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Decision support system for soil and water analysis and fertiliser recommendation for flue-cured Virginia (FCV) tobacco

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Soil fertility and water quality play an important role on the productivity of any crop. Soil and water test based fertilizer recommendation will help the farmers to optimize the resources and to improve the productivity. Decision Support System (DSS) was developed for calculating the instrument reading into final value of the test parameters of soil (pH, EC, organic carbon, available nitrogen, phosphorous, potassium and chloride) and water (pH, EC, chloride), to suggest the recommended doses of fertilizers for Flue-Cured Virginia (FCV) tobacco crop and to test their suitability for tobacco cultivation. DSS on soil and water analysis for tobacco crop was developed with Visual Basic. Net as Front-end and MS-Access as Back-end. In this system, by entering instrument reading, it will be transformed into soil / water testing value of the concerned parameter which will be compared with recommended values and finally suitability of soil and water for tobacco cultivation will be judged and recommended fertilizer doses for different tobacco zones will be prepared and printed in the prescribed format. This software will be helpful to the researchers / technical personnel in reducing time for preparation of reports, minimizing the errors in manual calculation and improves the precision. This system can be applicable to any soil testing laboratories, where recommendations are given to different crops based on soil and water test values with suitable modifications.

Key words: Decision support system, flue cured tobacco, irrigation water quality, soil testing.

INTRODUCTION

In India, tobacco is an important commercial crop grown in an area of 0.45 million ha with 750 million kg production (Anonymous, 2010). There are ten tobacco types grown in India, out of which flue-cured Virginia (FCV) tobacco is an important type used for manufacturing cigarettes. In India, FCV tobacco is grown in an area of 0.24 million ha in Andhra Pradesh and Karnataka states with an annual production of 300 million kg leaf out of which nearly 200 million kg is exported to different countries (Krishnamurthy and Anuradha, 2011). Tobacco is a quality conscious commercial crop. Soil, water and climatic factors play a predominant role on tobacco quality and yield (Davis and Nielsen, 2007). The chemistry and fertility of soils greatly influences the tobacco plant growth, leaf size, yield and physical, chemical and manufacturing properties of tobacco leaf. Evaluation of fertility status of the soil before tobacco planting is a pre-requisite for optimum NPK fertilizer recommendations to get quality tobacco. Among the several other factors influencing tobacco productivity, soil fertility and fertilizer use contributes nearly 50% of yield and quality improvement of tobacco crop (Krishnamurthy and Deosingh, 2002).

Irrigation is defined as an artificial application of

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Figure 1. Main menu.

water to the soil for the purpose of crop production. Quality of irrigation water plays an important role on the quality and quantity of tobacco production. Fertilizer recommendation based on soil test values will help in improving the fertilizer use efficiency thereby increase in yield and quality of tobacco. Soil and water testing laboratories for tobacco farmers are available at Central Tobacco Research Institute (CTRI), Rajahmundry and also in other parts of the country under the management of Tobacco Board, Ministry of Commerce, Government of India. In addition to that soil testing laboratories is available all over India to serve different crops. In these laboratories a large number of soil and water samples are being analyzed regularly and test reports along with fertilizer recommendations are being prepared manually, which consumes a lot of time and there is a possibility of committing errors. The information collected from technical persons involved in soil and water analysis laboratories indicated the difficulties involved in the calculation of soil and water test parameters and recommendation of fertilizer doses for a particular zone. As the laboratories are short of human resources and number of samples to be analyzed is more, development of an integrated system for calculation of soil and water parameter and to suggest the test based recommendations for a crop will help not only technical / research personnel but also the end users that is farmers.

Information Technology has become an integral part of our day-to-day life. In agriculture, computers are extensively used to disseminate the information on soils, water and climatic conditions. Decision Support Systems (DSS) are defined as computerized systems, which include models and databases and they are used in decision-making. They are "tools" that help farmers and everyone who makes decisions and in choosing the best (economic, social or environmental) alternative solution (Manos et al., 2004). Several scientific disciplines support the development of DSSs and constitute the necessary background for their effective planning.

