

Nutrient Expert® for Hybrid Cotton

Technical Bulletin and User Manual



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Nutrient Expert® for Hybrid Cotton

(Technical Bulletin and User Manual)

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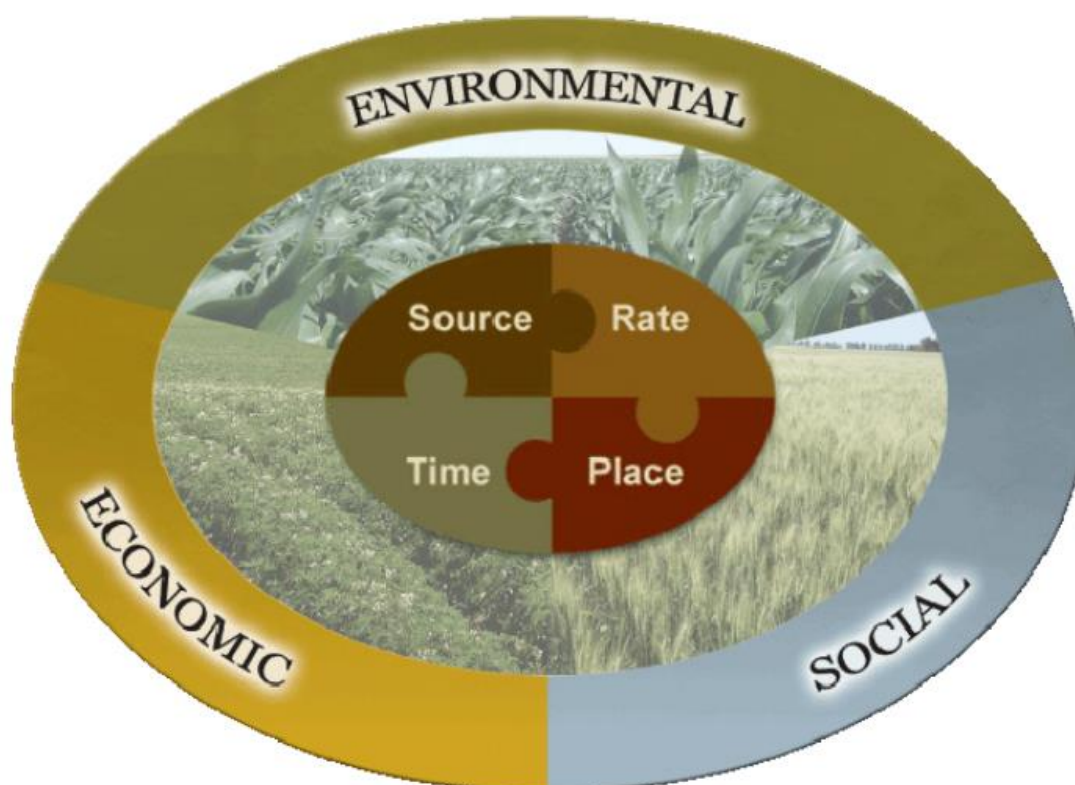
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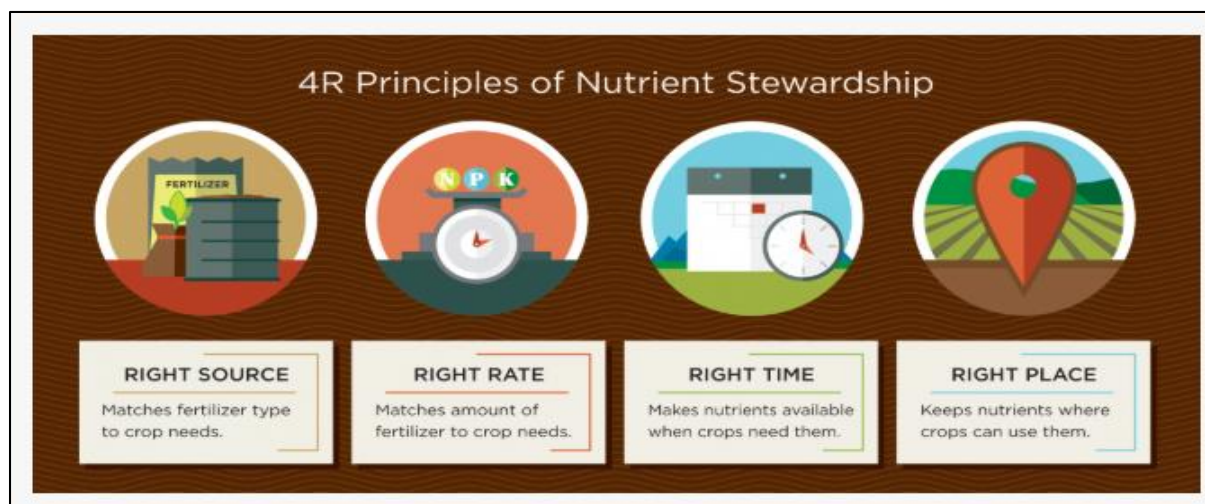


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Nutrient Expert® for Hybrid Cotton

This Technical Bulletin and User Manual is consistent with the 4R Nutrient Stewardship concept that defines the right source, rate, time, and place for plant nutrient application as those producing the economic, social, and environmental outcomes desired by all stakeholders to the soil-plant ecosystem. For more details on 4R Nutrient Stewardship visit www.ipni.net/4R



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DISCLAIMER: The International Plant Nutrition Institute (IPNI) and the decision support tool do not endorse or promote specific fertilizers and do not guarantee the accuracy of an analysis labelled on commercial fertilizers. The tool assumes that the N, P₂O₅, and K₂O analysis labelled on a bag of organic or inorganic fertilizer accurately reflects the content of plant nutrients in the fertilizer. In addition to nutrients, many factors (e.g. climate, crop care, water management) affect cotton yield. IPNI and the tool do not guarantee a targeted attainable cotton yield with the provided nutrient management guidelines.

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Nutrient Expert® for Hybrid Cotton is a user-friendly nutrient decision support tool that enables researchers, extension experts and industry agronomists to quickly develop field specific fertilizer recommendations for hybrid cotton.

SYSTEM REQUIREMENTS

Nutrient Expert for Hybrid Cotton requires about 17 MB of disk space and the following:

- Windows XP or higher
- MS Office 2003 or higher
- MS Access 2003 or higher. In the absence of MS Access application, download the MS Access Runtime from the Microsoft website (<http://www.microsoft.com/downloads/details.aspx?familyid=d9ae78d9-9dc6-4b38-9fa6-2c745a175aed&displaylang=en>).
- Acrobat reader 6 or higher (for reading saved outputs as PDF)

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1. INTRODUCTION

Cotton is the premier fiber crop of the semi-arid tropics of central India, cultivated on more than 7 Mha, predominantly under rain-dependent conditions. Despite the introduction of high-yielding transgenic *Bt* cotton hybrids with a yield potential ranging from 1,000 to 1,500 kg lint ha⁻¹, the region's average lint yield stagnates at a modest 495 kg ha⁻¹, significantly below the national average of 524 kg lint ha⁻¹. In Maharashtra, which contributes over 30% of the nation's cotton area with 4.2 million hectares during the kharif season, productivity is even lower at 344 kg lint ha⁻¹. This persistent yield gap is largely attributed to improper soil moisture management and poor nutrient application at critical crop growth stages, highlights the urgent need for improved nutrient management strategies.

