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Common Soil Test Methods for Fertilizer Recommendation: A Review

Yonika Saini[1] and Vinod Kumar Yadav[2]
[1]Ph.D Research Scholar, Department of Agronomy
[2]Assistant Professor, Department of Soil Science and Agriculture Chemistry
Agriculture University Kota, Ummedganj -325001, Kota

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Abstract

This paper summarises the findings of a recent scientific study conducted in several locations of India on the usage of soil test-based fertilisers to achieve crop yield targets. Soil testing, in its broadest definition, refers to any chemical or physical measurement done on a soil. Soil testing's main goal is to determine the soil's nutrient status and lime requirements so that fertiliser and lime recommendations may be made for productive farming. It aids in determining the state of soil fertility and making appropriate recommendations. Chemical fertiliser and organic manure provide a cost-effective nutrient dose for a variety of crops and cropping systems. Knowledge of nutrient requirements influences the pace of plant nutrient supply.Using post-harvest soil test value, have been developed for a variety of crops and cropping systems.

Keywords Approach, crop, fertilizer recommendation, nutrients, soil test

Introduction

STFRF (Soil testing and fertiliser recommendation facilities) can help farmers attain environmental and economic sustainability by assisting them in recognising their soil condition, reducing pesticide use, using the suitable amount of fertiliser, cutting input costs, and boosting output. Soil testing as a technique for cautious fertiliser administration is a eminent practise utilised all over the globe to avoid nutrient treatments that are either too little, too much, or imbalanced. Testing of the soil and fertility control programmes have been given enough weight in Indian agriculture to ensure crop output and balanced fertilisation.

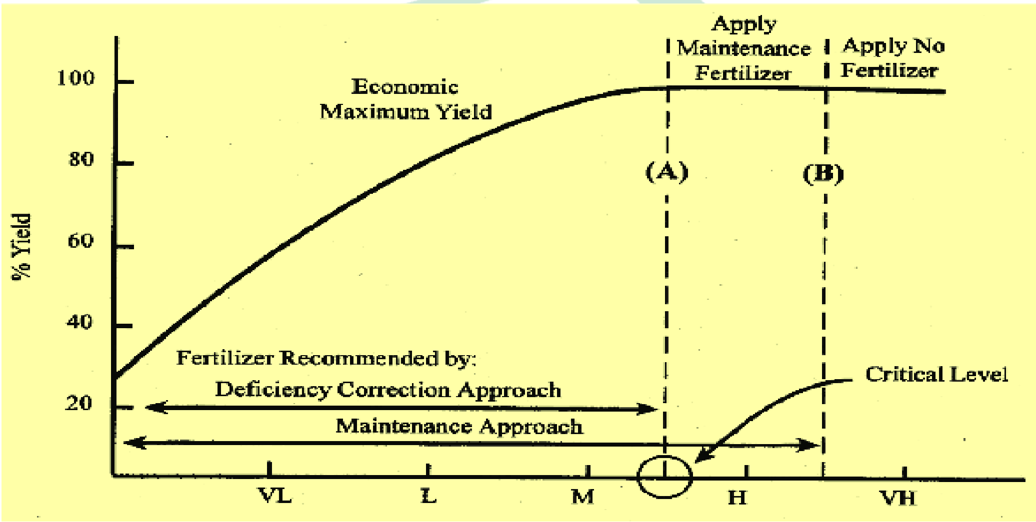
Fertilizer has been and will continue to be an important component of the country's food grain production targets. However, growing nutrient application costs, along with increased demand for fertilisers and worsening soil health, necessitate the employment of an effective approach. The true connecting link between research and its practical implementation in farmer's' fields is hence the soil test-based fertiliser suggestion. Soil testing is crucial for generating good yields and maximising the return on fertiliser investment.

Fertilizer is most expensive agricultural inputs, and getting the appropriate quantity is critical for farm productivity and environmental preservation (Kimetu *et al*., 2004). To address the present mismatch between fertiliser rates and nutrients demand in irrigated rice settings, managing location specific variability in nutrient delivery is a critical method. (Dobermann and Cassman, 2002).

For soils of different fertility, farmer resource circumstances, and levels of intended yield for similar soil classes and environments, location-specific fertiliser recommendations are conceivable (Ahmed *et al*., 2002). Fertilizer suggestion for a preset production objective is a sophisticated approach that is especially useful when fertiliser resources are limited. In this approach, fertilisers are suggested independently for various fields based on soil test results, and uniform yield objectives are defined based on fertiliser input availability.

