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Prescribing Optimum Doses of Nutrients for Targeted Yield Through Soil Fertility Maps in Andhra Pradesh (AP)

K.N. Singh, N.S. Raju, A. Subba Rao, Abhishek Rathore, Sanjay Srivastava, R.K. Samanta[1] and A.K. Maji
Indian Institute of Soil Science, Bhopal, MP
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SUMMARY

The present paper is an attempt to create spatial fertilizer recommendation system using available validated fertilizer adjustment equations (Generated by AICRP on Soil Test Crop Response Correlation) and Geographic Information System (GIS). For this district wise soil fertility maps were prepared by using the index values of nitrogen (N), phosphorus (P) and potassium (K). Then their corresponding equivalent of soil nutrient values with respect of N, P and K were calculated from these index values. Reasonable limits for targeted yields were identified and defined. Using the above information soil fertility maps of Andhra Pradesh is prepared. The recommendations in the form of equations for targeted yields developed by Rao and Srivastava (2001) have been interlinked with the fertility maps. The recommendation system suggested varied applications of nutrients for same-targeted yields in different districts of AP.

Key words : Targeted yield, Soil test values, Index values, Soil fertility, Geographic Information System (GIS).

1. INTRODUCTION

Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection (Kimetu *et al.* (2004)). To enhance farm profitability under different soil-climate conditions it is necessary to have information on optimum doses for crops. Traditionally, to determine the optimum doses of fertilizer most appropriate method is to apply fertilizer on the basis of soil test and crop response studies. During 1956-57 the semi-quantitative soil test calibrations were evolved and advocated for the use. Subsequently in India the quantitative refinements in the fertilizer recommendations based on the soil and plant analysis were made (1967-68) through the All India Coordinated Research Project for Investigation on Soil Test Crop Response Correlation (STCRC). The ICAR project on soil test crop response correlation used the targeted yield approach to develop relationship between crop yield on the one hand and soil test values and fertilizer inputs on the other. The project is working in India from past 32 years and has generated information regarding fertilizer doses based on soil test values for various Indian agro-eco regions. This information is particularly very useful for farmer community. However, AICRP has its own mechanism to disseminate this information to farmer community. It is primarily based on printing some charts and distributing them to farmers. Today, space-age technology is providing some important tools, which can be used in speedy dissemination of this research information to extension workers and farmers. One of them is use of soil fertility/ soil fertilizers maps for fertilizer recommendation with a support to calculate fertilizer doses based on soil test values interactively. Fertilizer recommendations provided in the form of spatial recommendation maps integrating Nutrient Requirement (NR), Fertilizer Nutrient Efficiency (EF) and Soil Nutrient Efficiency (ES) for variable yield targets can be very useful for soil testing laboratories and extension workers. Such maps will promote use of soil testing laboratories for obtaining soil test based recommendation and will also give accurate information of fertilizer application to farmers.

[1] *NBSS&LUP, Nagpur*

2. FERTILITY DATA PROCESSING AND MAPPING IN GIS

During this work N, P and K recommendation maps for Andhra Pradesh state were developed. For this, soil fertility database on N, P and K index values at district level was developed in MS-Access. As far as the district spatial layer is concerned, the state boundary maps, which consist of districts were scanned in *.tiff* format and imported to Arc GIS system ver 9.0. The ground control points (GCP's) were identified for the state and based on them the state map was geo-referenced. The polyconic projection system with modified Everest Datum was followed for the state during the geo-referencing. The state and district boundaries were digitized in polyconic mode in *.shp* format. After digitization, the necessary corrections were done to clean the state and district layer for topology building. The districts were assigned different ids (users defined identification for any feature say districts in this case) in the layer to assign various attributes in the database. Through ARC Catalog software the columns for N, P and K were added in the layer to enter the attribute data.

As far as the attribute database is concerned the N, P and K index values of each district in state were imported from MS-Access and assigned to Polygon Attribute Table (PAT) in the layer. The errors were rectified in master state layer to generate different thematic maps on N, P and K index values of each state in GIS. From the attribute database, different thematic layers have been reclassified to generate various thematic maps on N, P and K index values. The district wise index values have been assigned from the database generated on N, P and K index values to the corresponding district layer of the state in GIS and generated the thematic maps accordingly. Latter the classes in thematic layer were reclassified as low (0-1.5), medium (1.5-2.5) and high (>2.5) to generate the N, P and K index value maps in GIS. The suitable annotations like legend, palettes, north arrow and scale were composed on thematic maps. The thematic maps on N, P and K index values of Andhra Pradesh have been generated. The whole process is explained by the flow chart given in Fig. 1.

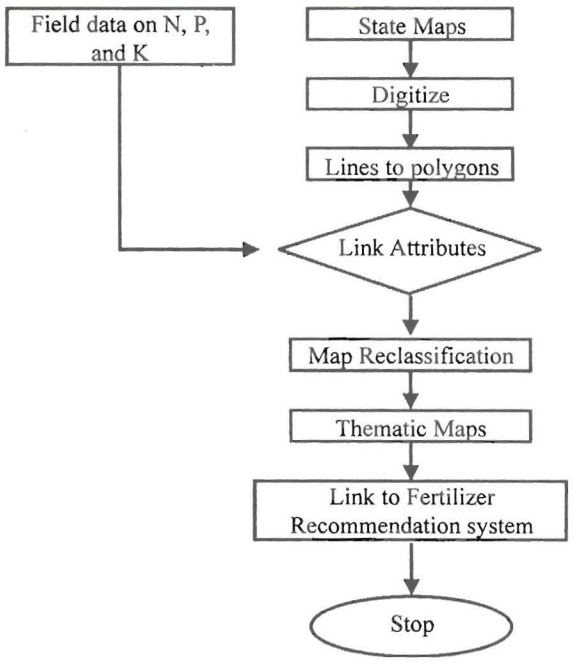

Fig. 1. Flowchart of important steps

3. PRESCRIPTION OF OPTIMUM DOSES

Index Values (IV) for the year 2001 were used to prepare soil fertility maps of Andhra Pradesh for N, P and K. Index values were calculated using standard procedure (Biswas and Mukherjee (1987)). The soil testing laboratories of different districts generally provide the test in the form of number of units (soil samples) in three categories viz. low, medium and high. IV have been calculated using the formula as follows.

$$IV = (N_l+2N_m+3N_h)/(N_l + N_m + N_h)$$

where, N_l, N_m and N_h are the number of soil samples falling in the categories of low, medium and high nutrient status and are given weightage of 1, 2 and 3 respectively. The number of samples has varied from district to district [8450 (Nalgonda) to 18347 (Warangal)] depending on the size and other conditions of the districts. These soil sample sizes are adequate to represent the districts. The IVs were classified into three categories viz. (Low : 0-1.5, Medium : 1.5-2.5 and High : > 2.5). In this paper STCR approach was used to prescribe optimum doses of nutrients, based on available soil nutrients. From available Index Values and STCR equations the backward calculation for soil test values (STV) were obtained as follows.