In Agriculture, DSS with varying capabilities have been developed viz., cropping systems simulation model (Stockle et al., 1994), crop rotation planning systems (Stone et al., 1992), Model of an Integrated dry-land agricultural system (Pannell, 1996). A few expert systems on tobacco cultivation were developed at CTRI including nutrient deficiency symptoms and disease management (Ravisankar et al., 2009, 2010). In the present study, efforts were made to develop a decision support system which will help technical personnel and researchers on preparation of soil and water test reports along with fertilizer recommendations instantaneously, which improves the precision, saves time and energy there by more number of soil and water samples can be analyzed.

MATERIALS AND METHODS

The DSS was developed using Visual Basic.Net (Balena, 2005; Gaddis et al., 2003) as front-end application and MS-Access (Nelson and Kelly, 2002) as back-end with user-friendly menus consisting 10 parameters as the attributes. The parameters ‘Name of the farmer, soil type, source of water, pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium and chlorides’ were selected for inclusion in the package. These fields are created with text-boxes for data and label-boxes for title of the text. The knowledge base for this system was soil and water testing methodologies developed by different scientists which are widely being followed in tobacco and other crops (Krishnamurthy and Nagarajan, 2001; Ghosh et al., 1983). Based on the knowledge base, this system has been developed (coding) which consists of 22 modules. Crystal reports 9.0 are used for designing and generating reports in an effective way.

The multiple document interface (MDI) form of the software consists of three options. The first option in the menu was “data entry” allows the user to enter the input data of various parameters for soil fertility and water quality evaluation. The second option is ‘Help’ which consists of a pull down menu and two sub options viz., ‘About the Project' and ‘Execution of the project'. The last option ‘Exit’ allows the user to quit from the software.

After the coding phase, the testing phase is performed by connecting the database to the developed modules with Open Database Connectivity (ODBC). Debugging is performed to correct the syntax and semantic errors in the developed program. Finally, a ‘setup’ program was prepared for easy loading and execution of the software.

RESULTS AND DISCUSSION

For executing this package, a PC with preloaded software of Visual Basic .Net and MS ACCESS are required. The procedure includes: Select the ‘Soil Project’ from the files and ‘open’ the software and then press F5 to execute. The first screen of the package 'Main Menu' gets displayed (Figure 1). Click ‘Data entry’ in the MDI form. A new screen with ‘Farmer Details Form’ as title bar gets displayed. Enter the ‘Farmer Name’, ‘Type of Soil’ and ‘Source of Water’ to enter a new record. Click ‘Soil analysis / water analysis’ option at the bottom of the

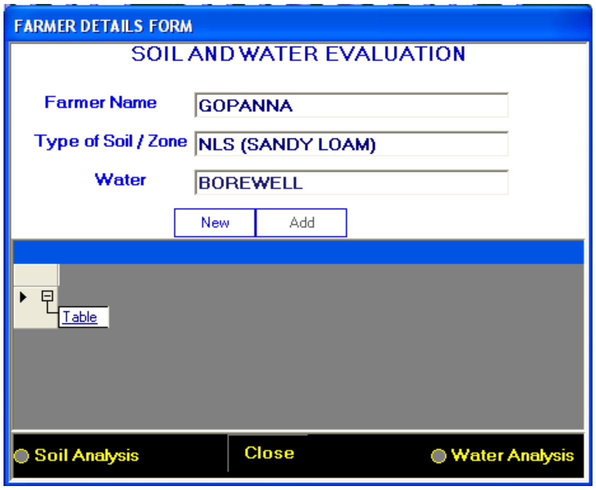

Figure 2. Farmer details form.