Soil Test Crop Response (STCR) field design and inductive approach

The Indian Council of Agriculture Study (ICAR) began the All India Coordinated Research Project in 1968, after Ramamoorthy (1968) created a novel field experimental technique for soil test crop response correlation research. The methodology is based on the principle that in order to develop a quantitative relationship between different measured levels of any one component of a crop production system (for example, fertiliser N) and the yield produced by that system, a field experiment with varying measured levels of that factor must be conducted and the resultant yield measured.



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In soil test crop response study, data containing the relevant range of values for each controlled variable (fertiliser dose) at various levels of the uncontrolled variable is required (e.g., soil fertility) because different values of the uncontrolled variable (for example, soil fertility) are unlikely to exist in the same spot, separate sites are often chosen to signify the various degrees of soil fertility, and the interpretation is inferred and used in general. (This is a deductive approach.)

Soil test crop response-based fertilizer application:

The quantity of nutrient extracted by the crop, the starting level of soil fertility, the efficiency of nutrient uptake from the soil, and fertilisers are all factors considered in the soil test crop response (STCR) method. The fertiliser dose calculated using this approach is intended to maintain soil fertility while reducing yield variations. Stewart (1947) conducted the first methodical research in the country to link soil data to fertiliser judiciousness. Based on this research, a fertiliser use initiative began in 1953, and soil testing facilities began in 1955-1956.

The interpretation of soil test ratings and fertiliser recommendations by soil test laboratories needed to be reoriented to suit modern agricultural technology by generating soil test calibration research work, especially with the introduction of fertiliser responsive high yielding varieties and hybrids of crops, intensification of cropping under expanded irrigation facilities during the 1960's, and the general fertiliser recommendations themselves being on the higher order. With this in mind, during the fourth five-year plan, ICAR launched the All-India Co-ordinated Research Project on soil test crop response correlation (1967-68). The project's research establishes a mathematical connection for modifying fertiliser dosages based on soil test data to achieve desired crop yields.

Troug (1960) proposed this as the foundation for fertiliser application for specified yields. The yield targeting approach is unique in that it not only reveals a soil test-based fertiliser dose, but also the amount of yield that a farmer may expect to attain provided proper agronomical practises are used in crop production.

- Nutrient requirements in kg/q of produce, grain, or other economic output
- The percentage contribution of the available nutrient in the soil.
- The contribution of the applied fertiliser nutrient in percent. (Ramamoorthy *et al*.,1967)

The following formula is used to determine the three parameters listed above:

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

Kg of nutrient/q of grain = Total uptake of nutrients (kg)/ Grain yield (q)

(a) Kg Nutrient per quintal grain production

$$NR = \frac{Uptake\ of\ nutrient\ in\ kg/ha\ from\ grain + straw}{Grain\ yield\ in\ q/ha}$$

(b) Contribution of nutrients from soil:

$$ES = \frac{Uptake\ of\ nutrient\ in\ kg/ha\ from\ grain + straw\ from\ control\ plot}{soil\ test\ value\ for\ available\ nutrien\ (kg/ha)\ from\ control\ plot}$$

(c) contribution of nutrient from fertilizer

$$Ef = \frac{\begin{array}{c}Total\ uptake\ of\ nutrient\ in\ kg/ha\\ -Soil\ test\ values\ of\ fertilizer\ treated\ plots \times Contribution\ of\ nutrient\ from\ soil\end{array}}{Fertilizer\ nutrient\ applied} \times 100$$

Calculation of fertilizer dose:

The following equation is used to convert the given basic data into a practical adjustment equation:

$$F = \left[\frac{NR}{E_f} \times y\right] - \left[\frac{ES}{E_f} \times sN\right] - \left[\frac{E_{FyM}}{E_f} xFYM(\mathrm{t\,h}\,a^{-1})\right]$$

Where, F = Fertilizer (kg ha^{-1})

NR = Nutrient requirement

Es = Per cent contribution from soil

Ef = Per cent contribution from fertilizer

E_{FYM} = Soil test value (kg ha^{-1})

STV = Per cent contribution from FYM

Y = Yield target (q ha^{-1})

FYM = Farmyard manure (t ha^{-1})

Fertilizer prescription formulation Equations

Soil test-based fertiliser recommendations are based on the concept that the fertiliser needed is equal to the crop's nutrient need minus the nutrient given by the soil. It entails measuring the quantity of nutrient extracted by a crop for a certain yield level, as well as the contribution of nutrient from the soil source, and then calculating the amount of fertiliser to be supplied to satisfy the crop's requirements while taking fertiliser efficiency into account.

