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Soil test crop response-based fertilizer recommendations in Meghalaya

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Abstract

Three STCR experiments were conducted on maize, rice and soybean. sub- treatments were imposed under four fertility gradient strips developed for each crop in the experimental block of Soil Science Division of ICAR Research Complex for NEH Region, Umiam. Main crops i.e. maize, soybean and rice were grown in the respective experimental plot of STCR. Fertilizer doses were applied in each sub- treatment of four fertility gradient strips on basis of treatment combination. The estimates of nutrient requirement (kg q^{-1}) value of nitrogen, phosphorus and potassium based on yield maximum method were 4.06, 1.60 and 2.15 respectively. The percent nutrient contributions from soil and fertilizer nutrients in Ultic Hapludalf were found to be 18.43, 6.82 and 8.98; 14.3, 85.07 and 12.7 for nitrogen, phosphorus and potassium, respectively under yield maximum method. Using fertilizer adjustment equations derived under yield maximum method, ready reckoner showing optimum N, P and K fertilizer doses at varying soil test values for attaining yield targets of 30 and 40 q ha^{-1} of rice yield was prepared. The results clearly indicated that the fertilizer dose required for attaining a specific yield target of rice yield decreases with increasing soil test values.

Key words: STCR, nutrient, yield, fertilizer, soybean, rice

Introduction

Meghalaya is one of the seven states of North-Eastern Region of India. Meghalaya is located between latitudes of 25º02' and 26º06' and longitudes of 89º48' and 92º50'E with an altitude ranging from 50-1961 above main sea level (msl). The total area of the state is 22,429 sq km with a population of 23,06,069 (Census of India 2001) and 103 persons/ km^2. The State is bounded by Assam in the North, East and West and Bangladesh in the South and southwest. The state is dominated by tribal population (90.46%). Jaintia and Khasi Hills administratively possess Jaintia Hills, East Khasi Hills, West Khasi Hills, Ri-Bhoi districts and Garo hills constitutes of East Garo Hills, West Garo Hills and South Garo Hills. The orography of the southern part of Meghalaya helps the occurrence of heavy monsoon rain where Mawsynram and Cherrapunji receives the highest rainfall in the world. The State is directly influenced by the South West monsoon and North Eastern winter winds. The region experiences tropical monsoon climate that varies from Western to Eastern part of the plateau. Garo Hills district has tropical climate characterized by high rainfall and humidity generally warm summer and moderately cold winter. Khasi and Jaintia Hills have high rainfall, moderately warm summer and severe winter with periodic depression below freezing point

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marked by appearance of ground frost at night and morning over higher elevated areas. The lower elevated areas experience fairly high temperature for most part of the year having a mean maximum of 23 to 26°C and a mean minimum of 12 to 17° C. The mean summer temperature is 26°C and the mean winter temperature is 9° C. As a whole state gets on an average 2000 to more than 10,000 mm annual rainfall concentrated from May to September. The humidity always remains more than 80% during the month's pre and monsoon period.

Rice and Maize are the important crops of Meghalaya and the area and production of these crops are 105.8 and 17.2 thousand ha and 120.3 and 24.9 thousand tones, respectively (Verma & Bhatt,2001). The low productivity of these crops is mainly due to very low and unbalanced use of fertilizers which can be well bridged if the fertilizer application technology is based on STCR approach. This will also, economize the use of fertilizers. By STCR correlation charts, balanced dose of fertilizers can be prescribed on the basis of soil test values for a reasonably desired target yield of these crops. From the nutrient management point of view soil-plant systems is also unique because it will provide a scientific basis for balanced fertilization not only among fertilizer nutrients themselves but also the soil available nutrients. In the present programme, the work was initiated with rice, maize and soybean for the soils of Meghalaya which are the most important cereal and oilseed crops for the state.