Low : 0.0 - 1.5 :: 0-a (a>0)

Medium : 1.5 - 2.5 :: a-b (b>a)

High : >2.5 :: >b

If IV<=1.5

STV= ax (IV)/(1.5)

If IV>1.5 and<= 2.5

STV= a+[(b-a) × (IV-1.5)]

If IV >2.5

STV=(b/2.5) × IV

Where a and b were positive coefficients used for describing the range of different nutrients. a and b values depend on soil characteristics and are different for different soils. These denote the fertility of a soil with respect to N, P or K and are determined through soil test crop response correlation experiments. If a soil sample has available nutrient (N, P or K) below 'a' that means it is low, between 'a' and 'b', it is medium and above 'b', it is high. The (a, b) values for N, P and K for the state of AP are (280, 560), (11, 25.6) and (120, 280) respectively. The range for different nutrients may vary from state to state, but the range for IVs have been kept fixed throughout the country.

Some of the equations (Subba Rao and Srivastava (2001)) used to obtain optimum doses for N, P and K for targeted yield (T q/ha) for the rice crop developed for different districts are given below.

FN = 3.92T–0.46SN, 4.26T-0.59SN, 3.47T-0.37SN, 4.00T-0.44SN, 3.78T- 0.48SN, etc.

FP_2O_5 = 2.61T- 2.45SP, 2.35T-3.16SP, 2.53T- 2.12SP, 2.32T-2.09SP, 2.39T-2.90SP, etc.

FK_2O = 2.47T-0.25SK, 1.89T-0.20SK, 2.12T-0.20SK, 1.82T-0.17SK, 1.24T-0.12SK, etc.

where, FN, FP_2O_5, FK_2O are fertilizer requirement to obtain T q/ha rice yield. SN, SP, SK are soil test values for N, P and K.

These equations have been interlinked with soil fertility maps along with range of targets to get optimum dose of fertilizer.

4. ON LINE SOIL TEST BASED RECOMMENDATION SYSTEM

The calculated soil test values were incorporated into the fertility maps to prescribe nutrients for targeted yields. This online application Software was developed to recommend fertilizer doses for the targeted yield at the district level. This system has the facility to input actual soil test values at the farmers fields to obtain optimum dozes. The application is a user-friendly tool to help the farmer in improving the efficiency (appropriate dose) of fertilizer use to achieve a specific crop yield. The glimpse of the application window for AP is as follows.

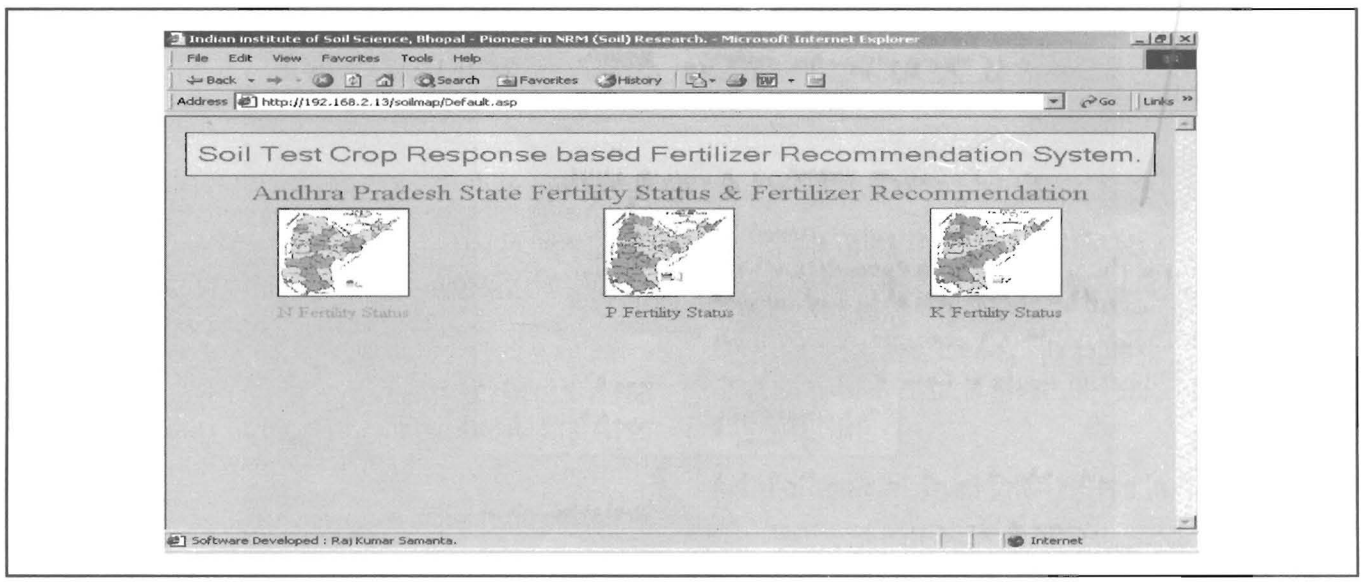

Fig. 2. First screen on running the application with an Internet browser

On running the application with an Internet browser the page shown in Fig. 2 will be displayed. All three images are clickable thumbnails to the corresponding larger images of N, P and K status of AP state. On clicking any of the links, the corresponding larger images containing nutrients availability will be displayed on the screen (Fig. 3-5).

