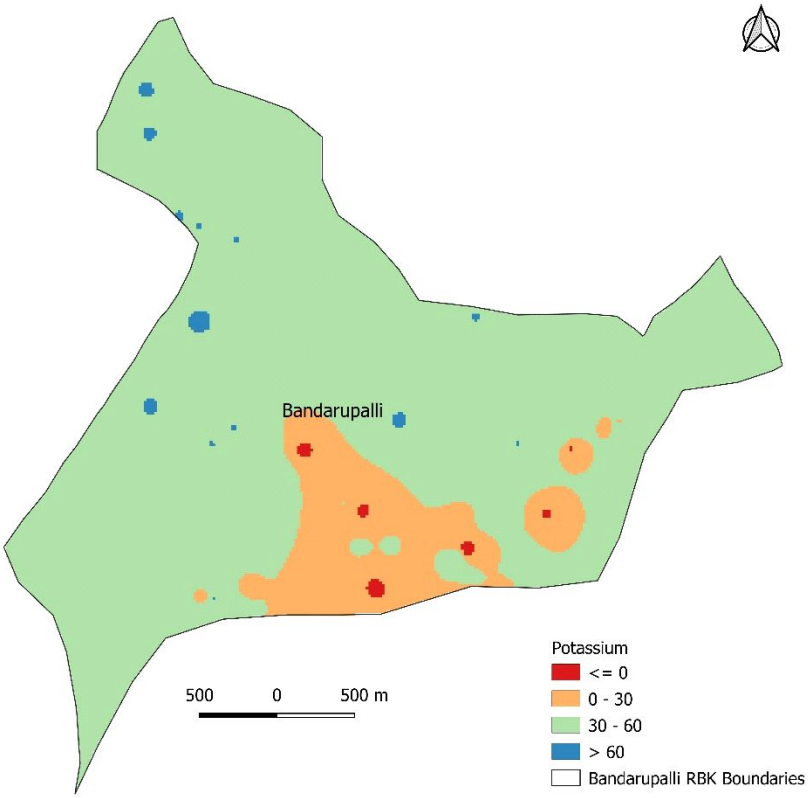


Figure 5. Spatial phosphorous recommendation map for groundnut



The spatial fertilizer recommendation mapping is pivotal for application of fertilizers at RBK level to ensure sufficient fertilizer reserves and for sustainable yields of the given area. The present fertilizer recommendation maps revealed that phosphorus and potassium fertilizers could be minimised because of higher contents in soils. About 47.5% of area were sufficient in P_2O_5 content and no need for P- fertilizers to rice crop, whereas, 25.8 per cent area required only 33 per cent of recommended P_2O_5 to rice crop. For groundnut, 40.8 per cent area do not require P-fertilization and 49.1 per cent area require 50 per cent of recommended P_2O_5 only. The potassium fertilizer requirement is only 60 per cent of recommended K for 26.6 per cent study area. Spatial fertilizer recommendations based on STCR minimizes the phosphorus and potassium fertilizers dose and cost to be incurred on chemical fertilizers required for rice and groundnut.

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