Research Article

Journal of Plantation Crops, 2014, 42(3):370-376

Site specific nutrient management software for coffee

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(Manuscript Received: 19-09-13, Revised: 10-06-14, Accepted: 18-07-14)

Abstract

Chemical fertilizers are integral part of agriculture and continue to be inevitable source of nutrients. A site specific soil test based nutrient management system ensures the judicious use of fertilizers by contributing to the sustainable and economic production without polluting the soil resources. Coffee is a major commercial crop of India and the site specific fertilizer recommendations for this crop have proved to have advantages over 'blanket fertilization' by improving the fertilizer use efficiency and profitability. The software was designed in such a way that entries corresponding to the block-wise soil test data *viz*., soil pH, available N, P and K generate necessary information on the quantity of suitable and available fertilizers that need to be applied to each block to meet the demand of the crop and plant.

Keywords: Coffee nutrition, FERREC, fertilizers, nutrient management, soil testing

Introduction

Among the production inputs, fertilizers have played a key role in increasing agricultural production in India ever since the dawn of green revolution. Fertilizers continue to contribute significantly to meet the growing demand of food grains for the ever increasing population. Moreover, in agricultural soils the fertilizer use efficiency is low and is a continuing challenge to improve the nutrient use efficiency in order to minimise non-point source of pollution of both surface and ground water. To get maximum benefit and reduce nutrient losses from fertilizers, they need to be applied in the right quantity, using the right source and in the right combination at the right time using the right method.

Hitherto, the agronomic packages of practice for crops were recommended uniformly irrespective of the intrinsic soil heterogeneity. Extrapolation of improved experiment based fertilizer recommendations evolved for a particular soil type, crops and genotype to large area may not hold good owing to inherent spatial variations in soils with respect to texture, reaction and fertility. In perennial crops like coffee, owing to large variations in the yields, blanket fertilizer recommendation seems to be unpractical and uneconomical. The response to fertilizers is greatly influenced by soil type besides spatial and temporal variability that has been imparted from complex geological and pedological processes. Spatial variations of soil properties are known to decrease fertilizer use efficiency (Bhatti *et al.,* 1991;Larson andRobert,1991*;* Miller *et al.,*1998).

Recommendation of the correct quantity of fertilizers for coffee is of vital importance for maximising the profits besides abating pollution hazards. Further, as the Indian coffee sector has a large number of planters having very small holdings, they are not well acquainted with soil test based, balanced fertilizer application. The necessity to educate the small planters to understand the optimum NPK ratio and blending the commercial fertilizers to arrive at that ratio, soil test based nutrient recommendation software 'Fertilizer Recommendation'(FERREC)was developed. Through this software, a more effective method is

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explored by integrating the information of average annual yield (3-5years) along with sustenance dose required for vegetative growth to arrive at unique kind of recommendation. Based on the consolidation, fertilizers ought to be applied to get targeted yields by selection of ideal combination of nutrient sources to maximise the return per unit area. In this backdrop, a study was conducted with the objectives of developing and validating a software for site specific major nutrient management in coffee and evaluating the accuracy of the software in fertilizer recommendation to arrive at the targeted yield in the practical situation.

Materials and methods

Structure of the FERREC software is user friendly and requires primarily a desktop computer running Windows 98 or later versions. The C language (Code Warrior software) is used in the development of FERREC for desktop computers. All tables and forms were hard-coded into the software, in part, to ensure maximum speed. The user interface as well as nutrient status and anticipated yield are developed using the C language while visual basic was deployed to fertilizer recommendation.

Overall program structure consists of a central database separated into three prominent sections. They are i) the user interface, ii) nutrient status or indigenous nutrient supplying capacity of soil and yield data and iii) fertilizer recommendation section. The second and third sections retrieve the information from the central database as per the soil test and yield based fertilizer recommendation for the growers (Jayarama, 2001).