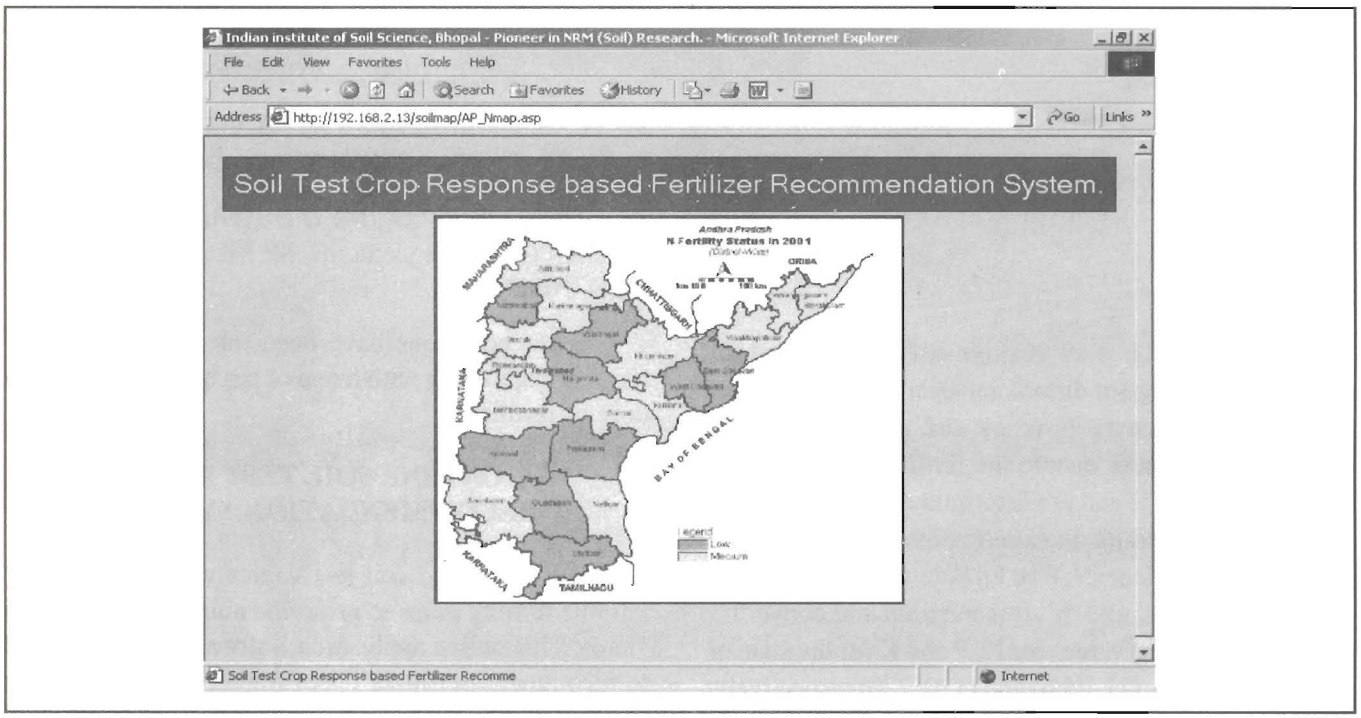

Fig. 3. District wise available soil nitrogen in AP

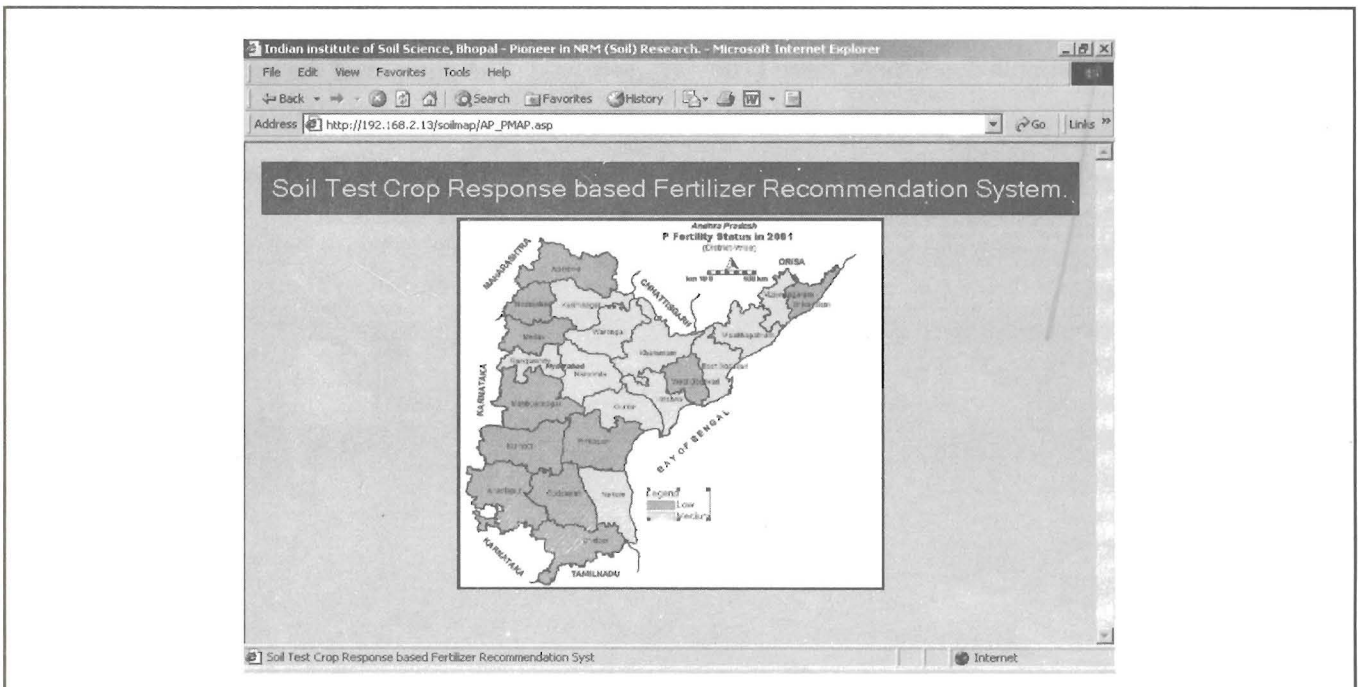

Fig. 4. District wise available soil phosphorus in AP

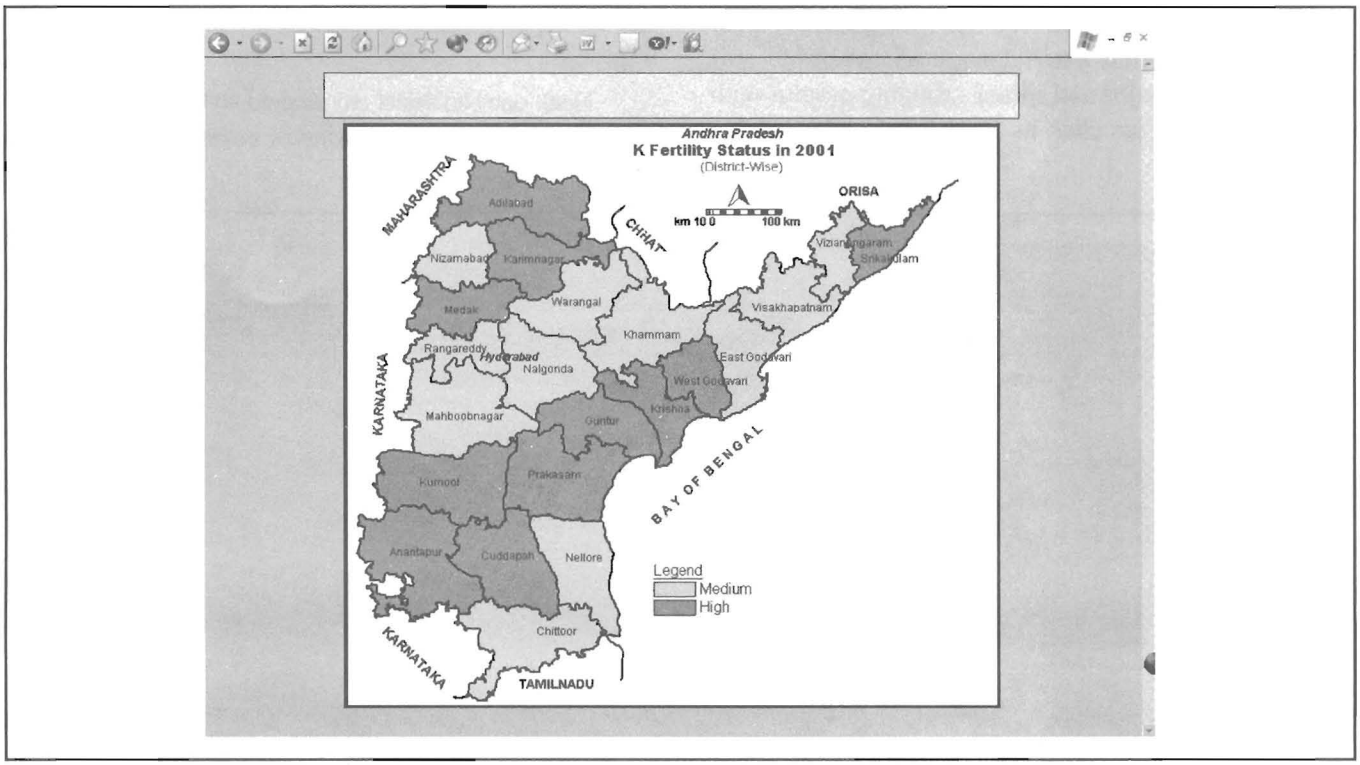

Fig. 5. District wise available soil potassium in AP

Each district on all the maps are uniquely identifiable and on clicking any district the relevant page for that district will be displayed. For example if the Nizamabad district in the N status map is clicked, the page displayed is shown in Fig. 6.

