*Indian Journal of Agronomy* **59** (2): 344–349 (June 2014)

**Research Communication**

# Decision support system for fertilizer recommendation–A case study

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Received : July 2013; Revised accepted : March 2014

## ABSTRACT

The present work carried during 2010–12 at the Dharwad, Karnataka, to provide support to the farmers of selected zones in decision-making process towards application of fertilizer in selected crops. A Decision Support System (DSS) on fertilizer recommendation was designed and developed using Visual Basic 6.0 as a plat-form taking help of the information from Soil Test and Crop Response (STCR) research. The developed DSS is a console application and helps in taking decision to farmers on amount of fertilizer to be applied in different crops. The study revealed that, on an average framers of Dharwad, growing maize (*Zea mays* L.) and chilli (*Capsicum* sp.) are applying 20 kg N, 10 kg $P_2O_5$, 12 kg $K_2O$ and 26 kg N, 36 kg $P_2O_5$, 15 kg $K_2O$/ha for each crop in excess of the required amount which caused not only unnecessary expenditure on fertilizer, amounting to ₹938 and ₹2,102/ha respectively, Thus, the developed DSS is useful in augmenting economic agricultural production maintaining soil and environmental health, avoiding unnecessary wastage of resources, even in absence of experts by the farmers themselves.

***Key words:*** Decision supporting system, Targeted yield approach, Visual basic

Indiscriminant and overuse of fertilizer resulted in environmental degradation. This has led to worldwide research on efficient, economic and environment friendly use of chemical fertilizer in a sustainable manner without compromising the growth in production to feed the ever-increasing world population. In this aspect, diagnosis of fertilizer requirement for a particular crop or cropping system plays a pivotal role. Widely used practice for deciding rates of fertilizer, is on the basis of local experience or general data on crop requirement. This is certainly useful for obtaining at least medium yield levels, but is not very effective nor economic.

Soils differ widely in their capacity for providing nutrients, depending on the amount of total reserves, mobilization or fixation dynamics, which determine their availability to the plants. Therefore, it remains necessary to assess empirically the nutrient status of soils and plants in order to provide guidelines for effective fertilizer use through diagnosis by fertilizer experiments.Because of the cost and labour involved, this method is not much suitable for individual farmers but suitable for Advisory Services and Research Institutes. Recommendations based on any of the above methods of diagnosis or in combination must take into account the farmer's objectives and the economics of fertilizer use. Unfortunately, the information is scattered at different places and the experts may not always be available. DSS may come in a great way in bridging the gap between the farmers and the experts.

With the passage of time computer and information technologies are coming in a great way to benefit the society. Taking into consideration the importance of fertilizer in feeding the ever-increasing population, its in-judicious/over-use vis-à-vis its impact on farm economics, environment and ultimately the sustainability of production system, it is felt increasingly to integrate. Information and Communication Technology (ICT) with modern agriculture technology can help in this regard. Precisely, the need for Decision Support System (DSS) was felt and attempted.

Information is a key input for an economic farming; information can efficiently be converted into economically rewarding opportunities. Keeping parity with the ever-increasing prices of fertilizer along with detrimental effects of inefficient and, or overuse of fertilizer, need for DSS is being felt day by day. The success of any DSS depends on the availability of situation specific information for different crops and its associated components. Attempts have been made under Indian context for development of crop

Based on a part of M.Sc. thesis of the first author submitted to UAS, Dharwad, Karnataka (Unpublished)

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specific and site specific DSS. Among these, the works of Pal *et al.* (2007) (Decision support system for nutrient management in crops), Ganesan (2007) for the leading crops in Kerala, Rao and Kumar (2006) for important crops in Andhra Pradesh are few to mention. The present work is an effort towards the development of 'Decision Support System for Nutrient Management in Crops' in Karnataka, India.