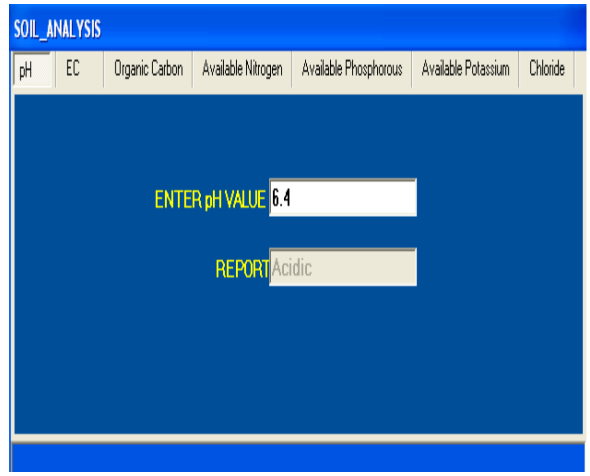

Figure 3. Data entry sheet for pH.

menu to enter the data (Figure 2). New screen with SOIL_ANALYSIS as title bar gets displayed. Various input parameters *viz.,* pH, EC, organic carbon, available nitrogen, available phosphorous, available potassium and chloride gets displayed. Click 'Add' button to add a new record. Click on the first parameter pH (soil reaction).

Soil analysis

Soil reaction (pH) is the key to plant nutrient availability in the soil. It controls fixation, release and availability of nutrients to the plants. Soil pH is an excellent single indicator of the general soil conditions. The ideal soil reaction for tobacco plant growth falls in the range of pH 5 to 6. Enter the pH value obtained from the pH meter, which will be compared with table values of soil pH viz. Acidic: < 6.5; Neutral: 6.5 to 7.5; moderately alkaline: 7.5 to 8.8, Alkaline: > 8.8 (Figure 3). The values were compared with table values. The electrical conductivity (EC) measurement is based on the principle that ions being the carriers of electricity, the EC of a solution increases with the soluble salt concentration. EC is measured by electrical conductivity solubridge, where the instrument reading is multiplied by K (cell constant) value to get the electrical conductivity in dS/m. EC will be calculated using the formulae embedded in the software. In case of sandy soils, the limits of EC were normal: < 0.40; critical: 0.41 to 0.80; injurious: > 0.80 (Table 1). Then Next parameter on the menu is organic carbon content in soil which is estimated by Walkley and Black (1934) titration method. Blank titre value and sample titre values are fed to the computer. The organic carbon content (%) will be calculated by using the formula:

Organic carbon (%): 10 (B-T) / B * 0.003 * 100 / 0.5.

Where B = Blank titre value, and T = sample titre value.

These values are compared with table values, that is, low: < 0.5%, medium: 0.5 to 0.75% and high: > 0.75% and the recommendations are prepared and stored.

Phosphorous is the life generating element and a good supply of phosphorus in the early stages promotes root development, growth and establishment of the seedlings and hastens crop maturity in the later stages. For estimation of available soil phosphorous, select the parameter 'available phosphorous' in the soil which is estimated by Brays method (Bray and Kurtz, 1945) in acid soil and Olsen method (Olsen et al., 1954) in alkaline soil. By feeding the instrument reading (R), soil available 'P' is calculated by using the formulae.

Olsen's P (kg/ha): R * (50 / 5) * (1/2.5) * 2.24; Brays P (kg/ha): R * (50 / 5) * (1/5) * 2.24;