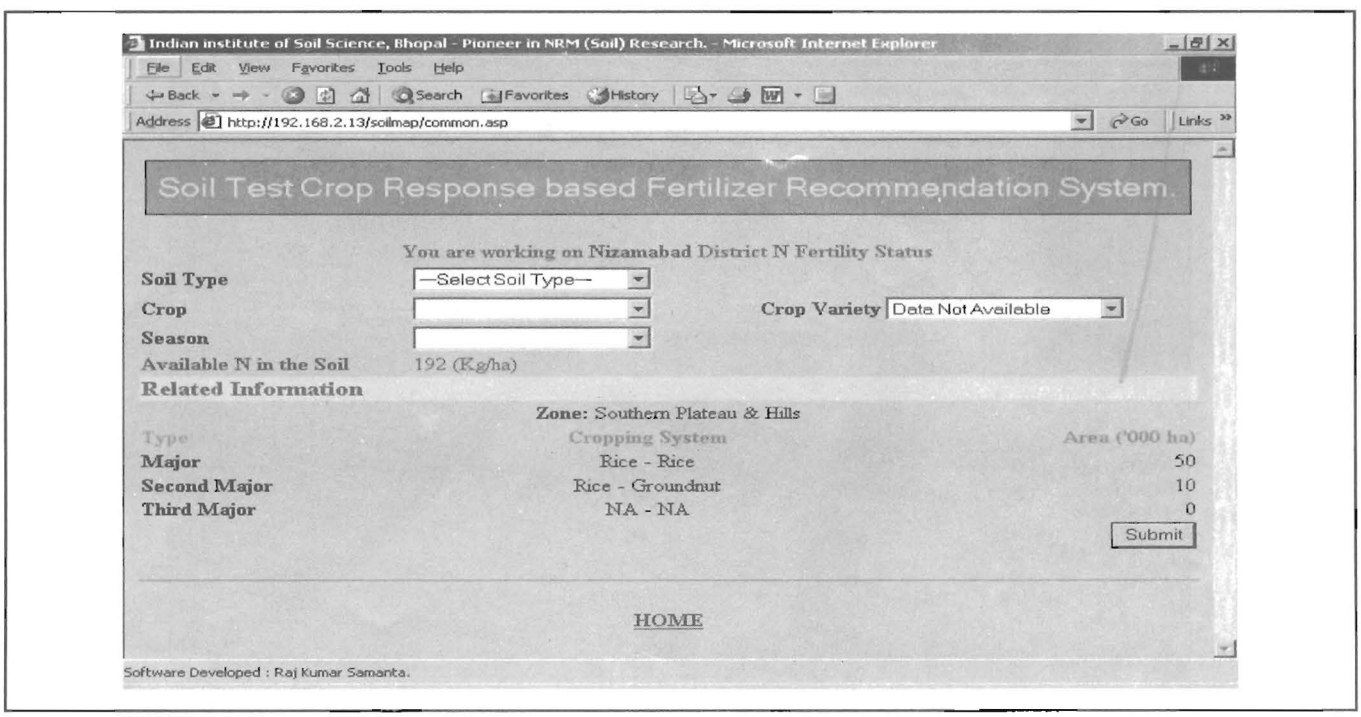

Fig. 6. Screen displaying details of Nizamabad district

Here, one can also see various other useful information for that district such as available soil nitrogen, zone, major and minor cropping system with area sown, etc. If we click in the soil type box one can see all types of soils present in the district as given in Fig. 7.

Here, one can select any desired soil type (say Chalka) and submit it. The resulting window is shown in Fig. 8.