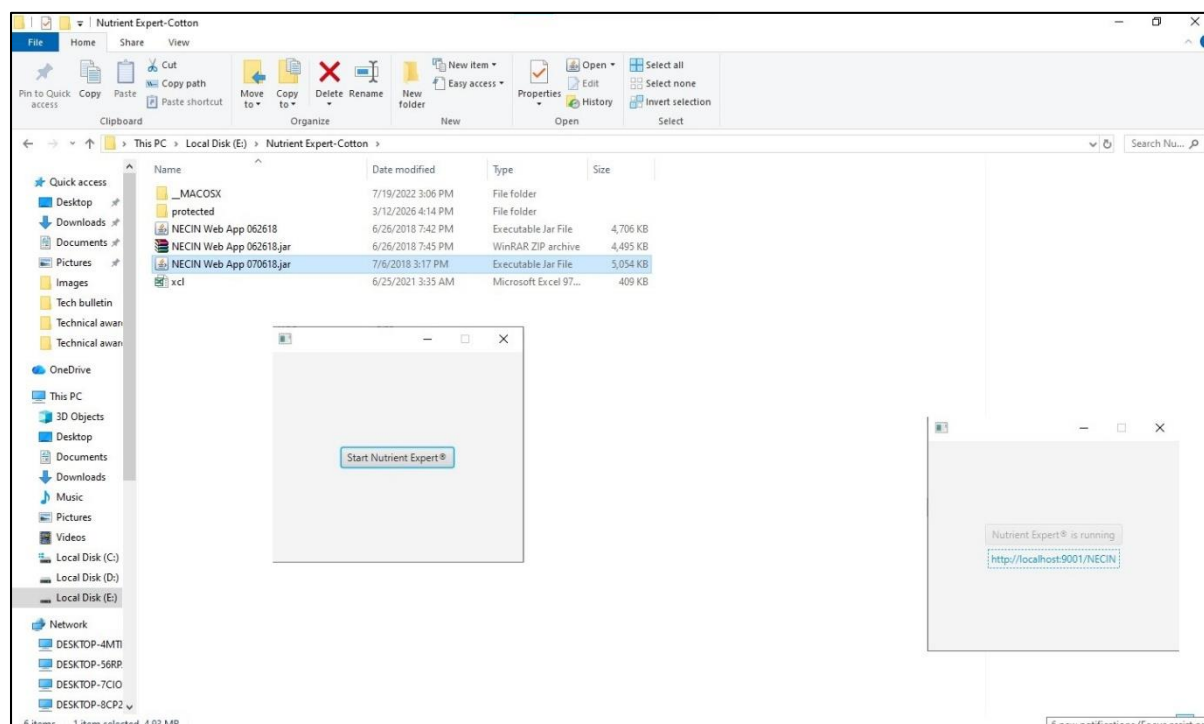
In India, cotton growing (12-13 Mha) is defined by small and fragmented land holdings, which exhibit high variability in indigenous plant nutrient availability between fields. However, conventional fertilizer recommendations, such as the recommended dose of fertilizer (RDF) developed from research station experiments, are typically uniform across large geographic areas. This blanket approach fails to account for field-specific conditions, often leading to nutrient imbalances. In response, farmers have resorted to applying 1.5 times or more of nitrogenous and phosphate fertilizers than the RDF, hoping for higher yields. This practice has not translated into productivity gains but has instead increased cultivation costs by 10%, driven by a 233% rise in fertilizer expenses and declining factor productivity. More advanced approaches, such as soil test crop response (STCR) methods, were developed to address soil nutrient supply but often prescribed rates exceeding RDF without fully considering crop yield potential, highlighting the need for more precise nutrient management. Site-specific nutrient management (SSNM) offers a robust alternative by integrating information from different scales to tailor nitrogen, phosphorus, and potassium management to individual fields. SSNM principles aim to account for indigenous nutrient sources, including crop residues and manures, and apply fertilizers at optimal rates and critical growth stages to meet the deficit between the nutrient needs of a high-yielding crop and the soil's indigenous supply. However, despite its proven effectiveness in improving cereal crop yields, large-scale adoption of SSNM by farmers remains limited. Extension agents often perceive the methodology as complex, requiring an understanding of concepts outside their experience, which has slowed its widespread promotion and acceptance.

To address this challenge, the International Plant Nutrition Institute (IPNI), in collaboration with the ICAR-Central Institute for Cotton Research (CICR), has developed Nutrient Expert® for hybrid Cotton. This new, easy-to-use, interactive decision support tool consolidates SSNM principles into a simple delivery system, enabling cotton farmers to rapidly implement field-specific nutrient management. Nutrient Expert® utilizes a systematic approach to capture site information crucial for developing location-specific recommendations without requiring exhaustive data. It can draw upon farmers' local knowledge, existing practices, and even integrate Soil Health Card results to provide meaningful yield targets. The tool formulates 4R nutrient prescriptions viz., right source, right amount, right time, and right method aimed at bridging yield gaps, improving farm profitability, and enhancing nutrient use efficiency while minimizing environmental hazards. Currently, Nutrient Expert® for Cotton is being evaluated for agronomic performance against existing nutrient management options, including CICR-recommended RDF, STCR, and farmer fertilizer practices. The tool can be downloaded free of cost as a mobile app or operated online, providing nutrient recommendations directly to farmers as a one-page report or text message. This technical bulletin and user manual, while describing the various steps involved in operating the tool, will assist users in developing improved nutrient management practices for attaining better cotton yields, ultimately contributing to the sustainable intensification of cotton production in India.

2. INSTALLATION OF NUTRIENT EXPERT FOR HYBRID COTTON

The Nutrient Expert for Hybrid Cotton is developed on a MS-Access platform. The package contains an Access based file called “NE Cotton South Asia.mde” along with two supporting programme files named “dynapdf.dll” and “StrStorage.dll”. Downloading the programme to a computer requires that all the three files are stored together in the same folder at an identified location. It is suggested that a single folder in the name of NE-Cotton be created at an identified location and all the above mentioned files may be extracted from the external source (Flash Drive/DVD/Website) to the NE-Cotton folder. In the following example (Figure 1), the Nutrient Expert-Hybrid Cotton software was downloaded from a zip folder in a flash drive. The three files in the zip folder are then extracted to a new folder “NE-Cotton” created on the desktop.

FIGURE 1. Illustration of extracting Nutrient Expert for Hybrid Cotton software on to the computer



2.1 ACCESSING THE NUTRIENT EXPERT FROM COMPUTER

I. Double click the NE-Cotton folder

II. The following three files will be visible

a) dynapdf.dll, b) NE Cotton South Asia.mde and c) StrStorage.dll

III. Double click the file named “NE Cotton South Asia.mde” keeping the other two supporting programme files undisturbed.

IV. The files with .dll extension are required for the “save as PDF” option of the outputs or reports

2.2 WORKING WITH NUTRIENT EXPERT®

On double click at the file named NE Cotton South Asia.mde, a security window opens as follows; Press the “Open” button to go to the main software page.

2.3 ASSUMPTIONS AND CONDITIONS

The guidelines provided by this software assume the following conditions:

- no serious limitation of water (i.e. drought) throughout the growing period
- any problem on acidity and/or micronutrients are properly addressed
- use of high-yielding cotton varieties
- no major damage caused by pests and diseases
- proper placement of fertilizer is practiced

3.THE “HOME” SECTION

The home page consists of five buttons representing five modules. Each module requires a set of information and provides a report (print or pdf). The user can navigate between modules and make changes, but the user must be aware that changes made in one module may affect other modules because of data sharing. To ensure that all data input have been properly accounted for in formulating the recommendations and profit analysis, the user must go through each of the modules beginning from the first module (Current NM Practice) to the last module (Profit Analysis).

In the home page, before developing a nutrient recommendation using the modules, the user needs to customize the software with the country, state, and the season for which the nutrient recommendation is being generated. This is done through the “Settings” button on the top right hand corner of the home page.

3.1 WORKING WITH THE “SETTINGS”

Single click on the “Settings” button opens up a new window (Figure 2) with three tabs.

FIGURE 2.

3.1.1 “SITE PROFILE”

The first tab on “Site Profile” allows identifying the country, state, season, preferred unit of area and grain weight of the produce of the farmer for whom the recommendation is being generated. Within the “Site Profile”, a new Window opens up (Figure 3) once the location (Country and State) information is selected.

FIGURE 3.

Provide the Site Name (For example Akola) and the Growing Season (Kharif for instance) and press Add. Use the “Edit button” to subsequently change the location for which a new Nutrient Expert® based recommendation is required. The user can also specify the preferred unit for area (e.g. acre) with the equivalent value in hectare (e.g. 1 acre = 0.4 ha). Similarly, the preferred grain weight unit can be specified with the corresponding equivalent in kilogram. If the user did not specify any area or grain weight unit, the default units are hectare for area and ton (1000 kg) for grain weight.

3.1.2 “INORGANIC FERTILIZERS”

Pressing the “Inorganic Fertilizers” Tab within the Settings window, opens a new window consisting of a list of most common chemical fertilizer sources with their nutrient contents and the price of a 50 kg bag of the concerned fertilizer. The pop-up list can be edited to include new fertilizer sources, their nutrient content and price (Figure 4) using the “Add new inorganic fertilizer source button”. The “Edit” button at the bottom allows making any changes to the existing fertilizer source in terms of its nutrient content or price.

FIGURE 4.

Fertilizer sources	N	P ₂ O ₅	K ₂ O	MgO	CaO	S	Zn	Fe	Cu	Mn	B	Price per bag (INR)
10-26-26	10	26	26	0	0	0	0	0	0	0	0	1,814.50
12-32-16	12	32	16	0	0	0	0	0	0	0	0	1,232.00
15-15-15	15	15	15	0	0	0	0	0	0	0	0	1,470.00
19-19-19	19	19	19	0	0	0	0	0	0	0	0	1,400.00
20-20-0-13S	20	20	0	0	0	0	0	0	0	0	0	1,500.00
Diammonium Phosphate	18	46	0	0	0	0	0	0	0	0	0	1,245.00
Muriate of Potash	0	0	60	0	0	0	0	0	0	0	0	874.00
Single Super Phosphate	0	16	0	0	20	0	0	0	0	0	0	402.00
Urea	46	0	0	0	0	0	0	0	0	0	0	278.00

Single Super Phosphate + 0.0 16. 0.0 0.0 20. 0.0 0.0 0.0 0.0 0.0 0.0 402.00

• The dropdown button will reveal more fertilizer. To add a fertilizer from the existing list, select a fertilizer and click save.
 • To add a new fertilizer, provide the name and other needed information in the data entry row above and click save.