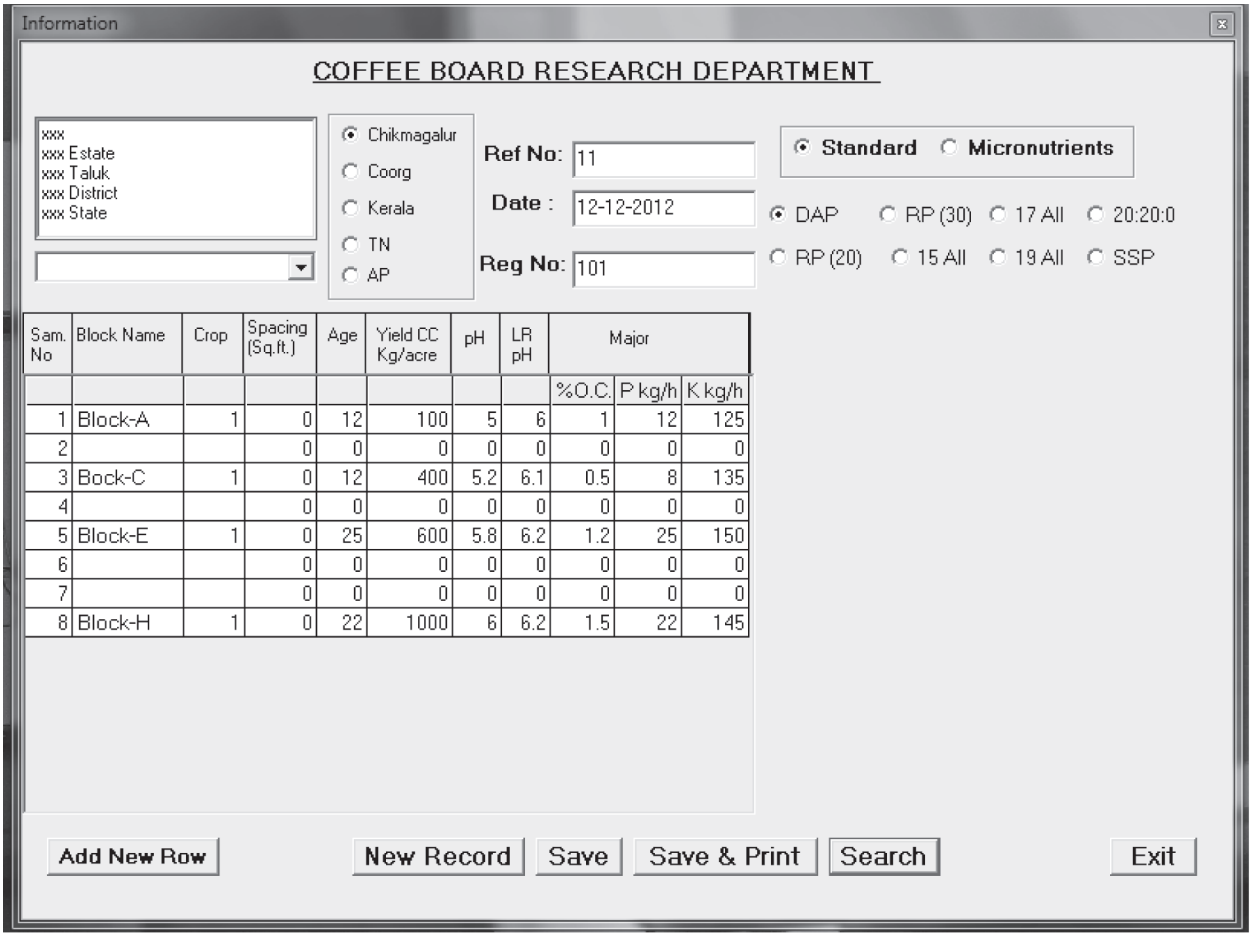


Fig. 1. User interface section

The user interface section envisages creation of the inventory to assess the potential of the block selected for recommendation (Fig. 1). A format is presented to the grower to gather the following information (all observable in the field as well as registered in the farm book). The sampling area of blocks having homogenous soil and crop usually the composite sampling is advised within 2 ha. In case of heterogeneity, higher number samples are required to achieve higher level of accuracy. A conventional name assigned by the planter for the block being revealed would facilitate identification, modifications and implementation of the recommendation. (Traditionally, coffee planters assign colloquial names like *Zari patte, Bunglow block, Line block, Pete makki, etc.* to identify different blocks in the estate. These blocks are bound to have physiographical differences upon which soil characteristics are dependent. For instance *Zari Patte* (Stream Block) is located at relatively higher elevation with steeper terrain comprising of lateritic soils (Ultisols); as the name suggests it is associated with water streams. The *Bungalow block* and *Labour line blocks* will be comparatively on a level terrain with red soils (Alfisols) with profuse influence of domestic animals. Similarly, *Pete makki* is assigned to paddy fields (Inceptisols) in the valleys with inherent drainage problems.)

Here two choices are deployed for depth of sampling, one, shallow root distribution zone (0-22.5 cm) and the other, moderately deep (22.5-45 cm) for problematic patches. Age of the plants has two options (less than 5 years and above 5years) based on the crop bearing characteristics. In case of non bearing juvenile plants the recommendation would be the sustenance dose based on the number of plants accommodated in a unit area (considering spacing). On the contrary, recommendation for bearing plants would be on the basis of the anticipated clean coffee yield, irrespective of the block area.

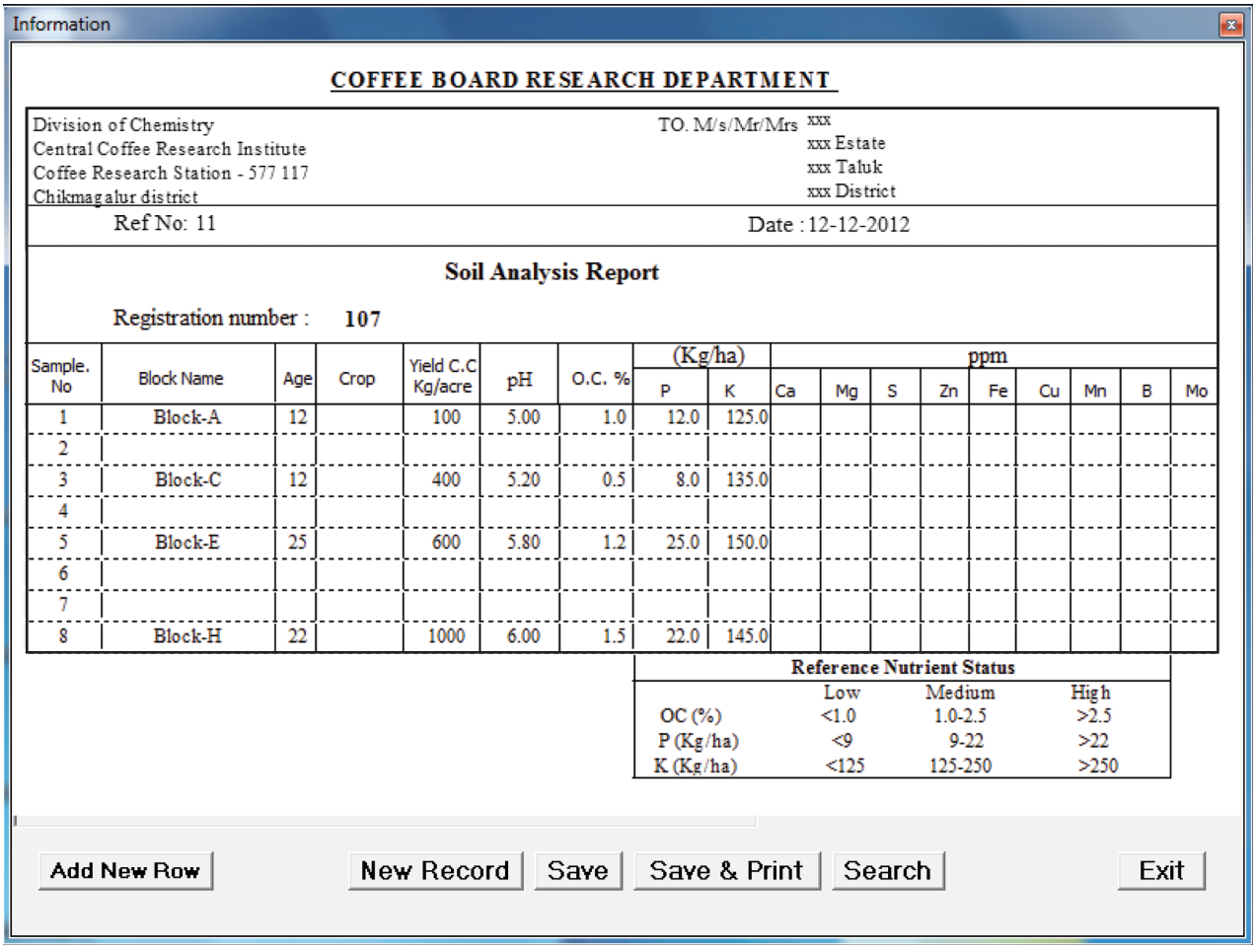
Arabica and Robusta coffee species are cultivated in India. The nutrition pattern and yield attributes between the two species are separately addressed while recommendation. Generally two categories of slope are employed. They are gentle and steep slope, which differ markedly with respect to soil, water and nutrient management strategies.