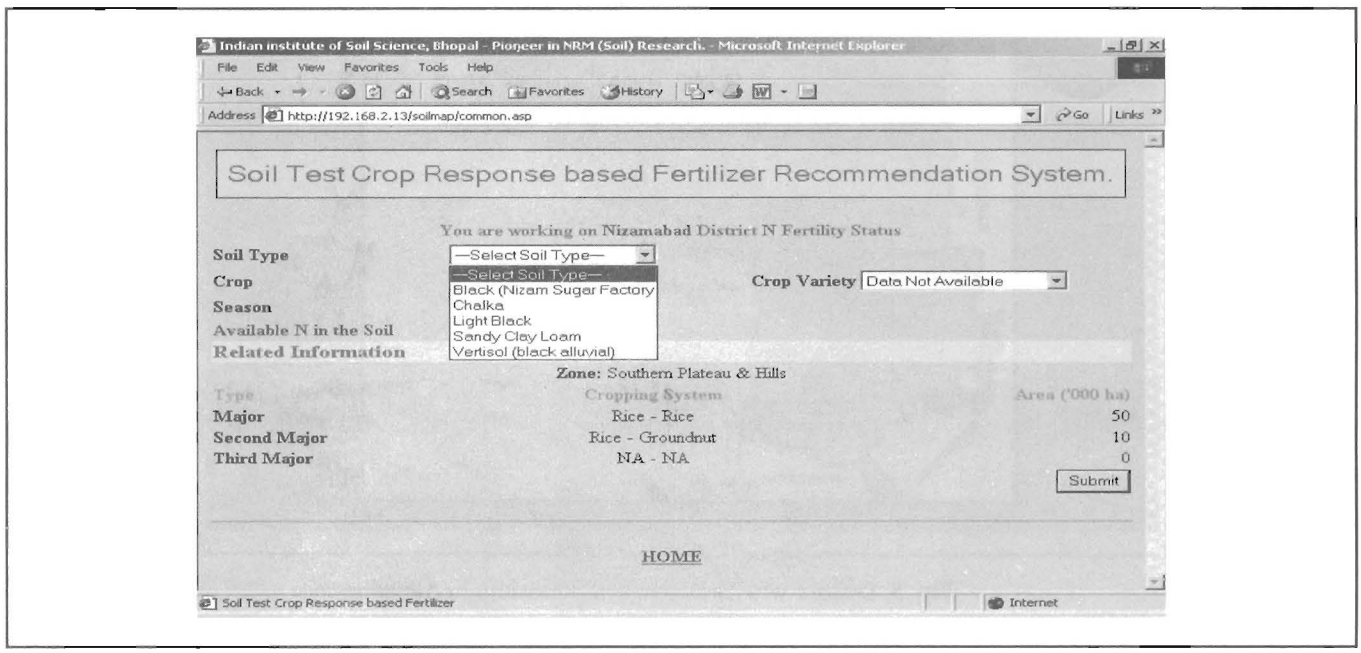

Fig. 7. Screen displaying all types of soils of Nizamabad district

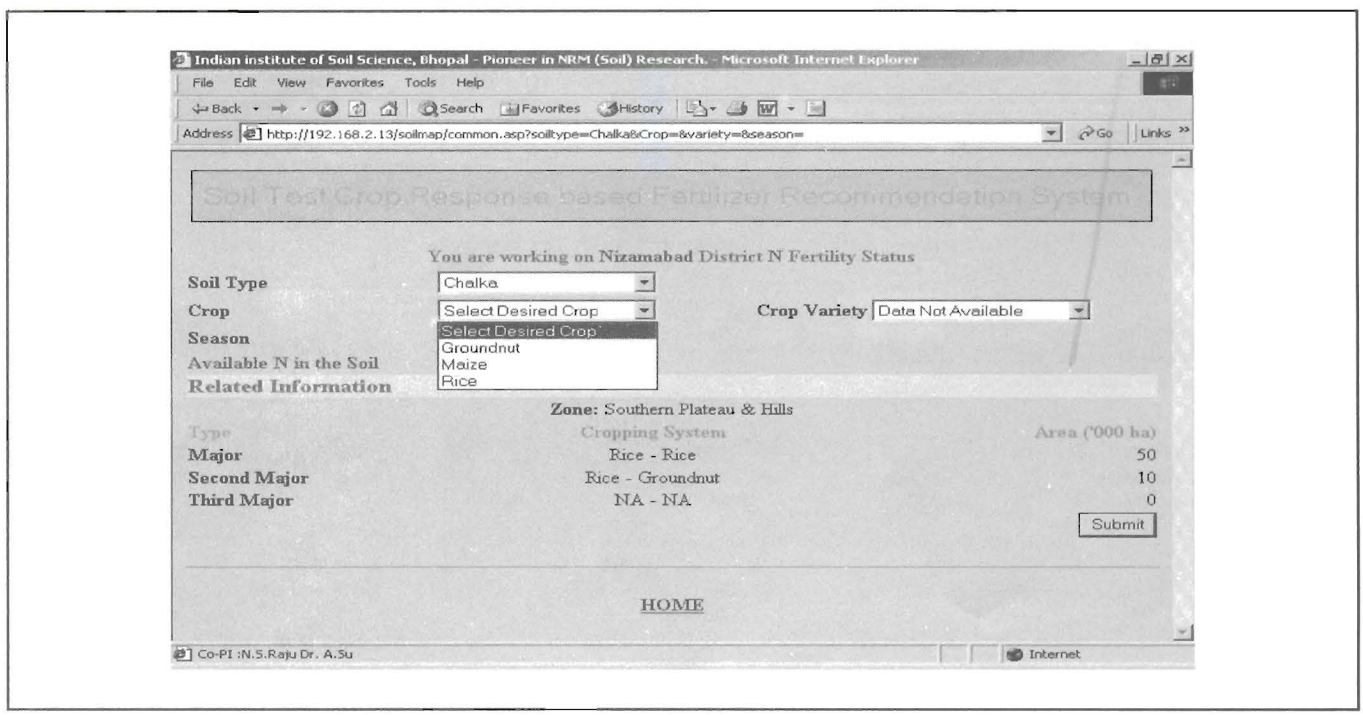

Fig. 8. Screen displaying selected soil type and the crops sown in Nizamabad district

Here, one can select the desired crop of the area. On clicking in the desired crop box one can see all the crops of the district (Fig. 8) for which information is available. Select the desired crop (say Rice) and submit it. The resulting window is shown in Fig. 9.

Now, one can select the desired variety of the crop by clicking in the crop variety box. On selecting the desired variety (say High-Yielding-Variety) and submitting, it will bring the resulting window as shown in Fig. 10.

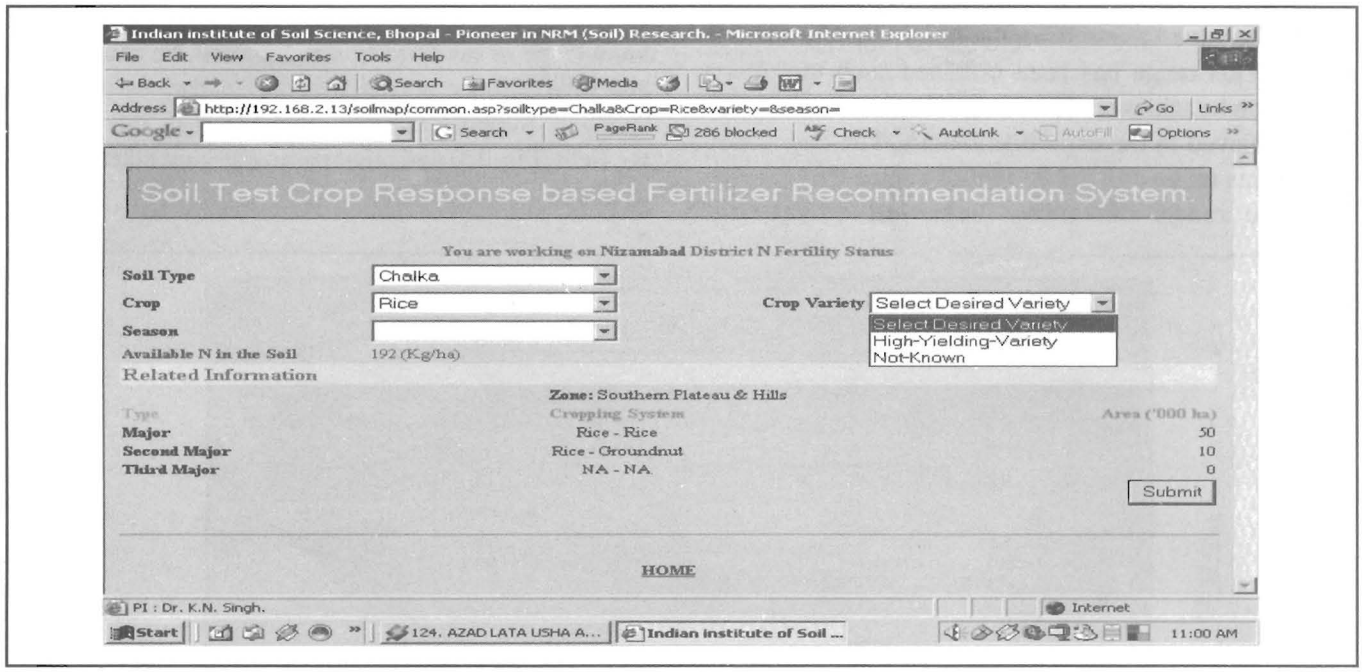

Fig. 9. Screen displaying selected soil type, crop and varieties for the selected crop in Nizamabad district