The results will be compared with the table value, that is, low: < 10 kg/ ha, medium: 10 to 25 kg /ha and high: > 25 kg/ha, and the suitable recommendation will be given from the stored data. Nitrogen is the "Master Nutrient" controlling the plant growth, yield and quality of tobacco leaf. Although, potassium is absorbed in the greatest quantity, nitrogen is the key nutrient in tobacco fertilization and leaf chemistry. Too low or too high N application, adversely affects the quality of tobacco. Excessive soil nitrogen will generally produce cured leaves with dark-brown to black in colour, dry and chaffy and have a strong and pungent smoke. In the field, deficiency of nitrogen causes premature yellowing of leaves, which when cured are generally pale in colour, close-grained and thin-bodied and their smoke is flat and insipid. 'Soil available nitrogen' is estimated by alkaline permanganate method (Subbaiah and Asija, 1956). Available nitrogen (kg/ha) in soil will be obtained by using the formula (R * N * (1/20) * 0.014 * 2.24), where R: volume of H_2SO_4 consumed. N: normality of H_2SO_4. By entering the input values of R and N, available nitrogen is

Table 1. Acceptable limits for salts (ds/m) in soil for FCV tobacco crop.

S/N	Total soluble salts	Sandy soils	Loamy soils	Clay soils
1	Normal	0.0 - 0.40	0.0 - 0.70	0.0 - 0.80
2	Critical	0.41 - 0.80	0.71 - 1.40	0.81 - 1.60
3	Injurious	> 0.80	> 1.40	> 1.60

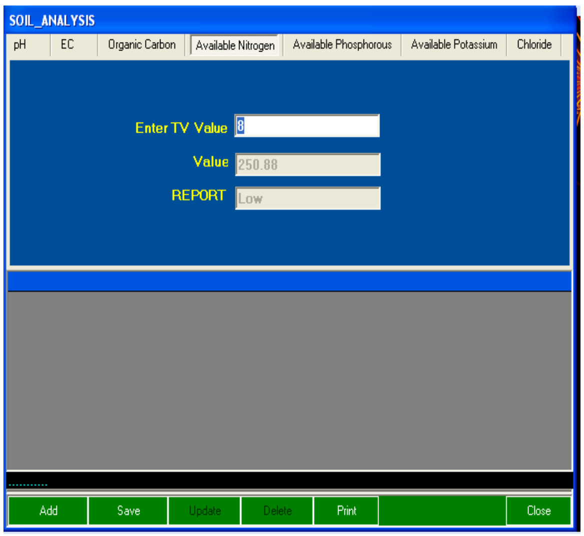

Figure 4. Data entry sheet for available nitrogen.

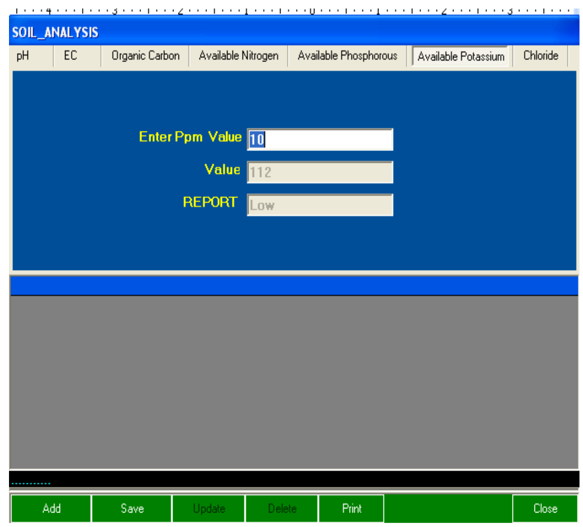

Figure 5. Data entry sheet for available potassium.

calculated and compared to table value that is, low: <250 kg, medium: 250 to 500 kg/ha and high: > 500 kg/ha, and nitrogen recommendation is provided from the stored data (Figure 4).