Materials and Methods

STCR Experiments in Meghalaya

Three STCR experiments were conducted on maize, rice and soybean. sub- treatments were imposed under four fertility gradient strips developed for each crop in the experimental block of Soil Science Division of ICAR Research Complex for NEH Region, Umiam. Main crops i.e. maize, soybean and rice were grown in the respective experimental plot of STCR. Fertilizer doses were applied in each sub- treatment of four fertility gradient strips on basis of treatment combination. On harvest, dry weight of grain and straw were recorded. The grain and straw samples have been collected at the time of harvest and samples were processed for estimation of N, P and K concentrations in grain and straw. The total uptake (kg/ha) of the respective crops have been calculated for further use in the adjustment equation of soil test crop response, the details are given in the text below. A field experiment based on STCR methodology on rice with the variety 'RCPL 1-87-4' was conducted at ICAR Research Complex for NEH Region, Umiam in Riboi district from 2004-05 to 2005-06. The soil at Umiam farm was Ultic Hapludalf with pH 4.75, organic carbon 18.3 g kg^{-1}, exchangeable Ca+Mg 1.76 $cmol(p^+)\ kg^{-1}$, available N (alkaline $KMnO_4$ oxidizable), P (Bray-2) and K (1*N* NH_4OAc extractable) 477, 11.5 and 167 kg ha^{-1}, respectively. The field layout for crop essentially comprised of four equal strips in which a gradient in soil fertility was artificially created by applying graded doses of N, P and K fertilizer so as get a wide range in soil fertility ($N_0P_0K_0$, $N_{½}P_{½}K_{½}$ $N_1P_1K_1$ and $N_2P_2K_2$; $N_1P_1K_1$: 80, 60, 40kg/ha). An exhaustive crop was later on raised on these four strips to stabilize the soil system. For the test crop of rice, the rice itself was the exhaustive crop. After the harvest of exhaustive crop, the experiment with rice as test crop was conducted in the subsequent season by dividing each of the four fertility strips into 30 plots which received 27 selected treatments out of the combination of three levels of N, three levels of P_2O_5 and three levels of K_2O. The remaining three sub-plots in each fertility strip were kept untreated as control and experiment was conducted in a RBD design (Ramamoorthy & Velayutham 1971). The plant samples viz. grain and straw samples collected at harvest were analysed for N, P and K and the plant uptake of nutrients was calibrated by using grain and straw yield data. Using the grain yield and nutrient uptake data, soil test values and applied fertilizer doses of treated and control plots, the basic data *viz*. nutrient requirement (kg q^{-1}), soil and fertilizer efficiencies (%) for making fertilizer recommendation were estimated by conventional procedure as discussed by Ramamoorthy *et al*. (1967).

STCR on Maize

Maize variety RCM-1-1 was grown in sub-plots of each strips i.e. $N_0P_0K_0$, $N_{½}P_{½}K_{½}$, $N_1P_1K_1$ and $N_2P_2K_2$. Fertilizer doses were applied in each plot on basis of treatment combination. Full dose of

P and K, and half dose of N were applied at the time of sowing and, the remaining half of N was top dressed in two split doses at 30 and 60 days after sowing. On harvest, dry weight of grain and straw were recorded.

Treatment details:
Nitrogen: 40, 80 and 120 kg N /ha
Phosphorus: 30, 60 and 90 kg P_2O_5 /ha
Potassium: 0, 30 and 60 K_2O kg/ha
Total treatment combinations: 27
Control plots: 3

The fertilizer materials used were Urea, SSP and MOP. Full dose of P and K, and half dose of N were applied at the time of sowing. The remaining half of N was top dressed in two split doses at 30 and 60 DAS. The representative soil samples (0 – 0.15m) were taken from each of 120 plots before the application of fertilizers and sowing of the crop. The yield data for grain and straw for all the plots were recorded at the harvest of the crop. Grain and straw samples were analysed for N, P and K. Similarly, available N (Alkaline $KMnO_{4)}$, available P (Bray-1) and available K (Neutral normal ammonium acetate) were determined in all the soil samples**.** With the help of nutrient uptake data and soil test values, the basic data (nutrient requirement in kg per quintal of grain, per cent contribution of a particular nutrient from soil, and per cent contribution of a particular nutrient from fertilizer) required for making fertilizer recommendations for different crop production levels were calculated according to procedure of Ramamoorthy et al. (1967).

The grain and straw sample have been collected at the time of harvest and samples were processed for estimation of N, P and K concentrations. The total uptake (kg/ha) of the crop has been calculated for further use in the fertilizer adjustment equation of Soil Test Crop Response of Maize. The soil efficiency was estimated from only unfertilized plots, while the fertilizer efficiency was estimated from fertilized plots. The nutrient requirement was estimated from both the fertilized and unfertilized plots. The computational procedure of basic data is well discussed in Ramamoorthy *et al*. (1967) and Reddy *et al*. (1994). The estimates of basic data were used for developing fertilizer adjustment equations for deriving optimum fertilizer test- based fertilizer recommendations had been prescribed in the from of a ready reckoner for different yield targets.

STCR on Soybean

Soybean variety JS - 335 was grown in sub-plots of each fertility gradient strips i.e. $N_0P_0K_{0,}$ $N_{½}P_{½}K_{½,}$ $N_1P_1K_1$ and $N_2P_2K_2$. Fertilizer doses were applied in each plot on the basis of treatment combination. Full dose of N, P and K were applied at the time of sowing. On harvest, dry weight of grain and straw was recorded.