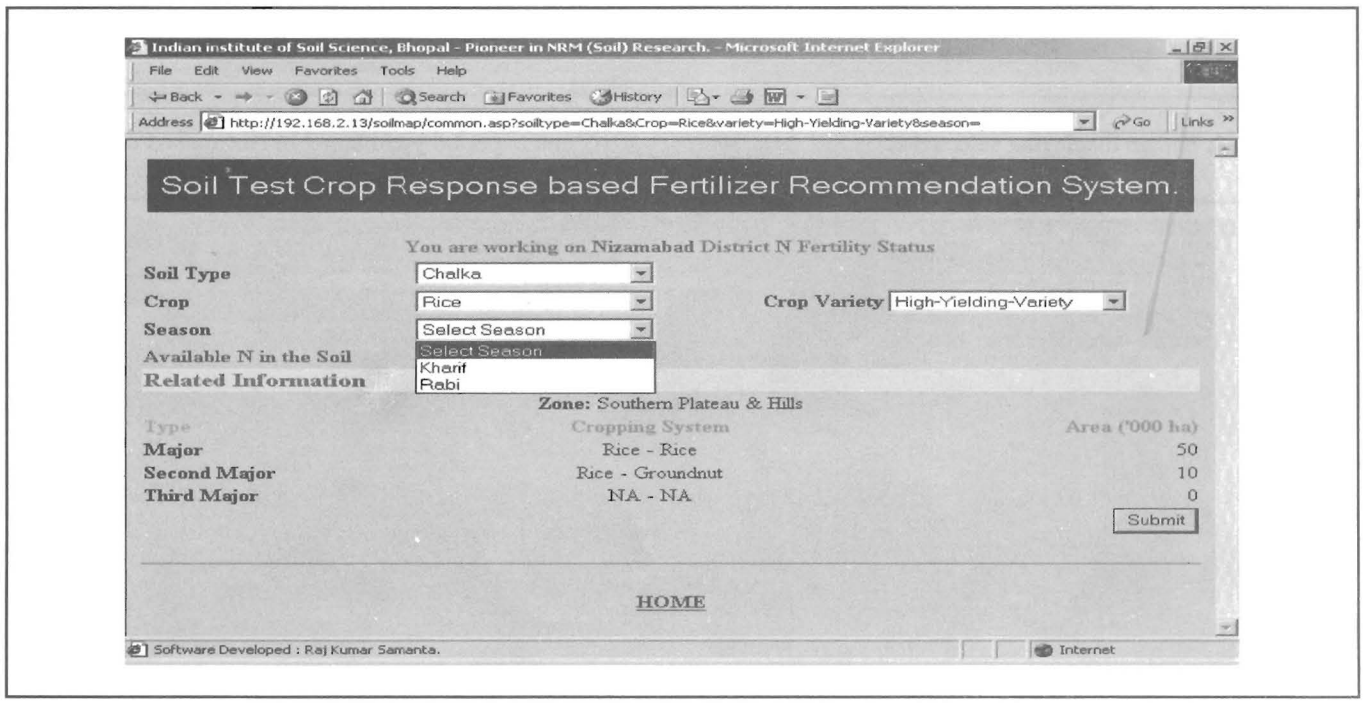

Fig. 10. Screen displaying selected soil type, crop, varieties and season in Nizamabad district

Here, one can select the season for the crop by clicking in the season box. On selecting the desired season (say Kharif) and submitting, it will bring the resulting window as shown in Fig. 11.

After submitting all the above parameters, the window of Target has been activated (Fig. 11). Here, one has to give targets from the range specified at the screen. This range has been obtained such that these targets can be achieved. This range of targets has actually been achieved in the experimentations. The targets out side of this range will not be realistic since they are out side the range of targets achieved during the experimentations. After giving target (say 45 q/ha) and submitting it, we will get recommendation shown in Fig. 12.

Similarly users can get the recommendation for P and K (Fig. 13-14).

In case a farmer in the district is having actual knowledge of his fertility status of soil, he can use that also. We will see how the recommendations are being changed. Suppose that the available N is 250 kg/ha in the field (Fig. 15) and other parameters are taken exactly as above.

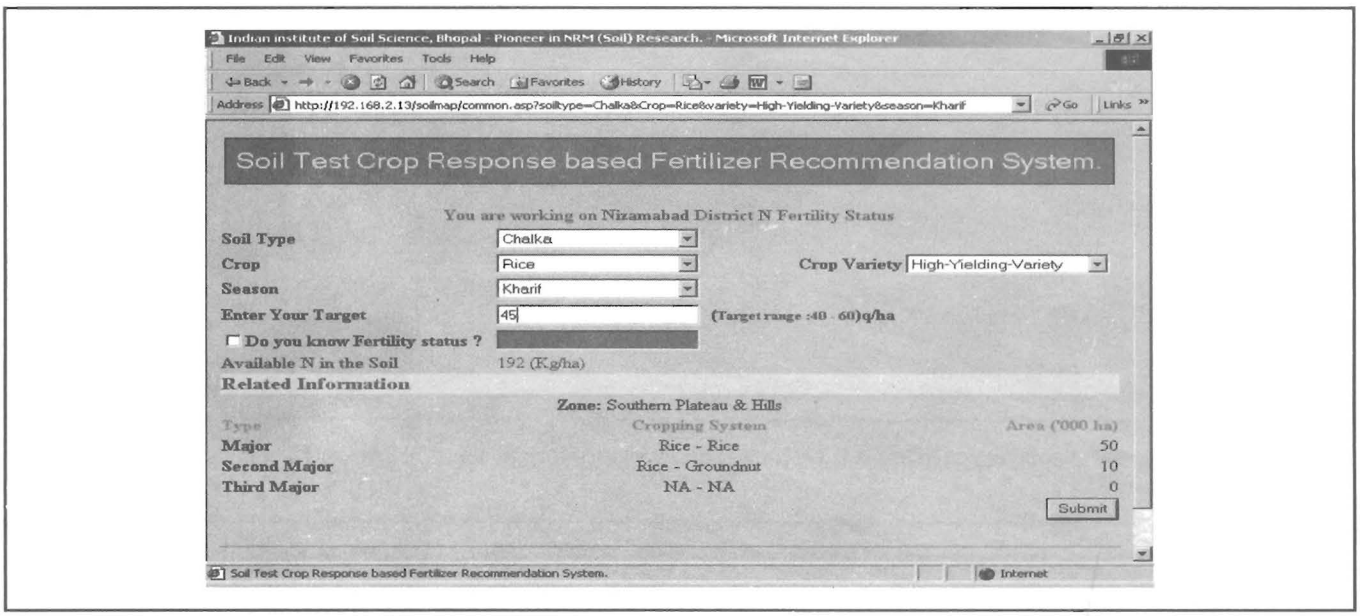

Fig. 11. Screen displaying selected soil type, crop, season, variety and expected yield target in Nizamabad district