Save Delete

3.1.3 “ORGANIC FERTILIZERS”

Pressing the “Organic Fertilizers” Tab within the Settings window, opens a new window (Figure 5) consisting of a list of most common organic sources of nutrients with their nutrient contents and the price of either a tractor load or a cart load of the concerned organic fertilizer source. The pop-up list can be edited to include new organic fertilizer sources, their nutrient content and price using the “Add new organic fertilizer source button”. The user can select either a “Tractor trolley” or a “Cartload” within the option of “select the local unit of the manure/organic”. The weight of the organic fertilizer carried by a tractor trolley or a cartload may be selected from the default values within the option “weight (kg)” or the user may change the default weight based on local knowledge using the “Edit” button. The “Edit” button also allows making any changes to the existing organic fertilizer source in terms of its nutrient content, weight or price.

Use the “Close” button to go back to the “Home Page” once all the required changes are made in the “Settings”.

FIGURE 5.

Settings

Site Profile Inorganic Fertilizers **Organic Fertilizers**

Select a local unit for manure/organics: tractor trolley weight (kg) 1200

Nutrient content and price of organic fertilizers

Fertilizer sources	N	P ₂ O ₅	K ₂ O	MgO	CaO	S	Zn	Fe	Cu	Mn	B	Price per unit (INR)
Cattle dung	0.35	0.12	0.17	0	0	0	0	0	0	0	0	2,500.00
FYM	0.75	0.2	0.5	0	0	0	0	0	0	0	0	3,000.00
Green manure (Dhaincha)	1.5	0.6	1.2	0	0	0	0	0	0	0	0	1,000.00
Green manure (Sunhemp)	1.3	0.5	1.8	0	0	0	0	0	0	0	0	1,000.00
Neem cake	5.22	1.08	1.48	0	0	0	0	0	0	0	0	5,000.00
Poultry manure	2.87	2.9	2.35	0	0	0	0	0	0	0	0	3,500.00
Rural compost	0.75	0.2	0.5	0	0	0	0	0	0	0	0	2,500.00

Add new fertilizer: Rural compost + 0.7 0.2 0.5 0.0 0.0 0.0 0 0.0 0.0 0.0 0.0 2500

• The dropdown button will reveal more fertilizer. To add a fertilizer from the existing list: select a fertilizer and click save.
 • To add a new fertilizer, provide the name and other needed information in the data entry row above and click save.

Save Delete

< Back Close

4. WORKING WITH THE “CURRENT NM PRACTICE” MODULE IN THE “HOME PAGE”

The Current NM Practice module assesses the yield levels achieved by the farmer for a particular location in the given season and the nutrient application rates used to achieve the yield levels.

INFORMATION REQUIRED

- Cotton yield in the farmers’ field for the season under consideration (with typical climatic condition)
- Farmers’ nutrient management practice – amount of fertilizer (inorganic, organic sources); timing of fertilizer application
- Yield and fertilizer inputs must be provided in field size basis.

EXPECTED OUTPUT

- Summary table of farmers' current nutrient management practice (N, P₂O₅ and K₂O). Nutrient rates per application are given in kg/ha basis.
- Total amount of applied N, P₂O₅ and K₂O separately for inorganic and organic sources.

This information is provided on a hectare basis.

Give the farmer "Name and/or location" (Village/Block/Mandal) and the actual "Field Size" at the provided space on the top of the page (Figure 6). The input for the actual field size must be in the unit specified in Settings as shown in Figure 6. For example, if the field size is 1.0 acre, the user should write 1 next to acre, and its equivalent in hectare (0.4) will be automatically calculated. If the user did not specify any area unit in the Settings, only hectare (ha) will appear under "Field size." In that case, a field of 1.0 acre should be written as 0.4 ha.

FIGURE 6.

The screenshot shows the 'Nutrient Expert® for Cotton' web application interface. At the top, there is a navigation bar with 'Home', 'Settings', and 'Help' links. Below the navigation bar, there are four tabs: 'Current FFP and Yield', 'SSNM Rates', 'Sources and Splitting', and 'Profit Analysis'. The 'Current FFP and Yield' tab is selected. The main input area contains the following fields:

- 'Name and/or Location': A text box containing 'Ketan Wankhede, Hatala Katol'.
- 'Field size': A numeric input box with '1.0' and a unit dropdown menu showing 'ha'. Below the input, it displays '2.4691356 acre'.
- 'Growing season': A dropdown menu with 'Kharif' selected.
- 'Planting Time': A date input box with '16-30 June'.

4.1 CURRENT FARMERS' YIELD

Question 1 in this module asks the farmer about the average cotton yield for the specified field over the past 3 to 5 years. Yields in abnormally good or bad seasons should be ignored while providing the input. Cotton yield for the specified field is then converted to a hectare basis considering the moisture content at harvest (Figure 7). Often, the moisture content is not known to the farmers and therefore a default value of 12% is used in such cases. However, the moisture content, if known, could be provided in the appropriate input box in the module for use in the yield calculation.

FIGURE 7.

This screenshot shows the same web application interface as Figure 6, but with the 'Current FFP and Yield' tab selected. Below the input fields for location and field size, there is a question: '1. What was the yield of cotton for a typical season in the past 3 to 5 years?'. Below this question, there is a text input box for 'Seed cotton yield (1000.0 kg/ton):' with the value '2.30' and a unit dropdown menu showing 't/ha'.

4.2 FARMERS' FERTILIZATION PRACTICE

The second question in this module assesses the rate and source of nutrient used by the farmer for achieving the above specified cotton yield. The inputs are divided into inorganic and organic fertilizer sources and the farmer provides the information on the basis of the actual field size (Figure 8).

- Pressing the "Inorganic fertilizers" button opens a new window to provide the inputs for amount and time of fertilizer application.
- First, choose the "number of times" fertilizer is applied by the farmer by clicking on the appropriate circle (1 time / 2 times / 3 times / 4 times).
- Based on the selection, the options for adding fertilizer sources appear at the bottom of the window. Provide the time of application at the space provided under "Days after planting"

option. For example, fertilizer applied as basal would mean an input of “0” to be written under “Days after planting”.

- Use the tab button on the keypad of your computer (or move the mouse cursor) to go to the “Fertilizer Sources” and type the name of the fertilizer source used by the farmer.
- Use the tab button again to go to the option “No. of bags” and write how many bags of the specified fertilizer source was used by the farmer at that time of application for the entire field. For example, a farmer applying 50 kg DAP and 15 kg MOP as basal would consider an input of 1 bag of DAP and 0.3 bag of MOP.
- Follow the same procedure to provide inputs when fertilizer is applied more than once during the crop growth period. For example, when fertilizer is applied three times during the crop growth period, information for “Days after planting”, “Fertilizer Sources” and “No. of bags” must be provided for each application time (Figure 8). Press the “OK” button once all inputs are provided.
- If the user wishes to account for secondary and micronutrients application, then appropriate secondary and micronutrient sources used by the farmer must be added to the list of “Inorganic Fertilizer” through the “Settings” option. This will allow choice of these sources while answering Question 2 in the “Current NM Practice” Module. The of secondary and micronutrients application rates will show up in the “Current NM Practice” Module in kg/ha (Figure 10).
- With this, the fertilizer sources and rates applied at different times of application would transform to the actual N, P2 O5 and K2 O rates on a hectare basis, irrespective of the farm size considered for providing inputs, and would appear under the “Inorganic fertilizers” section of the “Current NM Practice” module.

FIGURE 8.

The screenshot displays the 'Nutrient Expert® for Cotton' web application interface. The top navigation bar includes 'Home', 'Settings', and 'Help'. The main content area is divided into several sections:

- Current FFP and Yield:** Fields for Name and/or Location (Kotian Wankhede, Hatata, Katol), Field size (1.0 ha), Growing season (Kharif), and Planting Time (16-30 June).
- 1. What was the yield of cotton for a typical season in the past 3 to 5 years?** Seed cotton yield (1000.0 kg/ha) and 2.30 t/ha.
- 2. How much fertilizer does the farmer usually apply to the entire cotton field?** Split No. (1), DAS (0), Fertilizer (10-26-26), No. of bags (set to zero to remove from list) (0).
- Inorganic Fertilizers:** Fields for N (0), P₂O₅ (0), K₂O (0), and Others (kg/ha) including B, Mn, Cu, S, Fe, Zn, MgO.
- Organic Fertilizers:** Fields for N (0), P₂O₅ (0), K₂O (0), and Others (kg/ha) including Fe, Zn, MgO.
- Specialty Fertilizers:** Fields for N (0), P₂O₅ (0), K₂O (0), and Others (kg/ha) including B, Mn, Cu, S, Fe, Zn, MgO.
- Inorganic Fertilizers - Current FFP and Yield:** A table showing fertilizer application details for three applications.