This Decision Support System (DSS) is based on the Soil Test Crop Response (STCR) approach (An approach for fertilizer recommendation based on targeted yield concept). Based on a very large number of complex field experiments on diverse soils at different centers of STCR for major crops, fertilizer recommendations are provided for targeted yields based on soil tests. The fertilizer recommendation based on yield target concept have been tested in the follow up trials and in about 1,800 frontline demonstrations in the farmer's fields to verify the technology. The procedure provides a scientific basis for fertilization and balance between applied nutrients and nutrients available in the soil. Once this requirement is known for a given yield level, the fertilizer needed can be estimated taking into consideration the contribution from available nutrients in the soil. The essential basic data required for formulating fertilizer recommendation for targeted yield (T) are (i) nutrient requirement per unit of produce, grain or other economic produce, (ii) the per cent contribution from the soil available nutrient and (iii) the percent contribution from the fertilizer nutrients (Ramamoorthy *et al*. 1967).

1. Nutrient requirement of N, P and K for grain production

$$NR = \frac{\lambda}{Y}$$

where NR is the kg of nutrients/q grain, $\lambda$ is the total uptake of nutrients in kg, and *Y* is the grain yield in.

2. % acontribution of nutrient from soil

$$CS = \frac{X}{Z} \text{x}100$$

where X is the total uptake from the control plot in kg/ha, Z is the soil test values of nutrients in control plots in kg/ha.

3. Contribution of nutrients from the fertilizer

$$CF = U - \frac{(F - CS)}{100}$$

where U is the total uptake in treated plots kg/ha, F is the soils test values of particular nutrient kg/ha.

4. % contribution of nutrient from fertilizer

$$CF\% = \frac{CF}{F} \text{x}100$$

where CF is the contribution of nutrient from fertilizer, F is the fertilizer dose applied in kg/ha.

5. Calculation of nutrient dose

The basic data are transformed into workable adjustment equation as follows:

$$ND = \frac{NR}{CF} \text{x}.100\text{x}.T - \frac{CS}{CF\%} \text{x}.STV$$

where ND is nutrient dose, T is targeted yield with in limit, STV is soil test value.

The Decision Support System was developed for total 6 Zones, viz. Zone-3 (Northern dry zone), Zone-4 (Central dry zone), Zone-5 (Eastern dry zone), Zone-6 (Southern dry zone), Zone-7 (Southern transition zone) and Zone-8 (Northern transition zone) of Karnataka located at India. The data for Zone-3, 4, 5, 6, and 7 were collected from All India Coordinated Research Project (AICRP) on STCR project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Science, Bengaluru. For the zone-8 data were collected from Deshmukh (2008) and Abdhulahi (2010). The system was developed using Microsoft Visual Basic (V 6.0) platform.

The developed DSS was tested and validated using the information from 20 selected farmers each, growing maize and chilli in Zone 8, Karnataka. Data regarding the soil-test value and the amount of fertilizer used and the yield obtained were collected from the above farmers. The observed yield was compared with the corresponding yield that can be obtained if the concerned farmer had applied the fertilizer according to the DSS developed (equation) by employing the t-test.

There are 5 windows or sections in the software, viz. login window, zone selection window, crop selection window, calculation of fertilizer window, result box (Message box). Step by step working procedure are given below:

### *Development of the DSS*

Structurally the DSS developed is as shown in the following flow chart. (Fig. 1).

**Step1: Login window**

Once the user click and open the software, a login window (Fig.2) will appear on which the user has to enter the user name and password and then click on login, which displays the zone selection window.

**Step 2: Zone selection window**

The second window is zone selection window (Fig.3)