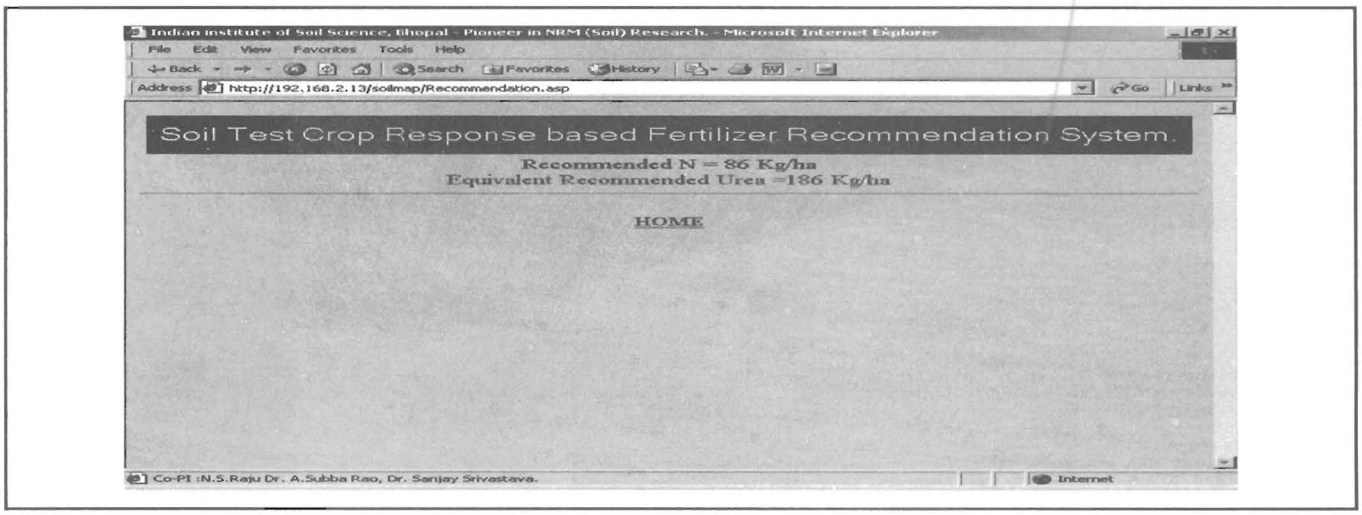

Fig. 12. Screen displaying recommendation for the use of Nitrogen for the specified target in Nizamabad district

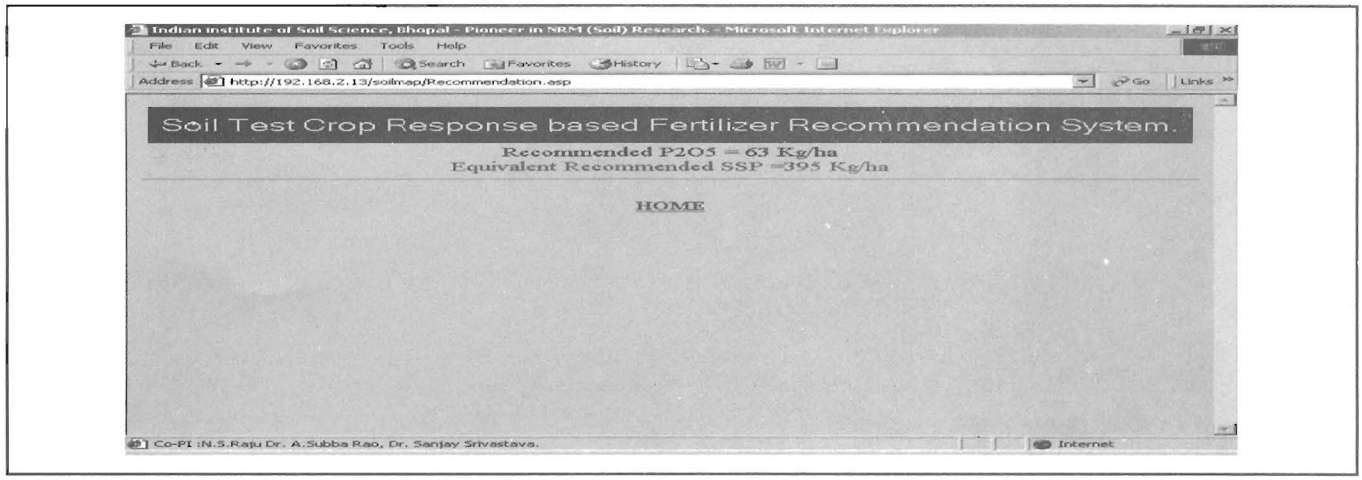

Fig. 13. Screen displaying recommendation for the use of Phosphorus for the specified target in Nizamabad district

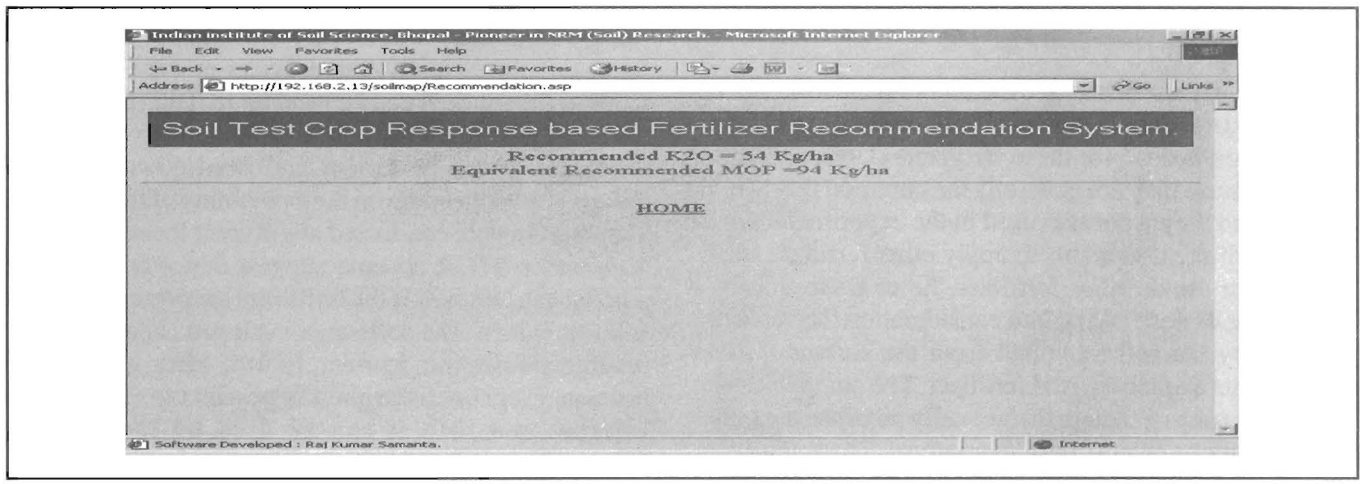

Fig. 14. Screen displaying recommendation for the use of Potassium for the specified target in Nizamabad district

