Soil Testing for Fertility Evaluation

Dr. V. K. Venugopal
Former Professor & Head
Department of Soil Science and Agricultural Chemistry
College of Agriculture, Vellayani
Consultant, Digital University, Kerala

Soil Testing

- Soil testing is a proven diagnostic tool to evaluate the available nutrient status of soil and evolve a fertilizer recommendation for crops

Steps involved in testing a soil sample

- Collection of a representative soil sample of the field
- Preparation of the sample
- Extraction of the available nutrients of sample with appropriate extracting agents
- Chemical analysis of the nutrient elements
- Soil test calibration and Interpretation of test results

Objectives of soil testing

- To assess the available nutrient status and problems of acidity/salinity , toxicity of soil
- Predict likely crop response of applied nutrient
- Classification of soils into different soil fertility groups for preparing soil fertility maps
- Assessment of extent of soil related constraints like acidity, salinity, toxicity and suggest appropriate ameliorative measures

Soil Test Reports

- Analytical data for soils on macro, secondary, micro nutrients, pH and conductivity
- Fertilizer recommendation for crops based on field history, research data crops and soils.
- Recommendation for soil amendments to correct acidity/alkalinity.
- Organic matter recommendation as per package of practices.
- Guidelines for fertilizer application and increasing use efficiency of fertilizers

Soil Test classes and Ratings

- Data on NPK will have to be classified into soil fertility classes Low, Medium, High based on pot culture studies with added fertilizers
- Ratings for Kerala soils have been published and being used by the Soil Testing Labs

Soil Test Calibration

- A soil test becomes useful only if it provides information on fertilizer requirement of crops for that nutrient.

Calibration studies involve the following steps

- Green house studies with graded fertilizer levels having low, medium, high rating to find out dose of fertilizer to produce optimum yield
- Validation trials in the farmer's field.
- Preparation of yield response curves between fertlizer levels and yield

Calibration information required

- Soil test level of a nutrient the produces maximum returns/ha.
- Quantity of fertilizer to be added to reach that test level.
- Calibration studies have to be carried out for different, soils, crops and nutrients.
- Predictions using mathematical models show deviations since crop production is dependent on factors like crop variety, plant population, climate, crop management soil, moisture. etc

Fertility Evaluation Approaches

Several approaches are available to convert soil test values to meaningful fertilizer recommendation for crops

- General/ Blanket recommendations.
- Soil test ratings and fertilizer adjustments – Low , Medium, High approach.
- Mitscherlich-Bray Approach in Fertilizer recommendation
- Fertilizer recommendation for maximum yield.
- Fertilizer recommendation for targeted yields.
- Soil Test Crop Response studies
- **General Recommendation**
- Based on the results of Simple fertilizer experiments conducted in Research Stations. followed by multi location trials in farmer's fields representing different soil, agro ecological regions, crops and soil fertility status

- Recommendation are arrived at through yield response trials for an optimum dose of fertilizer for various crops
- For eg 90:45:45 is the general recommendation for long duration paddy in Kerala as per the Package of Practices Recommendations of theKerala Agricultural University

Disadvantages

- Adoption of the recommendation uniformly over large areas can result in over use of fertilizers in areas with high fertility and under use in areas of deficieny
- This is due to the fact that spatial variations in soil fertility are not considered
- Soil test take care of the inherent variability in fertility

Fertilizer dose adjustment using   Low, Medium, High, approach

- Soil   test results are classified into Low, Medium, High classes or soil test ratings
- Permits adjustment of   fertilizer recommendations based on the inherent fertility of soil
- Recommendations followed in Kerala are given in Table

Soil Fertility Classes for OC, P and K (KAU)