Application	Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
1 st application	0 DAS				
	Sluric Super Phosphate	4	0	32	0
2 nd application	40 DAS				
	15-15-15	4	30	30	30
3 rd application	70 DAS				
	Urea	4	92	0	0
	Diammonium Phosphate	1	9	23	0

Press the “Organic Fertilizers” button to open another window to provide the source and the amount of organic fertilizer applied by the farmer in his field (Figure 9). Select the “Fertilizer” applied from the drop-down menu and specify the weight of the full unit (tractor trolley/cartload) and the number of units applied in the concerned field.

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FIGURE 9.

The screenshot shows the 'Current FFP and Yield' tab of the Nutrient Expert® for Cotton web application. The user has entered the following information:

- Name and/or Location:** Ketan Wankhede, Hatala, Katol
- Field size:** 1.0 ha (2.469135 acre)
- Growing season:** Kharif
- Planting Time:** 16-30 June
- Seed cotton yield (1000.0 kg/ton):** 2.30 ton (2.30 t/ha)
- Fertilizer:** FYM (1200 kg per unit)
- No. of units (set to zero to remove from list):** 4.0

The application displays the following fertilizer recommendations:

Inorganic Fertilizers:

N	P ₂ O ₅	K ₂ O
131 kg/ha	85 kg/ha	30 kg/ha

Organic Fertilizers:

N	P ₂ O ₅	K ₂ O
36 kg/ha	9.6 kg/ha	24 kg/ha

Others: kg/ha

B	Mn	Cu	S	Fe	Zn	MgO
0	0	0	0	0	0	0

Inorganic Fertilizers - Current FFP and Yield

1st application: 0 DAS

Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
Single Super Phosphate	4	0	32	0

2nd application: 45 DAS

Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
15-15-15	4	30	30	30

3rd application: 70 DAS

Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
Urea	4	92	0	0
Diammonium Phosphate	1	9	23	0

Organic Fertilizers - Current FFP and Yield

Source	No. of units	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
FYM	4	36	9.6	24

- Click the OK button once the inputs are provided.
- With this, the organic fertilizer sources and rates applied would transform to the actual N, P₂O₅ and K₂O rates on a hectare basis, irrespective of the farm size considered for providing inputs, and would appear under the “Organic fertilizers” section of the “Current NM Practice” module

FIGURE 10.

The screenshot shows the 'Current FFP and Yield' tab of the Nutrient Expert® for Cotton web application, displaying the output of the fertilizer recommendations. The user has entered the following information:

- Name and/or Location:** Ketan Wankhede, Hatala, Katol
- Field size:** 1.0 ha (2.469135 acre)
- Growing season:** Kharif
- Planting Time:** 16-30 June
- Seed cotton yield (1000.0 kg/ton):** 2.30 ton (2.30 t/ha)
- Fertilizer:** FYM (1200 kg per unit)
- No. of units (set to zero to remove from list):** 4.0

The application displays the following fertilizer recommendations:

Inorganic Fertilizers:

N	P ₂ O ₅	K ₂ O
131 kg/ha	85 kg/ha	30 kg/ha

Organic Fertilizers:

N	P ₂ O ₅	K ₂ O
36 kg/ha	9.6 kg/ha	24 kg/ha

Others: kg/ha

B	Mn	Cu	S	Fe	Zn	MgO
0	0	0	0	0	0	0

Inorganic Fertilizers - Current FFP and Yield

1st application: 0 DAS

Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
Single Super Phosphate	4	0	32	0

2nd application: 45 DAS

Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
15-15-15	4	30	30	30

3rd application: 70 DAS

Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
Urea	4	92	0	0
Diammonium Phosphate	1	9	23	0

Organic Fertilizers - Current FFP and Yield

Source	No. of units	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
FYM	4	36	9.6	24

Once all inputs are provided, the current NM practice module will show the amount of N, P₂O₅ and K₂O applied to the particular field, the fertilizer sources as well as the time of application (Figure 10).

The report of the output of the “Current NM practice” module could be saved as a pdf file or may be printed by pressing the “Report” button at the left bottom corner of the screen.

The entire information provided in this module may be cleared using the “Reset” button on the left bottom corner of the module for adding fresh inputs to the questions.

The “< Back” and “Next >” buttons at the bottom right-hand corner helps to navigate to the previous or to the next module respectively. The user may also navigate through the modules by clicking on the module tabs at the upper part of the page. Pressing the “close” button will take the user back to the home section.

Note: The utility of all the five buttons given in the bottom of each module remain same across the modules. Farmers’ yield will be used as (a) basis for suggesting a yield goal and (b) for estimating benefits in the “Profit Analysis” module; while farmers’ fertilizer practice will be used for estimating costs in the “Profit Analysis” module.

Press the “Next” button to go to the “SSNM Rates” module.

5. WORKING WITH THE “SSNM RATES” MODULE

This module uses the attainable yield target, calculates the nutrient balance in the cropping system considering the external nutrient inputs and combines that with the expected N, P and K responses in the concerned farmer’s field to provide nutrient recommendations for achieving the attainable yields.

INFORMATION REQUIRED

- Estimate of the attainable yield (if known)
- Alternatively, characteristics of the growing environment (irrigated/rainfed, risks of flooding and/or drought, presence of soil related constraints other than NPK) are used to estimate the attainable yield
- Estimates of yield responses to fertilizer N, P and K (if known)
- Alternatively, soil fertility indicators such as soil texture and colour, historical use of organic inputs, and information related to previous crop (yield, fertilizer inputs, crop residue management) will be used by the software to estimate yield responses.
- Crop residue management, use of organic inputs, and nutrient carry over from previous crop are used to adjust fertilizer P and K requirements as merited

EXPECTED OUTPUT

- N, P₂O₅ and K₂O requirements for the estimated attainable yield and yield responses to fertilizer.
- Nutrient credits or adjustments (as merited)

5.1 ATTAINABLE YIELD OF A LOCATION

Provide the attainable yield of a location in question 1 if it is already known. Attainable yield is explained as the yield obtained in a well-managed research plot with minimum constraints for a typical climatic condition.

If the attainable yield is not known, the user can press the “?” mark next to question 1 that opens a new window shown in Figure 11. This new window takes the user through a series of growing environment related questions to indirectly estimate the attainable yield of the location.

FIGURE 11.

Nutrient Expert® for Cotton (Web App Beta Version, July 2018)

Estimate Attainable Yield

Current FFP and Yield | SSNM Rates | Sources and Splitting | Profit Analysis

Name and/or Location: Ketan Wankhede, Hatala, Katol, A, Maharashtra | Growing season: Kharif

Field size: 2.5 acre | Farmer's Yield: 2.3 ton 2.3 t/ha

Describe growing environment

1. Water availability (source of water): ☒ irrigated ☐ fully rainfed ☐ rainfed with supplemental irrigation

1.a Do you have an estimate of the K input from irrigation water? ☐ Yes ☒ No 15.0 kg K₂O/ha/crop

2. Drought problems: ☐ often ☒ seldom ☐ never
[often = 2 or 3 out of 5 times; seldom = 1 out of 5 times]

3. Soil-related problems other than NPK:
☐ acidity 5.3 pH
☐ deficiency of secondary nutrients and micronutrients
☐ Boron ☐ Iron ☐ Magnesium ☐ Manganese ☐ Sulfur ☐ Zinc
☐ problem soils:
☐ saline soils ☐ alkali soils ☐ degraded soils
☒ none

1. What is the attainable yield for your location? Estimate yield: 2.75 t/ha

2. What does the farmer do with cotton residues after harvest?
☒ Remove all the above ground residues from the field
☐ Retain all the above ground residues in the field and incorporate
☐ Specify retention

3. Will the farmer apply organic fertilizers (eg. manure)? ☐ Yes ☒ No

Fertilizer: Cattle dung (1200 kg per unit)
 No. of units (set to zero to remove from list): 0

4. Estimate residual benefit from previous crop: Estimate

5. Estimate yield response to N, P, and K: Estimate

N response: 1.0 t/ha P response: 0.4 t/ha K response: 0.4

6. Account for P and K credits? ☐ Yes ☒ No

The attainable yield for your location: 2.75 t/ha
 Growing environment: Irrigated

N response (t/ha)	Fertilizer N (kg/ha)
0.9	117
1.0	123
1.1	128

P response (t/ha)	Fertilizer P ₂ O ₅ (kg/ha)
0.3	37 40 43
0.4	41 44 46
0.5	44 47 50

K response (t/ha)	Fertilizer K ₂ O (kg/ha)
0.3	56 60 65
0.4	59 64 68
0.5	63 67 72

N credits: 0 kg N/ha Final N Rate: 123 kg N/ha
 P credits: 0 kg P₂O₅/ha Final P Rate: 44 kg P₂O₅/ha
 K credits: 0 kg K₂O/ha Final K Rate: 64 kg K₂O/ha

Reset Report < Back Next >

The questions in the new window describes the growing environment.