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Truog (1960) demonstrated the feasibility of adopting the 'Prescription approach' of fertiliser application to achieve high maize yields by employing empirical nutrient availability from soil and fertiliser. Sharma and Singh (2000) devised the fertiliser adjustment equations FN = 4.86 T - 0.47 SN, FP2O5 = 2.92 T - 4.37 SP, and FK2O = 2.20 T - 0.26 SK for attaining desired wheat yield: FN = 4.86 T - 0.47 SN, FP2O5 = 2.92 T - 4.37 SP, and FK2O = 2.20 T - 0.26 SK, where T signifies. They conducted a repeated follow-up field trial at IARI farm and administered fertiliser doses based on targeted yield equations for the soil in order to achieve a wheat grain production objective of 42.53 q ha^{-1} of 103, 53, and 43 kg ha^{-1}. In comparison to the planned yield of 42.53 q ha^{-1}, the yield produced by targeted yield treatment was 44.17 q ha^{-1}. For calibrating and developing fertiliser recommendations, the nutrient demand in kg t^{-1} of grain produce (NR), the percent contribution from soil accessible nutrients (CS percent), and the percent contribution from applied fertilisers (CF percent) were calculated. More than 90% of the objectives set at various levels were met, demonstrating that the soil test-based fertiliser recommendation method was reasonably dependable.

Mishra *et al*., (2013) developed a fertiliser adjustment equation for tomato (cv, BT-10) grown in an Odisha Ustochrept under a rice-tomato cropping system. FN = 1.32T – 0.45SN, FP2O5 = 0.72 T – 1.72 SP, and FK2O = 0.92 T – 0.96 SK are the fertiliser adjustment equations, with T denoting the yield target in q ha1. The tomato fruit output improved with an increase in graded fertiliser dosages with an increase in fertility strip of 149.4, 162.7, and 175.8 q/ha in L0, L_1, and L_2, respectively.The fertiliser prescription equation was developed by Gogoi and Mishra (2015) based on the desired pumpkin yield. The results revealed that when pumpkin yield objectives climbed, fertiliser rates increased, but fertiliser rates declined as the starting soil test level increased. FN = 4.94 T – 1.25 SN, F P_2O_5 = 2.67 T – 2.71 S P_2O_5, F K_2O = 2.02 T – 0.55 S K_2O are the derived fertiliser adjustment formulae. Fertilizer dosages advised by soil testing laboratories were shown to be inferior to the targeted yield strategy. Bera*et al*., (2006) observed similar findings in their farm study of site - specific nutrient management in pearl millet based cropping systems on alluvial soils.

As a result, the targeted yield approach to fertiliser recommendations maintains nutrient balance to meet conditions involving various yield targets, soil fertility, and farmer resources (Dev *etal*, 1985).

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Soil test reports form a basis of sound recommendations on plant nutrient application through fertilizers and/or manures. The soil test based fertilizer use enhances productivity, improves nutrient use efficiency and minimises the risk of environmental pollution. Fertilizer rates needed for a crop generally depend on indigenous nutrient supply, and vary with the nature of crop, its yield potential, previous crop grown and agronomic management practices.

1. **General Recommendations: -** These recommendations are based on multi-locational studies using graded N, P, and K fertiliser dosages. Yield responses to applied nutrients are worked out and an optimum dose of fertilizers is recommended for individual crops in a given agro-ecological region. The major drawback with this approach is that the variation in soil fertility is not taken into consideration. Despite these limitations, general recommendations are being used extensively in India and many other Asian countries for their simplicity and exclusion of costs involved in soil testing. As the present day globally, competitive agriculture necessitates for an enhancement in input use efficiency, this fixed-rate approach needs to be discouraged.
2. **Recommendation Based on Soil Fertility Rating: -** The majority of soil testing laboratory recommendations in India are based on soil fertility ratings, with the medium soil fertility equating to the general recommended dose. Fertilizer dosages are raised or dropped by 25 to 50 percent of the general recommended amount in low and very low or high and very high categories, depending on the scenario.
3. **Critical Limit Based Recommendations: -** Cate and Nelson created the critical level idea (1965). The critical limit is the amount of accessible nutrient in the soil over which sufficiency occurs and the nutrient is no longer a significant limiting factor for crop output.
4. **Recommendations Based On Targeted Yield:** - A significant linear relationship has been reported between grain yield of crops and nutrient uptake. This forms the basis for targeted yield concept initially advocated by Troug (1960). Ramamoorthy *et al*. (1967) put forth the concept by which fertilizer recommendation for high yielding varieties for crops could be made. The needed parameters are i) nutrient requirement in kg per quintal of grain production, ii) per cent contribution from soil available nutrients (CS), and iii) per cent contribution from fertilizer nutrients (CF).Advantage

of this approach is that a farmer can select a suitable target according to his resources and management conditions.