Soil fertility class	% of organic carbon		N as % of general recommendation	Available P (kg ha^{-1})	Available K (kg ha^{-1})	P and K as % of general recommendation	Soil Fertility Rating
	Sandy	Clayey/ loamy					
0	0.00 – 0.10	0.00-0.16	128	0.0 – 3.0	0 - 35	128	Low
1	0.11 – 0.20	0.17-0.33	117	3.1 – 6.5	36 -75	117	
2	0.21 - 0.30	0.34-0.50	106	6.6 – 10.0	76 -115	106	
3	0.31 - 0.45	0.51-0.75	97	10.1- 13.5	116-155	94	Medium
4	0.45 - 0.60	0.76-1.00	91	13.6 -17.0	156-195	83	
5	0.61 - 0.75	1.01-1.25	84	17.1 -20.5	196 -235	71	
6	0.76 - 0.90	1.26-1.50	78	20.6- 24.0	236 -275	60	
7	0.91 - 1.10	1.51-1.83	71	24.1- 27.5	276 -315	48	High
8	1.11 - 1.30	1.84-2.16	63	27.6 – 31.0	316 -355	37	
9	1.31 - 1.50	2.17-2.50	54	31.1- 34.5	356- 395	25	

Secondary nutrients (Ca, Mg & S) Soil critical levels (KAU, 2012)

Nutrients	Deficiency	Adequate
Calcium	≤ 300 mg kg^{-1}	> 300 mg kg^{-1}
Magnesium	≤ 120 mg kg^{-1}	> 120 mg kg^{-1}
Sulphur	< 5 mg kg^{-1}	≥ 5 mg kg^{-1}

Micro nutrients (Cu, Zn & B) ,Soil critical levels (KAU, 2012)

Nutrients	Deficiency	Adequate
Copper	< 1.0 mg kg^{-1}	≥ 1.0 mg kg^{-1}
Zinc	< 1.0 mg kg^{-1}	≥ 1.0 mg kg^{-1}
Boron	< 0.5 mg kg^{-1}	≥ 0.5 mg kg^{-1}

Soil Test Fertilizer Recommendation based on Mitscherlich – Bray concept

- Mitscherlich's Law of Diminishing Returns:
- This law states that the increase in yield from adding a nutrient decreases as the amount of that nutrient in the soil increases.
- Bray's Concept of Nutrient Mobility:
- This concept emphasizes that the efficiency of a nutrient in influencing yield depends on its mobility in the soil.
- Mobile nutrients, like nitrates, are readily available to plant roots and can be efficiently utilized.
- Immobile nutrients, like phosphates, may require more fertilizer to achieve the same yield increase.
- Mitscherlich-Bray Equation: This equation combines these two concepts mathematically.
- It typically takes the form: $\log(A - y) = \log A - c_1 b - cx$.
- **A:** Represents the theoretical maximum yield possible under ideal conditions.
- **y:** Represents the actual yield obtained.
- **b:** Represents the initial level of the nutrient in the soil (determined by soil testing).
- **x:** Represents the amount of fertilizer applied.
- **c1 and c:** Are constants related to the efficiency of the soil and fertilizer nutrients, respectively.

Advantages

- The Mitscherlich-Bray concept allows for more precise and site-specific fertilizer recommendations and efficient nutrient use:
- It helps farmers optimize fertilizer use, potentially reducing costs and minimizing environmental impacts and improve crop yields

Fertilizer Recommendation for Maximum Yield

- Multiple regression equations in quadratic form are developed for prescribing fertilizer doses on soil test values for obtaining either max. yield or max. profit
- Relationship is established between soil Test Value, fertilizer dose of nutrient and crop yield by fitting Multiple Regression Equations of quadratic form Orthogonal polynomial yield response curve (Ramamoorthy ,1974)
- Data from multi location/single location trial are collected by creating artificial fertility gradient , Low, Medium, High in the same field
- Growing of experimental crop with graded levels of nutrients and preparing Multiple Regression Equations (MRE)
- From the statistically significant MRE, relationships will be developed between, soil test values and fertilizer doses which will be used to calculate the quantity of fertilizer for obtaining maximum yield