Fertilizer application details like the quantity of fertilizer and manure applied during previous years, the type of fertilizers used, number of split applications would form the basis for the current recommendation. The number of split application depends on the vulnerability of the soil to fertilizer losses and in turn lower fertilizer use efficiency. In any case, a single split should not exceed 40:30:40 NPK as it is likely to cause scorching effect on the young roots. Generally, two split dose for Arabica and three splits for Robusta under irrigated conditions are followed.

The details pertaining to lime application in the yesteryears enables to diagnose the soil health. Continuous application of calcite lime ($CaCO_3$) induces magnesium deficiency for which dolomite ($CaCO_3$ $MgCO_3$) is often recommended in the schedule. The planter has to disclose the available stock of fertilizers in the farm so that recommendations would be considering the same. As per these criteria various parameters need to be furnished to suit the conditions of the block under probe for recommendations. These observations would suffice the requirements of the software for preparing fertilizer recommendation.

Section B of the FERREC software involves nutrient status and anticipated yield. The FERREC software is designed to estimate the required N, P, and K of fertilizer based on indigenous nutrient status of soil. The lime requirement pH (LR pH) is determined by appropriate buffer solution. The soil N status is assessed by the organic carbon content while the available P is determined by Bray equation program and K availability is based on neutral normal ammonium acetate method. The availability of nutrients is classified into low, medium and high categories upon which the nutrient recommendation varies (Fig. 2).

Coffee is a perennial plant and rightly called as 'century plant'. Unlike annual crops, a uniform fertilizer recommendation does not operate in this crop. Separate recommendations are required to young non-bearing plants compared to the older bearing plants. Further, split applications to synchronize the nutrient requirement and assimilation rates of the plant. Long term fertilizer trials have revealed that 10:7:10 kg NPK is required to produce 100 kg clean coffee besides a sustenance dose of 20:20:20 kg NPK for promoting vegetative


Information

COFFEE BOARD RESEARCH DEPARTMENT

Division of Chemistry
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TO. M/s/Mr/Mrs xxx
xxx Estate
xxx Taluk
xxx District