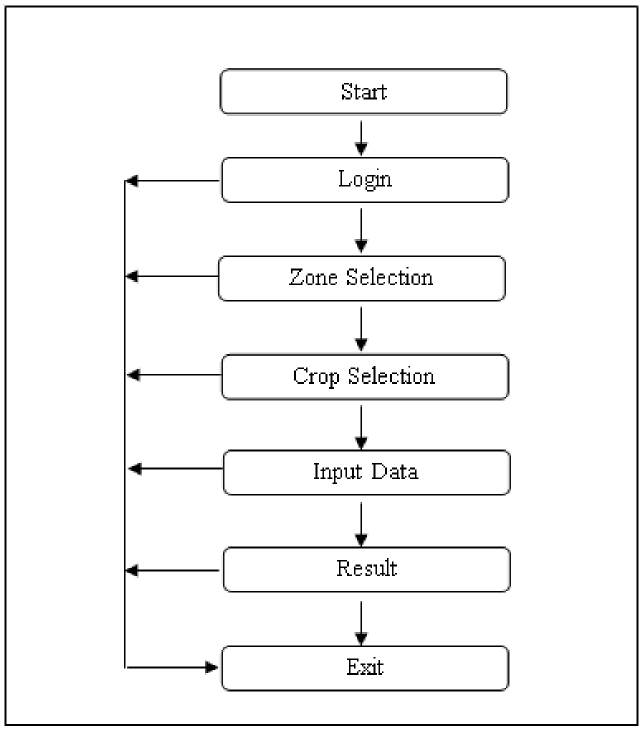


**Fig. 1.** Flow chart showing the operational aspects of DSS

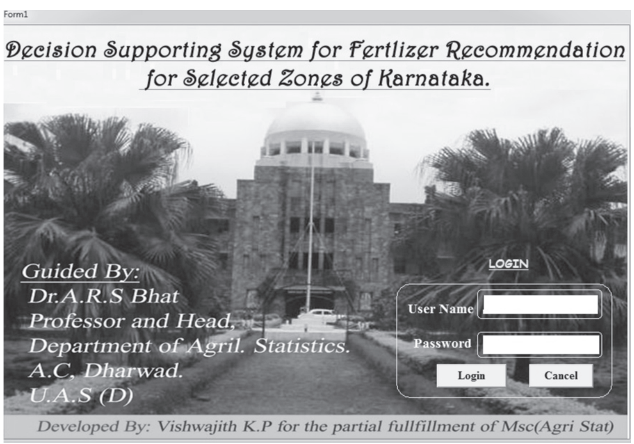


**Fig. 2.** Log-in window

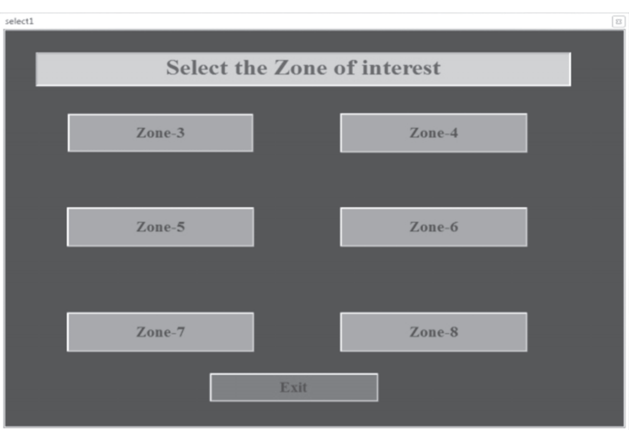


**Fig. 3.** Zone selection window

on which one needs to select the zone of interest by clicking on the zone.

### Step 3: Crop selection window

In this crop selection window (Fig.4), one needs to select the crop by clicking on crop listed, for which the user needs decision support on fertilizer application. This window also contains the information about the zone selected; like area, rainfall, elevation, soil type and important crops grown in the zone. By selecting the crop it will take to calculation window.

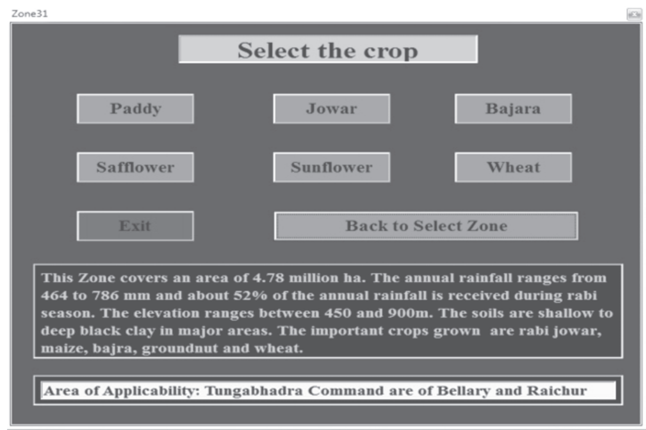


**Fig. 4.** Crop selection window

### Step 4: Calculation window

In calculation window (Fig.5) first user needs to select the yield level, enter the soil test value N, P and K in the input box provided, click on calculate to get the result. This section also contains some information about crops like seed rate, spacing, depth of sowing and FYM to be applied for the selected crop.