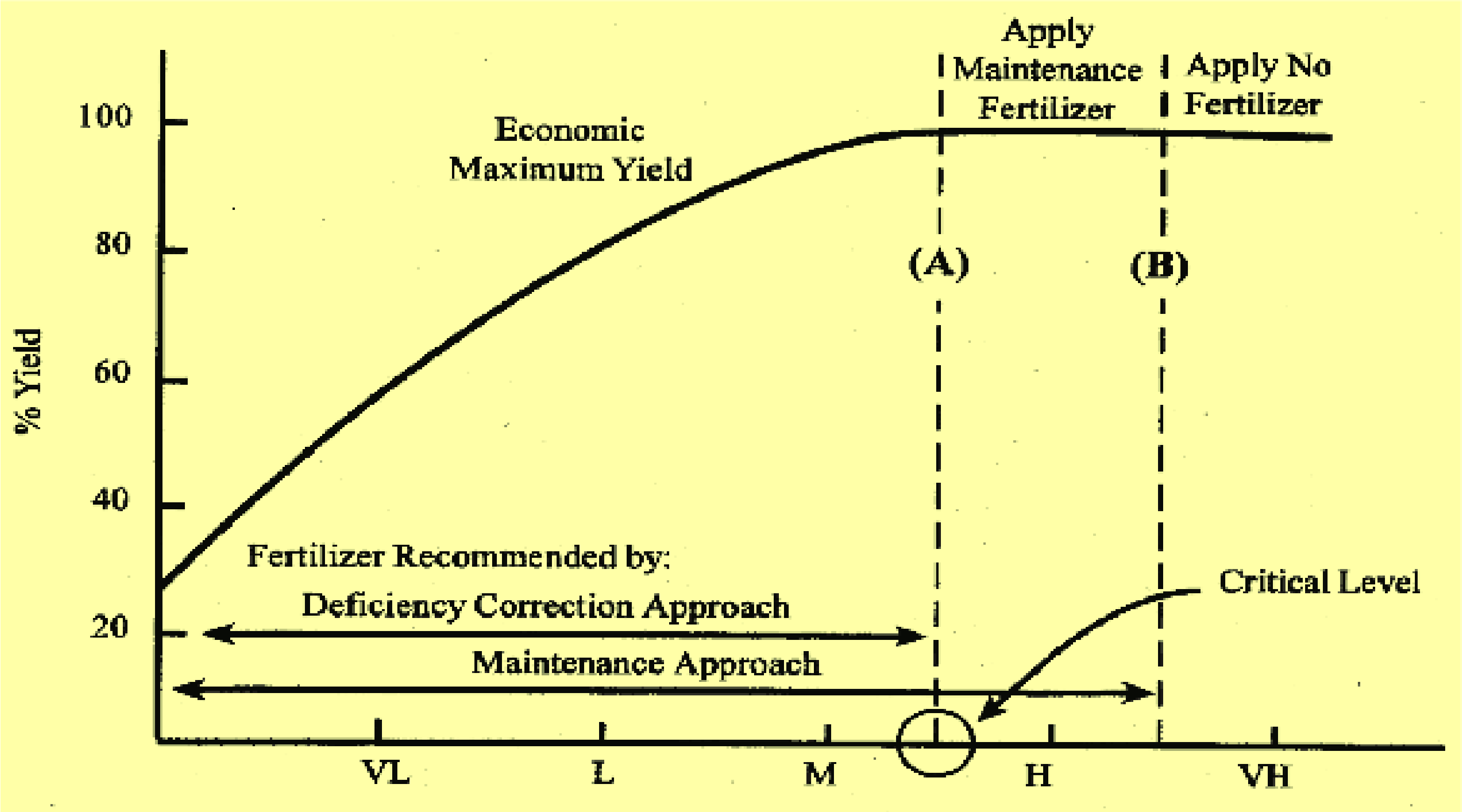
Targeted Yield concept (Soil Test Crop Response)

- Initially advocated by Troug 1960 and later by Ramamoorthy *et al*. (1967) by which fertilizer recommendation for high yielding varieties for crops could be calculated
- ICAR launched the All-India Co-ordinated Research Project on soil test crop response correlation (1967-68).
- Implemented in different Agricultural Universities covering various crops and agro ecological regions
- The research establishes a mathematical models for modifying fertilizer dosages based on soil test data to achieve desired crop yields.