Ref No: 11 Date : 12-12-2012

Soil Analysis Report

Registration number : 107

Sample. No	Block Name	Age	Crop	Yield C.C Kg/acre	pH	O.C. %	(Kg/ha)		ppm								
							P	K	Ca	Mg	S	Zn	Fe	Cu	Mn	B	Mo
1	Block-A	12		100	5.00	1.0	12.0	125.0									
2																	
3	Block-C	12		400	5.20	0.5	8.0	135.0									
4																	
5	Block-E	25		600	5.80	1.2	25.0	150.0									
6																	
7																	
8	Block-H	22		1000	6.00	1.5	22.0	145.0									

Reference Nutrient Status

	Low	Medium	High
OC (%)	<1.0	1.0-2.5	>2.5
P (Kg/ha)	<9	9-22	>22
K (Kg/ha)	<125	125-250	>250

Add New Row | New Record | Save | Save & Print | Search | Exit

Fig. 2. Nutrient section

growth by considering fertilizer use efficiency (Jayarama, 2001). This particular ratio (10:7:10) remains additive for incremental yields anticipated as the yield pattern is considered under log phase of the nutrient versus yield equation. It is interesting to note that current year's vegetative wood produced would have a bearing on the succeeding year. So it is important to encourage vegetative growth besides reaping the current harvest. The anticipated yield is fixed based on the average yield realized during past 3-5 years. Moreover, it is established that the current level of yield could be improved by about 100 kg in the next three years by better management (Jayarama, 2001). Hence the anticipated yield would be additional minimum of 100 kg over the average yield realized during preceding 3 to 5 years.

Section C of the FERREC software gives the fertilizer recommendation. Once the specific requirements of nutrients based on the anticipated yield are generated, an additional routine involves the available N, P, and K fertilizer materials to suit the most economical blend to match the specific requirement for N, P, and K.

It is necessary to emphasize the role of P in inducing good flowering and fruit set in turn to use water soluble P fertilizer during pre-blossom period. Since the P containing fertilizers are relatively expensive, amount of N-P fertilizer (such as 18-46 or 20-20-0-15) to meet the P requirement is ascertained with the software. Then the rest of the requirements of N and K are met with urea and muriate of potash (KCl), respectively. This step also indicates how much of each of the fertilizer material is needed to make the blend. After these calculations, the software reveals the amount of nutrients (N, P_2O_5 and K_2O) that are required for

the particular field besides furnishing the details of split application (usually 3) for the pre-blossom, pre-monsoon and post-monsoon periods. It also provides the bulk blending information on straight fertilizers, in case the recommended fertilizer grades are not available in the market (Fig.3).

As already indicated about inter-species differences with respect to mineral nutrition between Arabica and Robusta coffee, the rock phosphate (Tri-calcium phosphate) as P source recommended for Arabica during pre-monsoon may not be suitable for Robusta as the S requirement desires upon single super phosphate application. These preferences were adopted in the software to suit the nutritional management for each of the species.

Results and discussion

As indicated above the FERREC software is part of a larger effort to enable growers by providing them with site-specific nutrient management information of their estate. It is believed that the software is very successful in meeting this objective and has the same approach as site-specific nutrient management elsewhere(Attanandana and Yost, 2003). This particular programme consolidates soil analytical data, coffee yield particulars along with the crop type to reveal fertilizer recommendation as well as the optimal time of fertilizer application.

The FERREC program has the flexibility to calculate the amount of existing N, P and K for the straight and complex fertilizers. While site-specific nutrient management seems to have many benefits