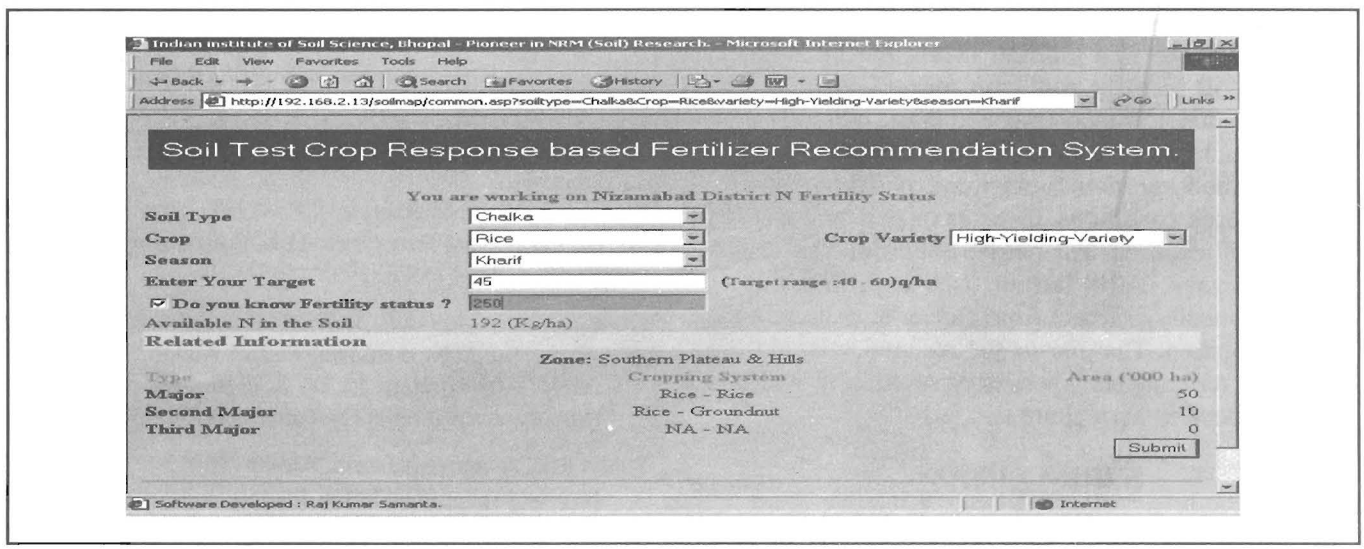

Fig. 15. Screen displaying selected soil type, crop, season, variety and known available nitrogen in Nizamabad district

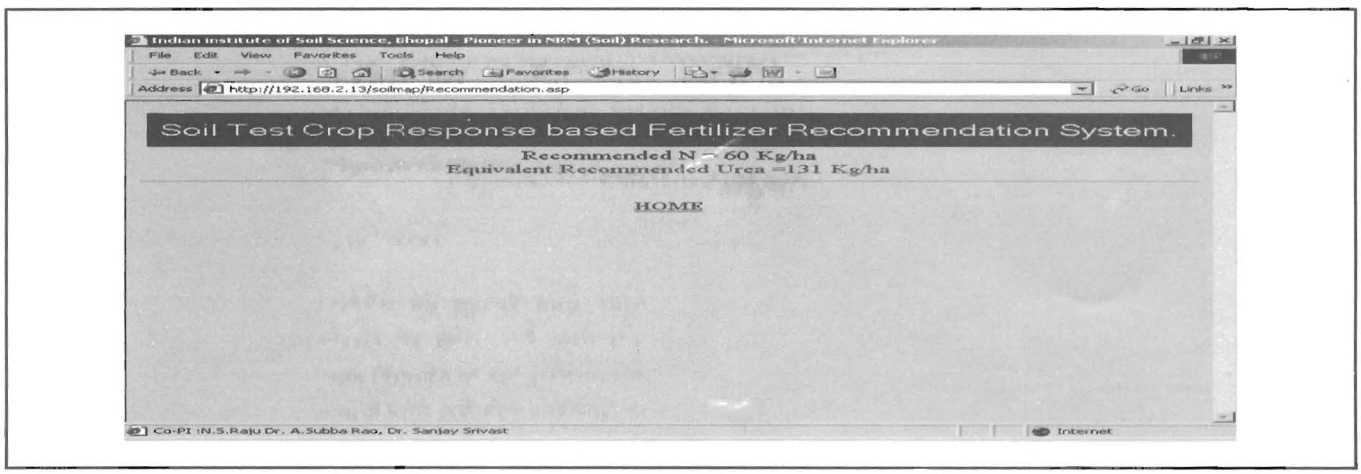

Fig. 16. Screen displaying recommendation for the use of Nitrogen for the specified target and specified available soil nitrogen in Nizamabad district

After submitting the target of 45 q/ha we will get recommendation shown in Fig. 16.

Similarly users can get the recommendation for P and K using actual known soil test values. The computation is done for these fertilizers (Urea, SSP and MOP) because they are generally the common fertilizers in India and they were also used in the experimentation. However, if the user wants to apply other fertilizer such as DAP, or some other fertilizer, he can use that by calculating its dose taking into consideration the nutrient required by the soil (obtained from the software) and the nutrients available in the fertilizer. The computations for other fertilizers though theoretically possible, are only approximations or next best alternatives. These nutrient recommendations are based on the soil test crop response field trials and the relationships were obtained under recommended management practices where other factors of crop production were not limited. It is a well known fact that if water is a limiting factor, the relationship between soil fertility and crop response can not be studied. Hence, it is recommended that while following these recommendations the farmers should use the recommended agronomic practices. It is obvious that under drought conditions, diseases or pest infestations, the desired response will not be obtained. The results may also vary if the farmer uses a variety that is characteristically different from the varieties used in the experimentation. That means the recommendations are subject to refinements when more responsive varieties are introduced in agriculture.

5. CONCLUSION

The system works as a ready reckoner to give prescription in the form of fertilizer available (eg. Urea, SSP, MOP etc.). In case of known fertility status one can give the known values for N, P and K and submit for calculation. This system provides real use of fertility maps to the users. It can be used up to field level also, if the farmer has the knowledge of his fertility status and the target. It can be further narrowed down to block/ village level depending on the availability of information. The experiments conducted at different locations in this state under STCR scheme suggest that a considerable amount can be saved if the fertilizers are prescribed using soil test values. The software developed is currently not on-line. However, in near future, after getting the necessary legal permission it is possible to launch it on Internet and then it can be used by the farming community.

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