- Water availability: Choose one of the three options that best describes the farmer's access to water (irrigated/fully rainfed/rainfed with supplemental irrigation)
- Flooding problems: Choose one of the three options (often/seldom/never), where • "often" means occurrence of flood in 2 or 3 years out of 5 years • "seldom" represents occurrence of flood in 1 out of 5 years • Choose "never" when there is no possibility of flooding
- Drought problems: Choose one of the three options (often/seldom/never), where • "often" means occurrence of drought in 2 or 3 years out of 5 years • "seldom" represents occurrence of drought in 1 out of 5 years • Choose "never" when there is no possibility of drought
- Soil depth: Choose one of the two options (deep/shallow) • "deep" refers to soil depth of 50 cm or more from surface to rock layer or parent material. • "shallow" refers to soil depth of less than 50 cm from surface to rock layer or parent material Note: A deeper soil, is generally associated with a higher soil fertility level whereas, shallow soils represent lower soil fertility levels
- Soil-related problems other than NPK: Acidity: Choose this option when the pH is below 5.3 and the selection of this option will ask the user to provide the pH value of the soil and if required, the software will suggest the lime requirement in the final recommendation report based on the level of soil acidity.
- Deficiency of secondary and micronutrients: Secondary and micronutrient deficiency in the soil can adversely impact the yield of cotton. Upon flagging such deficiencies, the software will recommend appropriate rate and source of application of secondary and micronutrients based on the current state recommendation, which will be included in the final report.
- Problem soils: Identifying the farmers' fields as acid sulfate soils, degraded soils or saline soil will be considered as a major constraint towards achieving high yields and thus limits the attainable yield to certain extent.
- Choose "none" if there are no soil-related problems other than NPK

- Press the “Estimate” button on the bottom left hand corner to estimate the attainable yield under the above constraint levels.
- Press “OK” to go back to the “SSNM Rates” module

5.2 MANAGING RESIDUES IN THE CURRENT COTTON CROP

A large amount of soil nutrients are removed from the field along with crop residues during harvest. This is particularly true for a high yielding crop like cotton which also produces a large amount of non-grain biomass. The macronutrient accumulation to produce 1 ton (1000 kg) of total above-ground cotton biomass (seed cotton, stalks, leaves, and burs at maturity) is approximately 63 kg of N, 23 kg of P and 83 kg of K. Generally, a substantial amount of non-lint biomass is removed from the field along with the harvested boll, causing extensive mining of nutrients from the soil. Recycling residues back to the field after harvest of the crop will stop such export of nutrients which can later be utilized by the succeeding crop. Such contribution of nutrients from the residues needs to be taken into account while formulating nutrient management strategies for cotton.

Farmers adopt different options of residue management although most farmers remove residues from their fields. The Nutrient Expert tries to capture the extent of nutrients recycled through residues under different options of residue management in Question 2 in the “SSNM Rates” module. This information is used to estimate the nutrient balance in a specified field. Therefore, it is important for the user to understand and select the right residue management option while developing the SSNM rates for a particular field.

Choose one among the following options to capture the residue management practice adopted by the farmer for the current cotton crop.

- Remove all the above ground residues from the field: Choose this option if all the above ground biomass is completely removed from the field along with the harvested product
- Retain stalk in the field and incorporate: Select this option when the above ground biomass is retained and incorporated in the soil
- Retain stalk in the field and burn: When the above ground biomass is left in the field and is burnt before planting of the next crop.
- Compost stalk for incorporation to next crop: When the above ground biomass is taken off from the field for making compost and later returned to the field as compost.
- Retain 50% of the stalk on the surface: When the cotton plants were cut to half of its height after harvest and the anchored residues were retained in the field
- Retain 100% of the stalk on the surface: When the whole cotton plants were retained in the field after harvest of the boll.

5.3 NUTRIENT CREDITS FROM ORGANIC INPUTS

Organic sources of nutrients, in addition to improving the physico-chemical and biological properties of soil, contribute to the nutrient requirement of the cotton crop when added in ample quantities. Therefore, it is important to capture such information in order to consider the nutrient contribution from such sources and accordingly give credits both in the nutrient balance and fertilizer recommendation calculations.

In Question 3 of the SSNM Rates module, the user is asked whether the farmer will apply any organic manure to the current crop Press “Yes” if the farmer plans to apply organic manure to the current cotton crop.

Pressing “Yes” will open a new window which allows the user to provide the type (“Fertilizer source”) and quantity (“Weight and Number of units”) of manure to be used by the farmer (Figure 12). The

Nutrient Expert calculates the contribution of N, P₂O₅ and K₂O from such addition and includes that in the nutrient rate calculation of the SSNM rate module.

Press “No” if the farmer does not plan to apply any organic manure in the current cotton crop.

FIGURE 12.

Nutrient Expert® for Cotton India (Web App Beta Version, July 2018) Home Settings Help

Current FFP and Yield **SSNM Rates** Sources and Splitting Profit Analysis

Name and/or Location Ketan Wankhede, Hatala, Katol, A; Maharashtra

Field size 2.5 acre **Growing season** Kharif

Fertilizer N, P, and K requirements are based on yield goal (i.e. attainable yield) and expected yield responses to fertilizer application.

1. What is the attainable yield for your location? Estimate yield 3.25 t/ha

2. What does the farmer do with cotton residues after harvest?

☒ Remove all the above ground residues from the field

☐ Retain all the above ground residues in the field and incorporate

☐ Specify retention

3. Will the farmer apply organic fertilizers (eg. manure)? ☒ Yes ☐ No

Fertilizer FYM (1200 kg per unit)

No. of units (set to zero to remove from list) 4.0

4. Estimate residual benefit from previous crop. Estimate

5. Estimate yield response to N, P, and K. Estimate

N response 1.2 t/ha **P response** 0.5 t/ha **K response** 0.5 t/ha

6. Account for P and K credits? ☒ Yes ☐ No

N response (t/ha)	Fertilizer N (kg/ha)
1.0	123
1.1	128
1.2	133

Yield (t/ha)	3	3.25	3.5
P response (t/ha)	Fertilizer P ₂ O ₅ (kg/ha)		
0.4	46	49	52
0.5	50	52	55
0.6	53	56	59

Yield (t/ha)	3	3.25	3.5
K response (t/ha)	Fertilizer K ₂ O (kg/ha)		
0.4	68	73	77
0.5	72	76	81
0.6	75	80	84

N credits 0 kg N/ha **Final N Rate** 133 kg N/ha

P credits -10 kg P₂O₅/ha **Final P Rate** 43 kg P₂O₅/ha

K credits -19 kg K₂O/ha **Final K Rate** 58 kg K₂O/ha

Reset Report < Back Next >

5.4 NUTRIENT CARRYOVER FROM PREVIOUS CROP

This section deals with the residual benefit from the nutrient application in the previous crop. Nutrients applied to a crop may remain unutilized due to lesser uptake while in some cases nutrient application may become inadequate and crop uptake may deplete soil nutrient reserves. In situations where nutrient is applied in excess of requirement (particularly P and K), it can become available to the next crop and should be taken into account while assessing the nutrient requirement of the succeeding crop. Similarly, inadequate nutrient application in the previous crop should be accounted for in the succeeding crop as a negative balance to stop unwanted exhaustion of indigenous nutrients by the crop.

Cotton may be grown in sequence with several crops namely rice, wheat, maize, cotton, sugarcane, pearl millet, sorghum, soybean, etc. Nutrient Expert estimates the balance of nutrients applied in the preceding crop and combines it with the nutrient balance for the current crop to determine excess amounts of nutrients that could be deducted from the total nutrient requirement.

Press “Yes” in Question 4 of the “SSNM Rates” module if the user wishes to account for the residual benefit from nutrients applied in the previous crop.

Pressing “Yes” will open a new window and the user will be asked to select a crop that was grown in the same field prior to the current cotton crop (Figure 13).

FIGURE 13.