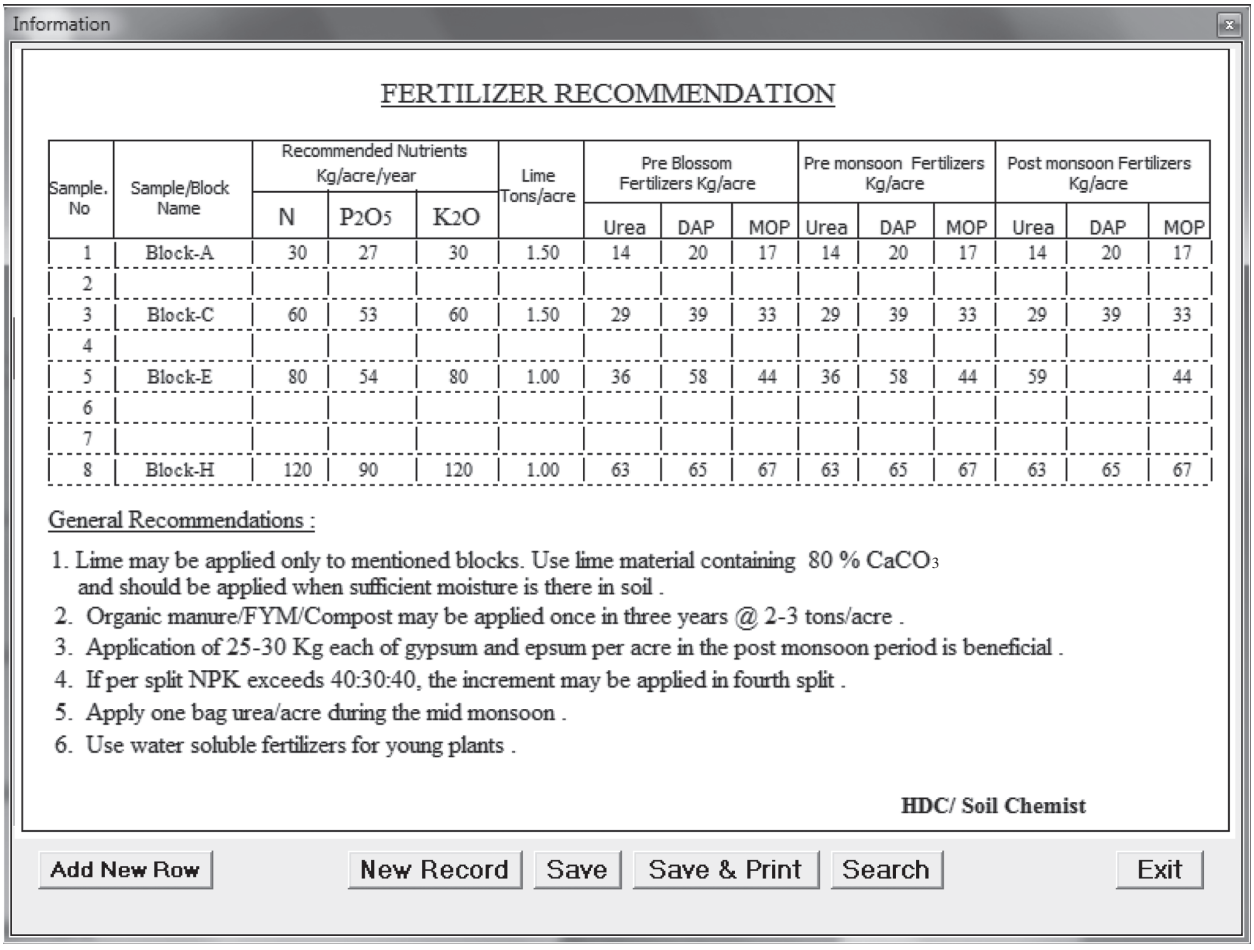

Fig. 3. Fertilizer Recommendation

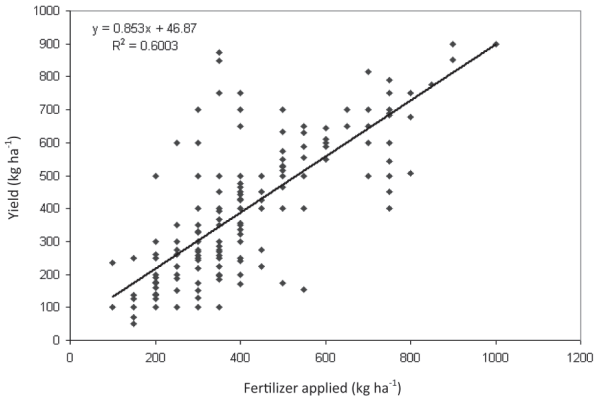

Fig. 4. Model validation for fertilizer vs actual yield realised

over 'blanket fertilization' such as the analytical results for N, P, and K from soils collected in the field. This information served two purposes in the overall approach 1) It permitted a diagnosis of whether the current soil nutrient status is sufficient and 2) It provided a quantitative estimate of status of N, P, and K of soil and knowledge of the coffee cultivar, permitted a prediction of the optimal time of manuring and the appropriate amounts of N, P, and K fertilizer to meet target yield levels.

The FERREC software is flexible enough to interpret the above collected data and information to carry out a quantitative calculation of the amounts and grades of fertilizers needed to meet the calculated requirements. The software is equipped with a spreadsheet-based calculator for fertilizer recommendation based on i) Site-specific nutrient status, ii) Targeted yield to actual yield over a period of 3-5 years and iii) Fertilizer selection.

The requirement of selected fertilizers for targeted yield in next 3 years is presented in Table 5. In case of targeted yield, it has been already established that in addition to existing mean yield for 3-5 years another 100 kg clean coffee per unit area can be obtained in next 3 years time (Jayarama, 2001) by efficient management. The software recommended additional dose of phosphorus and potassium over the actual practice when the status of P and K were deficient compared to the normal soils. On the contrary, the recommendation suggested for skipping one split application of phosphorus fertilizer if the soil available P is high. As per the recommendations of the software, fertilizer quantity varied from 0-50 per cent based on the nutrient status of soil. This software plays an important role in economizing and in optimizing fertilizer, so as to avoid the residual impact on the soil. This could be an eco-friendly package for the coffee growers without sacrificing the targeted yield.