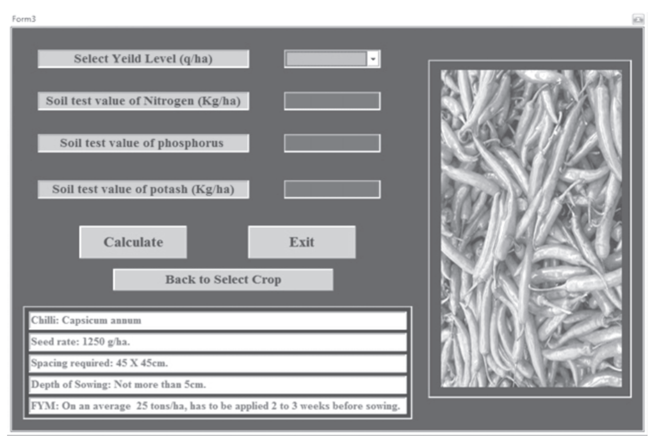


**Fig. 5.** Calculation window

### Step 5: Result box

After clicking on calculate button, the amount of N, P and K to be applied to get the selected yield for that soil condition which will be displayed in the form of message box (Fig.6).

### Fertilizer recommendation

Since different farmers use different commercial fertilizers, fertilizer recommendation would be problematic endeavor. To help the farmers in getting amount of commercial fertilizer to supplement the required nutrient, the DSS will give a list of amount of different fertilizers to be applied accordingly.

For example:

Amount of urea (kg) to be applied = 2.17 × N recommendation of crop by DSS.

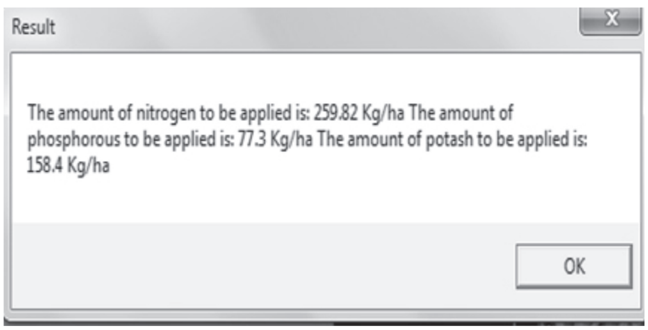


**Fig. 6.** Result box

Amount of DAP (kg) to be applied = 2.17 × P recommendation of crop by DSS.

= 5.55 × N recommendation of crop by DSS.

Amount of SSP (kg) to be applied = 6.25 × P recommendation of crop by DSS.

Amount of MOP (kg) to be applied = 1.66 × K recommendation of crop by DSS.

#### *Validation of DSS*

It has already been mentioned that the DSS was developed with the help of the data for maize (Abdhulahi, 2010) and chilli (Deshmukh, 2008) generated (Table 1) using STCR method and validated with the help of the data from farmers field at zone-8 (Dharwad, Karnataka, India). Results of the t-test to compare the equality of observed and expected yield with farmers data output reveals that the developed decision support system is on par with the farmers field condition, i.e. the farmers applying fertilizer according to the developed DSS are getting same yield with a standard deviation of 0.44 tonne/ha and C.V 8.30% (Table 2) in case of maize and with a standard deviation of 0.15 tonne/ha and C.V 11.81% (Table 2) in case of chilli. Though the results of the validation process of the DSS developed are quite satisfactory, the accuracy of the system could further be enhanced by taking non-linear