Nutrient Expert® for Cotton (Web App Beta Version, July 2016)

Home Settings Help

Current FFP and Yield SSNM Rates Sources and Splitting Profit Analysis

Name and/or Location Ketan Wankhede, Hatala, Katol, A. Maharashtra **Attainable Yield** 3.25 t/ha (13.5 % MC)

Field size 2.5 acre **Growing season** Kharif **Growing environment** Irrigated

Fertilizer N, P, and K requirements are based on yield goal (i.e. attainable yield) and expected. In the absence of omission plot results, we use general soil characteristics and nutrient balance to estimate yield responses. Please note that the estimated responses are subject to verification and fine tuning (e.g. through farmer participatory evaluation).

1. What is the attainable yield for your location? Estimate yield 3.25 t/ha

2. What does the farmer do with cotton residues after harvest?

☒ Remove all the above ground residues from the field

☐ Retain all the above ground residues in the field and incorporate

☐ Specify retention

3. Will the farmer apply organic fertilizers (e.g. manure)? ☐ Yes ☒ No

Fertilizer FYM (1200 kg per unit) No. of units (set to zero to remove from list) 4.0

4. Estimate residual benefit from previous crop. Estimate

5. Estimate yield response to N, P, and K. Estimate

N response 1.2 t/ha **P response** 0.5 t/ha **K response** 0.5 t/ha

6. Account for P and K credits? ☐ Yes ☒ No

The estimated yield responses are:

N response 1.2 t/ha **P response** 0.5 t/ha **K response** 0.5 t/ha

N response (t/ha)	Fertilizer N (kg/ha)
1.0	123
1.1	128
1.2	133

Yield (t/ha)	P response (t/ha)	Fertilizer P ₂ O ₅ (kg/ha)
0.4	46	49
0.5	50	52
0.6	53	56

Yield (t/ha)	K response (t/ha)	Fertilizer K ₂ O (kg/ha)
0.4	68	73
0.5	72	76
0.6	75	80

N credits 0 kg N/ha Final N Rate 133 kg N/ha

P credits -10 kg P₂O₅/ha Final P Rate 43 kg P₂O₅/ha

K credits -19 kg K₂O/ha Final K Rate 56 kg K₂O/ha

Reset Report < Back Next >

The user will need to choose a single crop from the provided options in question 1 of the newly opened window: Rice/Wheat/Maize/Other Crop (Cotton, Sugarcane, Pearl millet, Sorghum, Potato, Ground nut, Green gram).

In Question 2 in the new window (Figure 13), provide the yield of the crop grown in the previous season. The yield could be provided for the field size chosen in the “Current NM practice” module, which will then be converted to t ha⁻¹ by “Nutrient Expert®”. The user may provide the moisture content of the produce at the time of harvest or a default value will be used by the tool to calculate the final yield.

Farmer’s practices of handling the residues of the previous crop are captured in Question 3 of the new window.

For “rice” as previous crop (Figure 13), choose one among the following options to capture the residue management practice adopted by the farmer.

- Removed all above ground residues from the field: Choose this option if all the above ground biomass is completely removed from the field along with the harvested produce.
- Retained all above ground residues on the surface: Select this option when all the above ground biomass is retained on the soil surface after harvest of the crop.
- Retained all above ground residues in the field and burned: When the above ground biomass is left in the field after harvest and is burnt before planting of the next crop.
- Retained stubble but removed straw from the field: When the above ground biomass is removed leaving only the stubbles in the field

- Retained stubble and burned straw: When the rice straw is burnt in the field leaving only the anchored stubbles of the rice plants
- Retained stubble, burned straw and incorporated: When the rice straw is burnt in the field and anchored stubbles, along with the leftover ash, are incorporated in the field.

The options in Question 3 may vary with the chosen previous crop. In case of cotton, choose one among the six options given in Figure 14.

FIGURE 14.

Previous crop and management

1. What crop was grown on the same field in the previous season?

Maize

1a. Water availability (source of water):

☒ irrigated ☐ fully rainfed ☐ rainfed with supplemental irrigation

2. What was the yield of maize in the previous season?

Total amount harvested from the field (1000.0 kg/ton): 1.0 ton

Moisture content (if known): 15.5 %

Yield at 15.5% moisture: 1 t/ha

3. How much maize residue was retained in the field after harvest (in the previous season)?

☒ Remove all the above ground residue

☐ Retain all the above ground residue

☐ Specify Retention

4. How much fertilizer did you apply to your previous crop?

☒ Inorganic Fertilizers ☐ Organic Fertilizers

Fertilizer: 10-26-26

No. of bag(s) (set to zero to remove from list): 0.0

Similarly, when the previous crop is wheat, one among the following four options may be selected (Figure 15).

When the previous crop is other than cotton, rice or wheat, the user needs to select “other crop (select from list)” option and choose one among the seven crops given in the drop down menu. Choice of a crop from the “other crop (select from list)” menu provides the following two options of residue management in Question 3:

- Removed all the above ground residues from the field
- Retained crop residues for incorporation to next crop

Question 4 (Figure 15) in the window captures the amount of inorganic and organic fertilizers applied in the previous crop. However, the residual benefit of P and K application is only taken into account by the system while the N fertilizer benefit is not considered due to the inherent low N fertility status of soils of the sub-continent that rarely shows any positive residual benefit from N application in previous crop.

FIGURE 15.

Previous crop and management
✕

1. What crop was grown on the same field in the previous season?

Soybean

1a. Water availability (source of water):

☒ irrigated
 ☐ fully rainfed
 ☐ rainfed with supplemental irrigation

2. What was the yield of soybean in the previous season?

Total amount harvested from the field (1000.0 kg/ton): 2.0 ton

Yield: 2 t/ha

3. How much soybean residue was retained in the field after harvest (in the previous season)?

☒ Remove all the above ground residue
☐ Retain all the above ground residue
☐ Specify Retention

4. How much fertilizer did you apply to your previous crop?

Inorganic Fertilizers
Organic Fertilizers

Fertilizer: Urea

No. of bag(s) (set to zero to remove from list)
3.0

OK
Reset
Cancel

Inorganic Fertilizers - previous crop

Source	No. of bags	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
10-26-26	3	15	39	39
Urea	3	69	0	0

Inorganic Fertilizers

N 84 kg/ha

P₂O₅ 39 kg/ha

K₂O 39 kg/ha

Press “Inorganic fertilizer” or “Organic fertilizer” tabs to open new windows to provide the appropriate type and rate of fertilizers applied to the previous crop as described earlier in “Current NM Practice” module (Figure 16).

Press “OK” to go back to the “SSNM Rates” module page once all the inputs are given in the “Previous crop and management” window.

5.5 ESTIMATING EXPECTED N, P AND K RESPONSE IN THE FARMER’S FIELD

SSNM rates for a particular farmer’s field largely depend on the expected crop response to N, P and K fertilizer application. This could be ascertained from the nutrient omission plot results obtained in the particular field or a similar field in the vicinity of the farmer’s plot for which SSNM rates for cotton is being developed. Press the “?” tab at the end of question 5 of the “SSNM Rates” module for a brief description of the omission plot technique.

Press “Yes” and provide the N, P and K response values in the appropriate boxes in Question 5 of “SSNM Rates” module if the user has access to nutrient response information from an omission plot trial conducted in the same field or a nearby field with similar growing environment.

Nutrient Expert® is capable of estimating nutrient response for the field under study in situations where nutrient omission plot trials were not conducted in that particular area.

Press “No” in Question 5 of “SSNM Rates” module if nutrient response information from omission plots trial is unavailable. This will open a new window (Figure 17) with a series of questions on the growing environment that enables the user to estimate the expected N, P and K response in the particular field for which the SSNM recommendation is generated.

FIGURE 16.

Estimate Attainable Yield

Name and/or Location: Ketan Wankhede, Hatala, Katol, A; Maharashtra

Growing season: Kharif

Farmer's Yield: 2.3 ton, 2.3 t/ha

Describe growing environment

1. Water availability (source of water): ☒ irrigated ☐ fully rainfed ☐ rainfed with supplemental irrigation

1.a Do you have an estimate of the K input from irrigation water? ☐ Yes ☒ No 15.0 kg K₂O/ha/crop

2. Drought problems: ☐ often ☒ seldom ☐ never
[often = 2 or 3 out of 5 times; seldom = 1 out of 5 times]

3. Soil-related problems other than NPK:

☐ acidity 5.3 pH

☒ deficiency of secondary nutrients and micronutrients:

☒ Boron ☒ Iron ☒ Magnesium ☒ Manganese ☒ Sulfur ☒ Zinc

☐ problem soils:

☐ saline soils ☐ alkali soils ☐ degraded soils

☐ none

Estimate

The attainable yield for your location: 2.75 t/ha

Growing environment: Irrigated

OK Reset Close

5.5. 1. SOIL TYPE

Question 1 in the newly opened window (Figure 17) requires the information on soil texture.