It is necessary to emphasize that amelioration of acid soils through lime application can only be achieved over a period of time. In other words, instantaneous change in soil pH does not occur as soil system itself acts like a buffer. Thus a soil having an initial pH of 4.3 may require ten years of time to attain a pH of 6.5 (Somani *et al*., 1976) by proper amelioration measures. In general pH 4.0 and 6.2 are the distinctly different categories of coffee growing soils, where software differentially recommended liming materials (Agriculture lime, dolomitic lime *etc*.) to ameliorate the acidity. In general, soil pH around 6.0 would need only 625 kg of lime per hectare, while pH below 5.0 may require lime at the rate of 5.0 MT per hectare.

The validation and confirmation of the authenticity of the model is the important step forrendering advisory services. For this about 336 pairs of observations pertaining to the fertilizers dose and the corresponding yields were recorded and the linear relation was worked out (Fig.4).The relation between the applied fertilizer and the yield remained significant ($R^2 = 0.6003$) and is practically applicable to the coffee tracts of India.

Conclusion

Grower friendly computer based software 'FERREC' for fertilizer recommendation in coffee developed by CCRI is a step towards site specific nutrient management. The programme utilizes the data on type of coffee, age, nutrient status of the soil, pH, LR, pH and average yield of the past 3-5 years for recommending a need based and site-specific fertilizer by using locally available complex and straight fertilizers. This software is used for fertilizer recommendations in the CCRI and Regional stations for the samples received from the planters.

Acknowledgement

The authors are grateful to Dr. Jayarama, Director of Research, CCRI for the guidance and encouragement rendered in software development programme. We are greatly thankful to Dr. Sudhakar

Babu, Senior Scientist, Directorate of Oil Seed Research, ICAR, Hyderabad and Mr. Muralidhar, Liaison Officer, Coffee Board for their guidance, suggestions and help in developing the software programme and also in manuscript preparation.

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