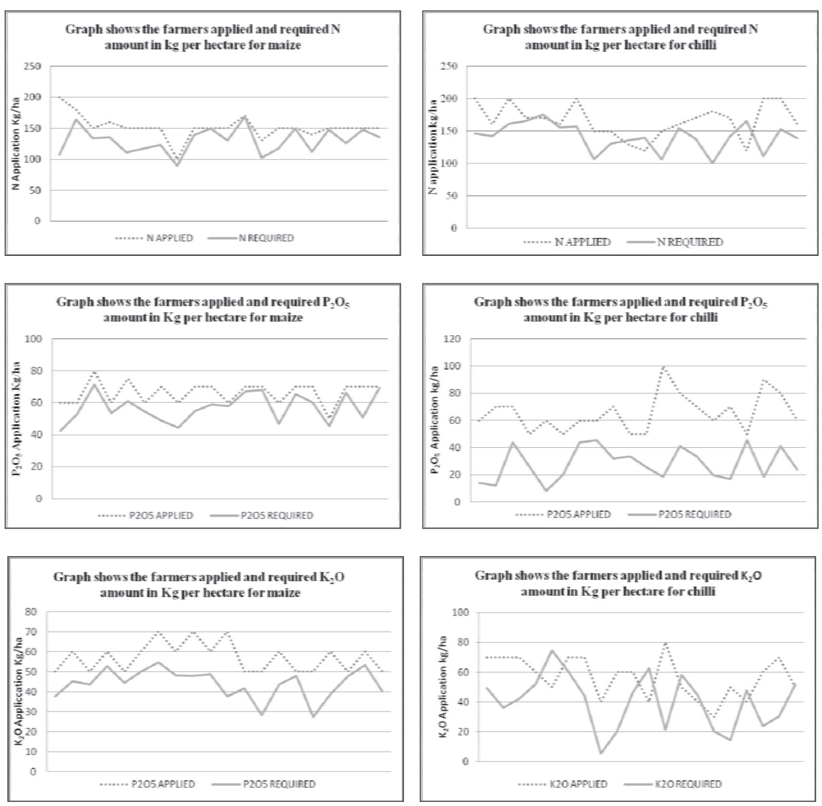


**Fig. 7.** Graph showing the amount of applied fertilizer and required fertilizer by selected maize and chilli growing farmers.

fertilizer-output relationship and also with the inclusion of other factors like rainfall, crop-protection measures etc. in the model.

On an average, farmers got 5.07 tonnes/ha (Table.2) of maize for applied fertilizer, viz. 150 kg/ha N, 67 kg/ha $P_2O_5$ and 55 kg/ha $K_2O$, in the soil containing 168.01 kg/ha N, 33 kg/ha $P_2O_5$ and 386 kg/ha $K_2O$. But according to DSS to get 5.07 tonnes/ha in Dharwad soil condition 131 kg/ha N, 56 kg/ha $P_2O_5$ and 43 kg/ha $K_2O$ are sufficient. This implies that on average each farmer is applying excess of 19 kg N, 11 kg $P_2O_5$ and 12 kg $K_2O$/ha (Fig. 7), which will remain in soil, thereby may contribute adverse effect to soil and plant environment besides causing unnecessary expenditure on fertilizer amounting to ₹937.80/ha (Table 3) on an average.

Coming to chilli-growing farmers, on an average farmers got 1.24 tonnes/ha (Table 2) of chilli for applied fertilizer, viz. 166 kg/ha N, 66 kg/ha $P_2O_5$ and 55 kg/ha $K_2O$ in the soil containing 153.03 kg/ha N, 35.21 kg/ha $P_2O$ and 392.15 kg/ha $K_2O$. But according to the decision support system, under the given soil condition, 140 kg/ha N, 30 kg/ha $P_2O_5$ and 40 kg/ha $K_2O$ are sufficient. This implies that, on an average each farmer is applying excess of 26 kg N, 36 kg $P_2O_5$ and 15 kg $K_2O$/ha (Fig. 7). This excess amount of fertilizer will account for waste of ₹2,101.59/ha (Table 3). Thus, DSS on fertilizer application helps not only in reducing the environmental hazard but also in improving the farm economy.

### *Economics of excess application of fertilizer*

An overall picture of the economics of fertilizer used by the maize-growing farmers under the study, as given in Table 3, reveals that the excess expenditure on nitrogenous fertilizer varies between ₹5.4 and ₹1,075/ha with a standard error of ₹53.5/ha. Similarly, for P and K fertilizers, the excess expenditure ranges are ₹14.6 and ₹480.4 with a standard error of ₹31.7/ha and ₹54.1 to ₹1,319/ha with a standard error of ₹72.8 respectively. Also, in-case of chilli-growing farmer's excess expenditure on nitrogenous fertilizer varies between ₹51.5 and ₹1,012/ha with a standard error of ₹60.1/ha. Similarly, for P and K fertilizers, the excess expenditure ranges are ₹99.9 to ₹1836 with a standard error of ₹97.4/ha and ₹67.5 to ₹1617.8/ha with a standard error of ₹116.1 respectively. Naidu *et. al.*, (2007) reported, that due to misapplication of chemical fertilizer excess expenditure, on an average ₹1,782/ha in wheat, ₹504 to ₹707/ha in sorghum and ₹1,086/ha in case of sunflower are being incurred by the farmers.