Soil texture is an important soil characteristic that drives crop production and field management. Of the three soil types given in question 1, the sandy soils tend to be low in organic matter and native fertility, and usually require higher amounts of fertilizer than clayey and loamy soils to achieve a desired yield goal. Whereas, clayey or loamy soils are generally more fertile than sandy soils, contain more organic matter and are better able to retain moisture and nutrients. Therefore, Nutrient Expert® uses the soil type information as an important input towards estimation of nutrient responses in a particular farmer's field.

A sandy soil feels rough and breaks easily if formed into a ball when moist. A loamy soil feels somewhat rough, but holds its shape if formed into a ball when moist. A clayey soil feels sticky between fingers when moist. Use the feel method and visual appearance to closely determine the soil texture of the farmer's field and choose one of the three options, “clayey”, “loamy” or “sandy”

5.5.2. SOIL COLOR AND ORGANIC MATTER CONTENT

Colour can be a useful indicator of some of the general properties of a soil, including soil fertility. Soil colour is usually determined by the amount and state of organic matter as well as the amount and state of iron oxide and soil aeration. A darker soil usually contains more organic matter and has higher soil fertility. Nutrient Expert® uses the information on soil colour as an important indicator of soil fertility and hence nutrient response in a particular farmer's field.

Choose one of the three options in question 2, “Reddish or yellowish”, “Grayish or brownish or black” or “very dark soil with high organic matter” based on the soil colour in the farmer's field.

5.5.3. APPLICATION OF MANURE AND/OR COMPOST

The frequency and the amount of organic manure application influence soil fertility. A frequent and high application rate (done continuously for several years) is associated with higher native soil fertility and a lower crop response to subsequent application of nutrients. Low or negligible rates of organic manure application and/or longer time intervals may not improve soil fertility level and may result in higher crop response to fertilizer application. Nutrient Expert® utilizes the rate and interval of organic manure application to estimate N, P and K responses in the farmer's field.

Indicate the interval of manure application, “once a year”, “once in two years” or “once in three years”, followed by the farmers in question 3a.

Indicate the amount of manure/compost usually applied by the farmer, “less than 5 t/ha” or “5 t/ ha or more” in question 3b.

5.5.4. SOIL ANALYSIS INFORMATION

Nutrient Expert® has been developed to provide SSNM based fertilizer recommendations to millions of small and marginal farmers of South Asia who do not have access to soil testing facilities. However, if a farmer has access to soil testing, then the available soil analysis data could augment the estimation of nutrient response in a particular farmer field.

Press “Yes”, if the soil in the farmer's field was analyzed for available P and K in the past 3-5 years. Provide the fertility levels of soil P and K, “low”, “medium” or “high”, in question “4a” and “4b”.

Press “No”, if the soil in the particular farmer's field was not analyzed within the last 3-5 years.

Press the “Estimate” button once all the inputs are given in the window to allow Nutrient Expert® to determine the expected N, P and K responses for the particular farmer's field as illustrated.

Press “OK” to go back to the “SSNM Rates” page

5.6. DETERMINING FINAL SSNM RATES

Pressing “OK” in the above window will take the user back to the main “SSNM rates” module where the estimated nutrient responses will appear in the appropriate boxes in question 5. Simultaneously, the SSNM rates for the predetermined attainable yield (Question 1 of “SSNM Rates” module) and the estimated nutrient responses will be highlighted in the ready reckoner tables as well as appear as final N, P2 O5 and K2 O rates per hectare basis under question 7.

5.7. ACCOUNT FOR NUTRIENT CREDITS

Nutrient credits are determined through a nutrient balance approach considering P and K sources such as crop residue, organic fertilizer, and carryover (residual benefit) from previous crop. The N content

of organic inputs is considered minimal compared to the total N requirements of cotton; hence no N credit for organic sources.

Nutrient Expert uses the combined nutrient balance of the crop grown before cotton (previous crop) and the current cotton crop to determine the possibility of accounting for nutrient credits. Nutrient credits refer to the allowable reductions in the recommended P and K rates. If the nutrient balance is positive (i.e. nutrient added is greater than nutrient removed), NE provides an option for reducing the recommended rates through the nutrient credits. If the nutrient balance is zero or negative, nutrient credits will be zero and the recommended rates can no longer be reduced.

Press “Yes” if the user wants to check for excess nutrients in the system that can be used to reduce the recommended rates for the current cotton crop.

Press “No” if the user does not want to consider possible reductions in the recommended rates.

The report of the output of the “SSNM Rates” module could be saved as a pdf file or may be printed by pressing the “Report” button at the left bottom corner of the screen.

Press the “Next” button to go to the “Sources and Splitting” module

FIGURE 17.

Estimate yield responses to fertilizer N, P, and K

Name and/or Location: Ketan Wankhede, Hatala, Katol, A; Maharashtra Attainable Yield: 2.75 t/ha (13.5 % MC)

Growing environment: Irrigated

In the absence of omission plot results, we use general soil characteristics and nutrient balance to estimate yield responses. Please note that the estimated responses are subject to verification and fine tuning (e.g. through farmer participatory evaluation).

1. Soil texture: ☐ sandy ☒ loamy ☐ clayey

2. Soil color and organic matter content:

☒ reddish or yellowish (low organic matter)

☐ grayish or brownish (moderate organic matter)

☐ very dark soil with high organic matter

3. Has the soil in this field been analyzed for OM, P and K in the past 3 to 5 years? ☒ Yes ☐ No

3a. Choose the level of soil OM ☐ low ☒ medium ☐ high

3b. Choose the level of soil P ☐ low ☒ medium ☐ high

3c. Choose the level of soil K ☐ low ☒ medium ☐ high

The estimated yield responses are

N response: 1.0 t/ha P response: 0.2 t/ha K response: 0.4 t/ha

6. WORKING WITH THE SOURCES AND SPLITTING MODULE

This module converts N, P₂O₅ and K₂O rates, calculated in the “SSNM Rates” module, into fertilizer sources, and rates of actual product, that are available with the farmer. This is important as most small and marginal farmers do not have the capacity to transform nutrient rates in to desired amounts of fertilizer sources. Further, this module helps in deciding the right time of application of fertilizers as well as splitting of N and K fertilizers to match nutrient application with crop requirement.

INFORMATION REQUIRED

- Locally available inorganic fertilizers (single and compound) – identified by the user in the “Settings”

EXPECTED OUTPUT

- Options for translating the recommended N, P₂O₅, and K₂O rates into locally available single element or compound fertilizer sources
- A fertilizer guideline with the right source, right rate, and right time of fertilizer application tailored for a field or growing environment

The final calculated N, P₂O₅ and K₂O rates in the “SSNM Rates” module is the input for question 1 of “Sources and Splitting” module and is automatically transferred from the previous module.

Question 2 allows the user to modify information about the growing environment that was provided earlier.

For “Irrigated” and “Favorable Rainfed” situations, select the appropriate box in question 2.

Select a preferred splitting such as “Two times (50:50)”, “Three times (33:33:33)” or “Three times (50:25:25)” in Question 3

6.1. FERTILIZER APPLICATION AT CRITICAL GROWTH STAGES

The required fertilizer N is distributed in several applications during the crop growing season. This is particularly so in the tropics to meet the crop’s need for supplemental N. Fertilizer P and K are applied in sufficient amounts early in the season to overcome deficiencies and maintain soil fertility. Fertilizer K is often applied in two split applications early and near mid-season.

Three splits

1. BD0 (0-15 DAS), pre-emergence to emergence. Fertilizer application is important at this stage to support early germination and true leaves development of the plant. Fertilizer P, in particular, is required for root growth.
2. T1 (around 35-40 DAS), the plant has six fully-developed leaves. Fertilizer application is important at this stage to sustain the rapid seedling growth and square formation that will occur during the seedling and vegetative growth stages.
3. T2 (around 55-60 DAS), the plant has fully-developed leaves. Fertilizer application is important at this stage to sustain the crop’s rapid, steady increase in growth as well as the development of square and flower initiation stage at vegetative mid stage.

Four splits

1. BD0 (0-15 DAS), pre-emergence to emergence
 2. T1 (around 30 DAS), the plant has fully-developed leaves. Fertilizer N is applied at this growth stage (instead of square) when the expected N response is low to moderate, because of low attainable yield and/or high indigenous N supply.
 3. T2 (around 55-60 DAS), the plant has fully-developed leaves. Fertilizer application is important at this stage to sustain the crop’s rapid, steady increase in growth as well as the development of square and flower initiation stage at vegetative mid stage.
 4. T3 (around 85-90 DAS), the plant has small bolls. Fertilizer application is important at this stage to sustain the crop’s yield.
- ❖ An additional late watersoluble fertilizers (macro and micro nutrients) foliar application before flowering and after flowering is recommended when high yields are expected or when deficiency is observed as determined using a soil and leaf nutrient status.