Treatment details:
Nitrogen: 25 N kg/ha
Phosphorus: 30, 60, 90 and 120 P_2O_5 kg/ha
Potassium: 25, 50, 75 and 100 K_2O kg/ha
Total treatment combinations: 16

Control plots: 3. The grain and straw samples have been collected at the time of harvest and samples were processed for estimation of N, P and K concentrations. The total uptake (kg/ha) of the crop has been calculated for further use in the Fertilizer Adjustment Equation of soybean of Soil Test Crop Response. Nutrient requirement, Soil efficiency percent (FE%), and Fertilizer efficiency percent (SF%) were also calculated.

Results and Discussion

Fertilizer prescription equation for Rice

The basic data *viz*., the nutrient requirement (kg q^{-1}) for producing one quintal of rice yield, soil and fertilizer efficiencies or the percent contribution from soil and fertilizer nitrogen, phosphorus and potassium were calculated from each plot based on the data and have been presented in table 1. The estimates of nutrient requirement (kg q^{-1}) value of nitrogen, phosphorus and potassium based on yield maximum method were 4.06, 1.60 and 2.15, respectively. The percent nutrient contributions from soil and fertilizer nutrients in Ultic Hapludalf were found to be 18.43, 6.82 and 8.98; 14.3, 85.07 and 12.7 for nitrogen, phosphorus and potassium, respectively under yield maximum method. Using fertilizer adjustment equations derived under yield maximum method, ready reckoner showing optimum N, P and K fertilizer doses at varying soil test values for attaining yield targets of 30 and 40 q ha^{-1} of rice yield was prepared. The results clearly indicated that

Table 1: Basic data for targeted yield equation for Rice

Particular	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Nutrient required kg/q of grain (NR kgq^{-1})	4.06	1.60	2.15
Factor for efficiency soil nutrient (SE%)	18.43	6.82	8.98
Factor for efficiency fertilizer nutrient (FE%)	14.3	85.07	12.

the fertilizer dose required for attaining a specific yield target of rice yield decreases with increasing soil test values. Earlier reported studies (Mahadeva Swamy et al. 2020), (Ravindra et al. 2021).

Table 2: Fertilizer adjustment equations for rice

Crop		Fertilizer equation
Rice	FN	=2.82 x T- 0.13 x SN
	FP_2O_5	= 1.88 x T- 0.08 x SP
	FK_2O	= 1.69 x T- 0.07 x SK

Note: FN, FP_2O_5 and FK_2O are fertilizer N, fertilizer P_2O_5 and fertilizer K_2O, respectively, and SN, SP and SK are the soil test values for N, P and K in their elemental form and T is the predetermined crop yield target (qha^{-1}).

Fertilizer prescription equation for Maize

The basic data *viz*., the nutrient requirement (kg q^{-1}) for producing one quintal of maize yield, soil and fertilizer efficiencies or the percent contribution from soil and fertilizer nitrogen, phosphorus and potassium have been calculated from each plot based on the data and have been presented in table 3. The estimates of nutrient requirement (kg q^{-1}) value of nitrogen, phosphorus and potassium based on yield maximum method were 6.97, 1.42 and1.04, respectively. Earlier reported studies Anila et al (2018) and Sharma et al (2022). The percent nutrient contributions from soil and fertilizer nutrients in Ultic Hapludalf were found to be 22.63, 11.30 and 4.87; 38.50, 26.24 and 23.00 for nitrogen, phosphorus and potassium, respectively under yield maximum method. The result clearly indicated that the fertilizer dose required for attaining a specific yield target of maize yield is decreasing with increasing soil test values.

Table 4: Fertilizer adjustment equations for maize

Crop		Fertilizer equation
Maize	FN	= 1.99 x T- 0.11x SN
	FP_2O_5	= 1.49 x T- 0.11 x SP
	FK_2O	= 0.83 x T- 0.06 x SK

Note: FN, FP_2O_5 and FK_2O are fertilizer N, fertilizer P_2O_5 and fertilizer K_2O, respectively, and SN, SP and SK are the soil test values for N, P and K in their elemental form and T is the predetermined crop yield target (qha^{-1}).

Fertilizer prescription equation for Soybean

The basic data *viz*., the nutrient requirement (kg q^{-1}) for producing one quintal of soybean yield, soil and fertilizer efficiencies or the percent contribution from soil and fertilizer nitrogen, phosphorus and potassium have been calculated from each plot based on the data and have been presented (Table 5).