DSS has been developed with an objective to provide decision support to the farmers, agriculture workers, students, research workers, extension workers and others, even in absence of the experts. The present study clearly indicated that the DSS system may provide a valuable basis of fertilizer application and help in bringing fertilizer economy in crop production besides maintaining soil and environmental health. Currently, there are provisions for a

**Table 1.** Sample of input data set used for DSS based on STCR results for various crops of Zone 8 of Karnataka.

| Targeted yield Equation | Basic data | | |
|---|---|---|---|
| | NR (kg/tonnes) | CS (%) | CF (%) |
| *Maize* | | | |
| $NDN=4.36T-0.52STV$ ($KMnO_4$-N) | 0.402 | 48.6 | 92 |
| $NDP_2O_5=2.73T-2.12STVP_2O_5$ (Olsen's $P_2O_5$) | 0.12 | 79.13 | 37.33 |
| $NDK_2O=1.66T-0.10STVK_2O$ ($NH_4OAC$-$K_2O$) | 0.402 | 24.58 | 242 |
| *Chilli* | | | |
| $NDN=14.59T-0.26SSTVN$ ($KMnO_4$-N) | 0.44 | 7.9 | 30.15 |
| $NDP_2O_5=6.04T-1.5STVP_2O_5$ (Olsen's $P_2O_5$) | 0.097 | 8.2 | 10.38 |
| $NDK_2O=11.8T-0.26STVK_2O$ ($NH_4OAC$-$K_2O$) | 0.62 | 3.4 | 52.44 |

NDN, Nutrient dose for N; $NDP_2O_5$; Nutrient dose for $P_2O_5$; $NDK_2O$, Nutrient dose for $K_2O$; T, Targeted yield; STV, Soil test value; NR, Nutrient requirement; CS, Contribution of nutrient from soil and CF, Contribution of nutrients from fertilizer

**Table 2.** Comparison of average yield of maize and chilli between sampled farmers and according to DSS

| Particular | Maize | | Chilli | |
|---|---|---|---|---|
| | Farmers practice | DSS | Farmers practice | DSS |
| Mean Yield (tonne/ha) | 5.07 | 5.40 | 1.24 | 1.32 |
| SD (tonne/ha) | 0.53 | 0.44 | 0.16 | 0.15 |
| CV % | 10.48 | 8.30 | 13.15 | 11.81 |
| $t_{cal}$ | 1.97 | 1.97 | 1.58 | 1.58 |
| $t_{tab\ (0.05)}$ | 2.02 | 2.02 | 2.02 | 2.02 |

**Table 3.** Economic value of excess application of fertilizers in maize and chilli.

| Particular | Maize | | | Chilli | | |
|---|---|---|---|---|---|---|
| | Urea ₹/ha | Single superphosphate ₹/ha | Muriate of potash ₹/ha | Urea ₹/ha | Single superphosphate | Muriate of potash ₹/ha |
| Mean | 241.16 | 208.02 | 488.62 | 381.94 | 840.07 | 879.58 |
| Standard Error | 53.53 | 31.71 | 72.83 | 60.13 | 97.374 | 116.091 |
| Range | 1,069.42 | 465.75 | 1,265.05 | 965.49 | 1,736.10 | 1,550.42 |
| Minimum | 5.42 | 14.63 | 54.07 | 51.51 | 99.90 | 67.485 |
| Maximum | 1,074.84 | 480.38 | 1319.12 | 1016.99 | 1,836.00 | 1,617.90 |

Note: Price data as on 2011-12, http://fert.nic.in/, Department of fertilizer, GOI

few crops in the system; this can be made to work for other crops as well. The system is menu driven and user-friendly. Hopefully, the use of this system will provide intellectual support to farmers in proper application of fertilizers in different crops.

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