Potassium is the "Element of Quality" in tobacco. Tobacco is known to be a luxury consumer of potassium and the crop removes about 160 kg K_2O/ha from the soil (Krishnamurthy and Nagarajan 2001). K-deficiency is noticed in tobacco crop grown in light soils due to inherent low K status. K-deficiency may be aggravated by excess nitrogen fertilization. Leaf colour, texture, combustibility and hygroscopic properties of cured leaves are believed to be enhanced by potash fertilization. 'Soil available potassium' is estimated by neutral normal ammonium acetate using flame photometer (Hanway and Heidal, 1952). By feeding the instrument reading (R), available potassium in kg / ha will be calculated by the formula R × 11.2, where R = ppm of potassium in the extract. Results will be compared with table values, that is, low: <118 kg / ha, medium: 118 to 280 kg/ha and high: >280 kg/ha, and suitable suggestions will be made for the FCV tobacco for the particular zone (Figure 5).

Chloride is an essential micronutrient for tobacco. It plays an important role in influencing the leaf quality and leaf burn. When present in small quantities (< 1.0%), it improves the yield and certain quality factors like colour, moisture content and keeping quality. Larger amount of chloride (> 1.5%) produces cured leaves of muddy and uneven colour with excessive hygroscopic and poor burn. Soils containing chlorides <80 ppm: highly suitable, 80 to 100 ppm: suitable, >100 ppm: unsuitable. Chlorides in soil and water are estimated by titrating with N / 35.5 silver nitrate using potassium chromate as indicator (Krishnamurthy and Nagarajan, 2001). Soil chlorides (ppm) will be calculated by R* 200, where R is the titre value. The results are compared with table values for recommendation. Once the soil samples are analyzed for different parameters, depending upon the tobacco zone from where samples are collected, site specific fertilizer doses are recommended automatically from the data already fed to computer. Then Click 'Save' option at the bottom of the menu to store the record into the database. To modify the input value of any parameter click 'Modify' option at the bottom of the screen. To take the hardcopy of the report for all parameters, click 'Print' option at the bottom of the screen (Table 2).

Water analysis

In Northern Light Soils (NLS) of Andhra Pradesh, the flue-cured tobacco crop is given 8 to 10 irrigations while in Southeren Light Soils, one life-saving irrigation is given to the crop. The quality of water used for irrigation in

Table 2. Final report for soil analysis and recommendation of fertilizers.

Soil analysis		
Parameter	**Value**	**Report**
pH	6.40	Acidic
EC	0.42	Critical
Organic carbon	0.55	Medium
Available nitrogen	250.88	Low
Available phosphorus	8.96	Low
Available potassium	112.00	Low
Chloride	80	Suitable

An amount of 120 kg N/ha – 60 kg P_2O_5 and 120 kg; K_2O is recommended in the form of diammonium phosphate, calcium ammonium nitrate and potassium sulphate.

Table 3. Final Report for Water Analysis and Recommendation of fertilizers.

Water analysis		
Parameter	**Value**	**Report**
pH	6.40	Acidic
EC	0.42	Unsuitable
Chloride	16.00	Suitable

The water is suitable for irrigating FCV tobacco.

different agro-climatic zones varies widely, particularly the ground water. Continued use of high chloride waters can lead to salinization of soils and consequently the production of saline leaf (Cl > 1.5%). The quality of irrigation water generally depends on the total concentration of dissolved salts, particularly ions like Na^+ and Cl^-. Therefore, analysis of the water samples in these areas is as important as the soil analysis. For evaluating the quality of irrigation waters, electrical conductivity (taken as a measure of total soluble salt content), chlorides and pH of the water are determined. The pH of water is determined by pH meter. In case of water, the limits were Acidic: < 6.5, Neutral: 6.5 to 7.5, Alkaline: > 7.5. After comparing, the inference will be stored.

EC is measured by electrical conductivity solubridge as it was in soil. When the irrigation water contains EC more than 0.4 (ds / m) at 25°C, it is unsuitable for irrigation. The obtained EC of water will be compared with recommended values. Chloride content in irrigation water is estimated as it was in soil analysis. Chlorides in water is calculated by using the formula R*40, where R is the titre value. If the chloride content is greater than 40 ppm, such water is rated as saline and is unsuitable for irrigating flue-cured tobacco crop in light soils. Once the water samples are analyzed for different parameters, then Click ‘Save’ option at the bottom of the menu to store the record into the database. To modify the input value of any parameter click ‘Modify’ option at the bottom of the screen. To take the hardcopy of the report for all parameters, click ‘Print’ option at the bottom of the screen (Table 3).