Needed parameters are

- Nutrient requirement in kg per quintal of grain production,
- Per cent contribution from soil available nutrients (CS),
- Per cent contribution from fertilizer nutrients (CF).
- Advantage is that the farmer can choose a fertilizer dose according to his resources

Relationship between percent yield and levels of soil nutrient



Fertilizer prescription formulation Equations

- First step is to test the inherent fertility of the soil
- Crop response studies carried out in the field with different doses of fertilizers and measuring the corresponding yield levels
- Based on the data from crop response studies, mathematical equations are developed that relate soil test values to the amount of fertilizer needed to achieve a specific yield target.
- Farmers can specify a desired yield for their crop, and the STCR approach provides a prescription for fertilizer application that is tailored to that target,

Benefits Of STCR

- Allows precise application of nutrients and achieve full yield potential
- More efficient nutrient utilization and minimizing waste impact on environment and reducing costs

How STCR is carried out

- Developing soil fertility gradients in the same field by inductive approach or selecting different fields with varying soil fertility in the deductive approach
- Results from the experiment are validated by carrying out multilocational trials with the crop in farmer's field

Site Specific Nutrient Management

- Takes into account indigenous nutrient supply and the crop's nutrient demand in order to achieve the desired yield. goal
- Plant analysis or soil-cum-plant analysis might be used to develop the SSNM recommendations
- It believes that the crop's nutritional status is the greatest measure of soil nutrient supply and crop nutrient needs.
- For field-specific fertilizer NPK recommendations for rice or other crops, Witt and Dobermann (2002) outlined five important processes

1. Selection of yield goals

- When there are no other variables affecting crop development, the Y is defined as the maximum feasible grain yield restricted only by the meteorological conditions of the site.
- The logic behind setting a yield goal of 70-80% of Y is that internal nutrient use efficiencies decline at very high yield levels near Y,
- The best farmers can achieve around 80% of Y max.
- The Decision Support System for Agro-technology Transfer (DSSAT) crop simulation models can be used to simulate crop growth, development, and yield.
- It's a sophisticated software tool that integrates data on weather, soil, and management practices to predict crop performance under various conditions

2. Assessment of crop nutrient requirement

- The QUEFTS (Quantitative Evaluation of the Fertility of Tropical Soils) model is used to evaluate fertiliser requirements in SSNM for the yield goal (Janssen et al. 1990).
- 3. Estimation of Indigenous Nutrient Supply (INUS)
- Defined as the total quantity of a specific nutrient accessible to the crop from the soil over the duration of the crop.
- INUS is made up of crop residues integrated into the soil, as well as water and atmospheric deposition.

4. Computation of fertilizer nutrient rates

- Field-specific fertilizer N, P or K recommendations are calculated on the basis of above steps 1 to 3, and the expected fertilizer recovery-efficiency (RE, kg of fertilizer nutrient taken up by the crop per kg of applied nutrient).

5.Dynamic adjustment of N rates

- P and K, fertilizer rates can be calculated as computed above, are applied basally at the time of sowing/ planting,
- N rates and application schedules can be further adjusted according to crop demand using chlorophyll meter (Soil Plant Analysis Development ,SPAD) or leaf color chart (LCC).

Soil Cum Plant analysis

Combination of soil and plant nutrient analysis is the best option to arrive at a fertilizer use plan to achieve economic yield without depleting the soil nutrient reserves

Soil Test Summaries and Nutrient Iindex

Soil test summaries of different regions are useful in delineating areas of sufficiency and deficiency of one or more nutrients. When carried out over a period, they are useful in the study of changing patterns in soil fertility, fertiliser use, etc.

Nutrient Index as suggested by Parker *et al*. (1951)

$$\text{Nutrient Index} = \frac{(N_l \times 1) + (N_m \times 2) + (N_h \times 3)}{N_t}$$

where, N_l - Number of samples in low category,
N_m- Number of samples in medium
N_h- Number of samples in high category
N_t- Total number of samples

Nutrient index classes

Low : < 1.5 ; Medium : 1.5 -2.5 ; High : > 2.5

Based on the nutrient index, fertilizer recommendation (NPK) is given as the percentage of general recommendation now being followed by the State Soil Testing laboratories.

Reference

Fundamentals of Soil Science, Revised: February 2012, Indian Society of Soil Science


Thank You