5. **Recommendations Based on Nutrient Index:-** Fertilizer recommendation as per this approach is based on summarizing the overall availability status of a particular nutrient in a given area into low, medium and high categories according to the method given by Parker *et al.* (1951). The nutrient index is calculated as follows:Where, NL, NM and NH are the number of soil samples falling in low, medium and high categories, respectively and NT is the total number of soil samples analysed. If nutrient index is <1.5, the soil fertility status is low, a value from 1.5 to 2.5 indicates medium fertility, and a nutrient index value >2.5 refers to high fertility status. Later, it was felt that these limits attach undue weight age to medium class, hence the limits were modified by Ramamoorthy and Bajaj (1969) as <1.67 for low, 1.67 to 2.33 for medium and >2.33 for high fertility status.
6. **Recommendation For Cropping Sequences:** - Meeting the fertilizer need of a cropping sequence as a whole is more important than those of indidual crops. Legume-based cropping sequences can be taken up with lower fertilizer N doses due to the added advantage of symbiotic N-fixation. Also, utilization of phosphatic fertilizers by first crop of a sequence is very low (around 25%), and it is also not lost by any other process except erosion.
7. **Use of Simulation Models: -** Conventional fertiliser recommendations based on crop responses and soil test readings are frequently difficult to generalise to areas/regions with varying agro-climatic conditions. In that case one option is to conduct expensive field experiments under individual situations for developing fertilizer recommendations. Alternatively,modern techniques simulation modelling can used for purpose.This approachrequires specific knowledge of the use of simulation models and also proficiency of working on computer.
8. **Site-Specific Nutrient Management (SSNM):-** This relatively recent nutrition recommendation method is mostly focused on the soil's indigenous nutrient supply and the crop's nutrient demand in order to achieve the desired yield. Plant analysis or soil-cum-plant analysis might be used to develop the SSNM recommendations.

A. Plant Analysis Based SSNM

It believes that the crop's nutritional status is the greatest measure of soil nutrient supply and crop nutrient needs. For field-specific fertiliser NPK recommendations for rice or other crops, Witt and Dobermann (2002) outlined five important processes (listed below):

1. **Selection of yield goat**: When there are no other variables affecting crop development, the Y is defined as the maximum feasible grain yield restricted only by the meteorological circumstances 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, and the best farmers can achieve around 80% of Ymax. Crop growth models (e.g. DSSAT) can be used to calculate Y for a crop variety under a given climatic condition.
2. **Assessment of crop nutrient requirement**:A crop's nutrient absorption needs are determined by both the yield objective and Y. The QUEFTS (Quantitative Evaluation of the Fertility of Tropical Soils) model is used to evaluate fertiliser requirements in SSNM (Janssen et al. 1990). In a high producing season, nutrient needs for a certain yield objective of a crop variety may be lower than in a low yielding season.
3. **Estimation of indigenous nutrient supplies:** When other nutrients are present in appropriate amounts, indigenous nutrient supply (INUS) is defined as the total quantity of a specific nutrient accessible to the crop from the soil over the duration of the crop. The INUS is made up of crop leftovers that have been integrated into the soil, as well as water and atmospheric deposition.
4. **Computation of fertilizer nutrient rates:** Field-specific fertilizer N, Por 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:** Whereas fertilizer P and K, as computed above, are applied basally at the time of sowing/ planting, the N rates and application schedules can be further adjusted according to crop demand using chlorophyll meter (popularly known as SPAD) or leaf color chart (LCC).

B Soil-cum-Plant Analysis Based SSNM

In this situation availability of nutrients in the soil and plant nutrient demands for a high yield target and recovery-efficiency of applied nutrients are considered for making fertilizer use plan to achieve highest economic yield of a crop variety. In order to ascertain desired crop/plant growth, not limited by apparent or hidden hunger of nutrients, soil analysis done for all macro and micronutrients well before sowing. Field-specific fertilizer rates are then suggested to meet nutrient demands of the crop (variety) without depleting soil reserves. Such recommendations often include 4 to 7 plant nutrients depending on the existence of multi-nutrient deficiency or nutrient inadequacy for high yield targets.

Conclusion

By setting the production objective at a level where the cost of fertiliser is more or less the same as what the farmer was doing previously, soil testing becomes more relevant and valuable. When fertiliser supply is limited, and farmers' resources are also restricted, planning for moderate yield objectives that are greater than the farmers' regular yield levels give a way to saturate additional regions with available fertilisers while also insuring enhanced total production.The result indicated that fertiliser usage efficiency and overall output are greater when available fertilisers are used to achieve low yield objectives rather than fertiliser dosage reductions.

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