The DSS helps in preparation of report instantaneously and reduces the time taken for computation of results, avoids the errors in calculation and preparation of reports. As this DSS provide a recommendation of fertilizer doses and suitability of water for tobacco crop, it will be highly helpful to the farmers to optimize their resources. This DSS is applicable for other crops also with slight modifications, if the same methods are adopted for estimation of soil and water quality parameters.

REFERENCES

Anonymous (2010). Annual Report, Tobacco Board, Ministry of commerce and Industry, Guntur, Andhra Pradesh. pp. 143-154.

Balena F (2005). Programming Microsoft Visual Basic NET. Microsoft Press, USA.

Bray RH, Kurtz LT (1945). Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 59:39-45.

Davis DL, Nielsen MT (2007). Tobacco Production, Chemistry and Technology. Black well publications, London, P. 461.

Gaddis T, Lrvine K, Dention B (2003). Starting out with VB.Net Programming, Dream Tech Press, New Delhi, 2nd ed.

Ghosh AV, Bajaj JC, Hassan R, Singh D (1983). Laboratory manual on soil and water testing methods. Division of soil science and agricultural chemistry. IARI, New Delhi.

Hanway JJ, Heidal H (1952). Soil analysis methods used in Iowa State College, soil testing laboratory. Iowa Agron. 57:1-31.

Krishnamurthy V, Nagarajan K (2001). A manual on soil testing and irrigation water analysis for tobacco. Central Tobacco Research Institute, Rajahmundry.

Krishnamurthy V, Deosingh K (2002). Flue-cured tobacco soils of India: their fertility and management. Central Tobacco Research Institute, Rajahmundry, pp. 31-33.

Krishnamurthy V, Anuradha M (2011). Nitrogen nutrition of flue-cured tobacco. Tobacco Res. 37(1):1-17.

Manos BA, Ciani Th, Bournaris I, Vassiliadou J, Papathanasiou (2004). A Taxonomy Survey of Decision Support Systems in Agriculture. Agric. Econ. Rev. 5(2):80-92.

Nelson SL, Kelly J (2002). Office XP: The Complete Reference. Tata Mcgraw-Hill publishing Ltd, New Delhi.

Olsen SR, Cole CV, Watanabe FS, Dean LA (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circ. U.S. Department Agriculture. P. 939.

Pannell DJ (1996). Lessons from a decade of whole-farm modeling in Western Australia. Rev. Agric. Econ. 18:373-383.

Ravisankar H, Anuradham M, Chandrasekhararao C, Ravisankar H, Siva Raju K, Krishnamurthy V, Raju CA (2010). Expert system for identification and management of abiotic stresses in tobacco. Indian J. Agric. Sci. 80:151-154.

Ravisankar H, Anuradham M, Chandrasekhararao C, Nageswara RK, Krishnamurthy V (2009). Expert System for the diagnosis of nutrient deficiencies in flue-cured tobacco. Indian J. Agric. Sci. 79:45-49.

Stockle CO, Martin S, Campbell GS (1994). Crop Syst, a cropping systems model: water / nitrogen budgets and crop yield. Agric. Sys. 46:335-359.

Stone ND, Buick RD, Roach JW, Scheckler RK, Rupani R (1992). The planning problem in agriculture: Farm-level crop rotation planning as an example. AI Appl. 6(1):59-75.

Subbaiah BV, Asija GL (1956). A rapid procedure for the determination of available nitrogen in soils. Curr. Sci. 25:259-260.

Walkley AJ, Black IA (1934). Estimation of soil organic carbon by the chromic acid titration method. Soil Sci. 37:29-38.