Table 3: Basic data for targeted yield equation for Maize

Crop	Particular	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Maize	Crop nutrient requirement (kg q^{-1} grain)	6.97	1.42	1.04
	Nutrient contribution from soil (%)	22.63	11.3	4.87
	Nutrient contribution from fertilizer (%)	38.50	26.24	23.00

Table 5: Basic data for targeted yield equation for Soybean

Crop	Particular	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Soybean	Crop nutrient requirement (kg q^{-1} grain)	6.97	1.42	1.04
	Nutrient contribution from soil (%)	22.63	11.3	4.87
	Nutrient contribution from fertilizer (%)	38.50	26.24	23.00

Table 6: Fertilizer adjustment equations for soybean

Crop	Fertilizer equation
Soybean	FN= 1.81 x T- 0.06 x SN
	FP_2O_5 = 5.42 x T- 4.33 x SP
	FK_2O = 4.51 x T- 0.21x SK

Field verification trials on Rice

Field verification trials were conducted in two villages of Riboi district for attaining a yield target of 30 and 40 q ha^{-1} during kharif 2006 (Table 7). The doses tested were based on the fertilizer adjustment equations calibrated for rice crop, along with the farmers' practice (FP). The yield target of 30 q ha^{-1} could be achieved in both locations tested, but 40 q ha^{-1} yield target could not be achieved.

Field verification trials on Maize

Field verification trials were conducted in two villages of Riboi district for attaining a yield target of 40 and 50 q ha^{-1} during kharif 2006 (Table 8). The doses tested were based on the fertilizer adjustment equations calibrated for maize crop, along with the farmers' practice (FP). The yield target of 40 q ha^{-1} could be achieved in both locations tested, but 50 q ha^{-1} yield target could not be achieved. Earlier reported studies (Amanullah et al. 2016) and (Padbhushan et al. 2021, 2022).

Table 7: Field verification trials of fertilizer adjustment equations of rice in Ultic Hapludalf of Riboi district of Meghalaya

Farmer /Village	Soil test values(kg ha^{-1}) N	P	K	Treatment	Fertilizer doses(kg ha^{-1}) N	P_2O_5	K_2O	Yield (q ha^{-1})
O. Khapran/Phyllum block IV	464.13	12.31	284.93	FP	Nil	Nil	Nil	20.12
				40q ha^{-1}	28.55	58.25	16.10	47.28
				50q ha^{-1}	48.45	73.15	24.40	48.75
O. Khapran/Phyllum block II	423.03	16.75	201.16	FP	Nil	Nil	Nil	19.89
				40q ha^{-1}	33.07	57.76	21.13	45.62
				50q ha^{-1}	52.97	72.66	29.43	47.55

*FP = Farmer's practice

Table 8: Field verification trials of fertilizer adjustment equations of maize in Ultic Hapludalf of Riboi district of Meghalaya

Farmer /Village	Soil test values(kg ha^{-1}) N	P	K	Treatment	Fertilizer doses(kg ha^{-1}) N	P_2O_5	K_2O	Yield (q ha^{-1})
O. Khapran/Phyllum block IV	464.13	12.31	284.93	FP	Nil	Nil	Nil	20.12
				40q ha^{-1}	28.55	58.25	16.10	47.28
				50q ha^{-1}	48.45	73.15	24.40	48.75
O. Khapran/Phyllum block II	423.03	16.75	201.16	FP	Nil	Nil	Nil	19.89

Table 9: Field verification trials of fertilizer adjustment equations of soybean in Ultic Hapludalf of Riboi district of Meghalaya

Farmer /Village	Soil test values(kg ha^{-1}) N	P	K	Treatment	Fertilizer doses(kg ha^{-1}) N	P_2O_5	K_2O	Yield (q ha^{-1})
O. Khapran/Phyllum block IV	464.13	12.31	284.93	FP	Nil	Nil	Nil	20.12
				40q ha^{-1}	28.55	58.25	16.10	47.28
				50q ha^{-1}	48.45	73.15	24.40	48.75
O. Khapran/Phyllum block II	423.03	16.75	201.16	FP	Nil	Nil	Nil	19.89
				40q ha^{-1}	33.07	57.76	21.13	45.62
				50q ha^{-1}	52.97	72.66	29.43	47.55

*FP = Farmer's practice

Field verification trials on Soybean

Field verifications trials were calculated in similarly for soybean and the details are given in table 9.

Epilogue

Soil test calibration that was intended to establish a relationship between the levels of soil nutrients determined in the laboratory and crop response to fertilizers in the field permitted balanced fertilization through right kind and amount of fertilizers. Nutrient supplying power of soils, crop responses to added nutrients and amendment needs can safely be assessed through sound soil testing programme. A well established STCR calibration will help to apply fertilizers in precise and judicious amounts, obtain high use of applied fertilizer nutrients and maximum possible yields of the crops. **Earlier reported studies (Nirmala et al. 2021), (**Srilatha **et al. 2021) and (Verma et al 2019).** Adoption of the best time, method and dose of fertilizer application by the farmers is essential to achieve higher use efficiency. Soil testing to determine the fertilizer need, suitable fertilizer drills for placement of fertilizers, promotion of slow release materials, IPNS and other improved agronomic practices will certainly help in increasing efficiency of applied fertilizers. Use of coated urea, USG, precision farming using GIS for decision support system in efficient use of fertilizer will become necessary to enhance the fertilizer Use Efficiency.

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