6.2. GUIDELINES FOR DETERMINING THE NUMBER OF FERTILIZER SPLITS DURING THE SEASON

6.2.1 SPLITTING RATIO FOR N

- If the total fertilizer N requirement (FN) is 120 kg N/ha or less, the default is two splits. • If FN is more than 120 kg N/ha but less than 160 kg N/ha, the user can choose either two or three splits.
- If FN is 160 kg N/ha or higher, the default is three splits.

Notes on N splitting ratio

- Actual splitting ratio may vary slightly from the planned ratio depending on the fertilizer material (single source or compound) applied at the 1st split. The planned splitting ratio/distribution can be implemented easily when using single element sources; while it can be more challenging for compound fertilizers.
- When using compound fertilizer for the 1st application, the P requirement (FP) is used as the driver (i.e., FP determines the amount of the compound fertilizer to be applied), which means that the amount of N at the 1st application can be more or less than the planned proportion.
- The rates of the 2nd and 3rd splits (applied as urea) depend on the actual amount of N applied at the 1st split.

6.2.2 K SPLITTING

- If K requirement (FK) is more than 60 kg K₂O/ha, apply at least 50% at the 1st application and apply the remainder of FK at the 2nd (for 2 N splits) or 3rd application (for 3 N splits).
- If FK is 60 kg K₂O/ha or less, apply 100% of FK at the 1st application.

6.2.3 TIMING AND SPLITTING RATIO OF FERTILIZER N, P, AND K WHEN SOIL MOISTURE IS SUFFICIENT (PLAN A)

Three splits (Plan A):

Application No.	Growth stage	Days after Planting	%of FN	% of FP	% of FK
1	BD0	0	30	100	50-100
2	TD1	35	35	-	-
3	TD2	60	35	-	0-50

Four splits (Plan A):

Application No.	Growth stage	Days after Planting	%of FN	% of FP	% of FK
1	BD0	0	10	50	50-100
2	TD1	30	30	50	0-50
3	TD2	60	30	-	-
4	TD3	90	30	-	-

6.2.4 ALTERNATIVE PLAN FOR ‘LESS FAVORABLE RAINFED’ ENVIRONMENTS

If the growing environment is “Less favorable rainfed,” where there could be a shortage of soil moisture at pre-determined application time, the software will provide two plans—Plan A (when moisture is sufficient, Figure 18) and Plan B (when adjustments are needed because of rainfall delay). For “Irrigated” and “Favorable Rainfed” environments, only Plan A is presented.

Example of a “Plan A” report for less favorable rainfed environment. It is assumed that soil moisture will be sufficient at critical growth stages for fertilizer application.

Example of a “Plan B” report for ‘less favorable rainfed’ environment. The supposed application of urea at V6 is omitted due to insufficient soil moisture and the rate of the succeeding urea application (when soil moisture condition becomes favorable) is adjusted

FIGURE 18.

6.2.5. GUIDELINES FOR FERTILIZER SPLITTING FOR AN ALTERNATIVE PLAN (PLAN B)

If soil moisture is insufficient (due to delayed rainfall) during the planned 2nd fertilizer application, apply a reduced rate (70%) of the remaining N requirement as soon as soil moisture condition becomes favorable. In case of a 2nd application of K, apply a reduced rate (50%) of the remaining K requirement.

Three splits (Plan B):

Application No.	Growth stage	Days after Planting	%of FN	% of FP	% of FK
1	BD0	0	20	100	50-100
2	TD1	25	40	-	-
3	TD2	65	40	-	0-25

Four splits (Plan B):

Application No.	Growth stage	Days after Planting	%of FN	% of FP	% of FK
1	BD0 (After Germination)	15-20	10	50-100	50-100
2	TD1(After Square)	40-45	30	50-100	0-50
3	TD2(After Flowering)	65-70	30	-	-
4	TD3 (Post flowering)	95-100	30	-	-

In question 4, the user needs to select the fertilizer sources to be applied as basal application. If the user intends to use straight grade fertilizer sources, then press “Single sources” option and select the preferred fertilizer sources from a new window.

If the user plans to use any of the complex fertilizers, press “Compound fertilizers” and choose the preferred P-containing fertilizer source from the newly opened window (Figure 19). In such a case, the system will automatically select default fertilizer sources for N and K.

FIGURE 19.

3. Select P fertilizer source.

Single-element

Compound

N Source

Urea

P Source

Single Super Phosphate

K Source

Muriate of Potash

P Source

10-26-26

After selection of single source or compound fertilizers, a new window will open to show the fertilizer application schedule for the given field and the yield target.

In the event, the user wants to consider options to address the risk associated with water availability (lack of rainfall during designated fertilizer application time), then the user may choose the “less favorable rainfed” option to get further advice on readjusting the time and rate of split application of fertilizer. Once the “less favorable rainfed” is selected, an option for water shortage condition will be available (“Plan B” button at the bottom part of the page). Under “less favorable rainfed” option, the farmer would choose “Plan A” if there is no water constraint during the growing season.

However, the farmer would choose “Plan B” if there is a problem with a moisture deficit (lack of rainfall) which develops during the growing season (Figure 20). This option provides the grower with multiple recommendations, which can allow for changes in application rates during the growing season based on precipitation. The multiple recommendations are critical to enabling the farmer to manage the risk that comes with water stress and its negative impact on grain yield. The same approach, multiple runs of the software with differing target yield goals, could also be used to help farmers select a nutrient management plan which best fits their economic situation. An example may be that while yields in the

region could be increased from 3.0 to 4.0 t/ha, the farmer may feel the investment in nutrients for the 4.0 t/ha yield is too expensive for him. Running the model to show nutrient management options for 3.0, 3.2, 3.4 and 4.0 t/ha would give the farmer a number of options to consider and select from.

FIGURE 20.

Nutrient Expert® for Cotton India (Web App Beta Version, July 2018) Home Settings Help

Current FFP and Yield SSNM Rates Sources and Splitting Profit Analysis

Name and/or Location Ketan Wankhede, Hatala, Katol, A; Maharashtra

Field size 2.5 acre **Growing season** Kharif

1. Recommended fertilizer N, P, and K rates:

N 151 **P₂O₅** 19 **K₂O** 48 kg/ha

2. What is your growing environment?

☒ Irrigated ☐ Favorable rainfed ☐ Less favorable rainfed

3. Select an option for fertilizer N splitting.

☐ 3 times ☒ 4 times ☐ 5 times

4. Select P fertilizer source.

N Source: Urea

P Source: Single Super Phosphate

K Source: Muriate of Potash

1st application at 0 DAS

Source	Amount kg	N kg	P ₂ O ₅ kg	K ₂ O kg
Urea	82	37.72	0	0
Single Super Phosphate	122	0	19.52	0
Muriate of Potash	24	0	0	14.4

2nd application at 20-30 DAS

Source	Amount kg	N kg	P ₂ O ₅ kg	K ₂ O kg
Urea	82	37.72	0	0

3rd application at 50-60 DAS

Source	Amount kg	N kg	P ₂ O ₅ kg	K ₂ O kg
Urea	82.12	37.78	0	0
Muriate of Potash	28.13	0	0	16.88

4th application at 75-90 DAS

Source	Amount kg	N kg	P ₂ O ₅ kg	K ₂ O kg
Urea	82.12	37.78	0	0
Muriate of Potash	28.13	0	0	16.88

Fertilizer rates are adjusted to field size

Note: The change from “Plan A” to “Plan B” will reduce the N application rate as the moisture deficit at critical growth stages increases, preventing the achievement of the desired yield goal.

Note: The above examples (Figure 19) are based on selecting a N splitting strategy of “Three times (33:33:33)”. For other options of “Four times (10:30:30:30)” or “Three times (20:40:40)”, the user can also choose “Plan A” or “Plan B” under less favorable rainfed situations.

Press the “Report” tab at the left bottom corner of the screen to open the final report (Figure 21) that could be printed out for sharing with the farmer. The report could also be saved as a pdf file in the computer for future use.

Four sections of the final report (Figure 22) have been highlighted by red boxes and represents the following information:

- **Red Box:** describes the farmer with his name, address, growing season, field size, current yield, growing environment, and the targeted yield for which the recommendation is developed. **Blue Box** – identifies the main physiological stages of cotton, time of application of fertilizers matching the physiological stages, sources of fertilizers to be used and their amount to be applied in terms of 50 kg bags. It also shows the amount of nutrients coming from the organic sources used by the farmer in the current crop.

Nutrient Expert® for Hybrid Cotton

- Green Box: indicates the rate of deficient secondary or micronutrients to be applied, in this case zinc, that were flagged as deficient in the “SSNM Rates” module. The secondary and micronutrient recommendations are based on current state recommended rates.

Press the “Next” button to go to the “Profit Analysis” module.

FIGURE 21.

Nutrient Expert® for Cotton - Recommendation Sheet

Name and/or Location Ketan Wankhede, Hatala, Katol; A; Maharashtra **Field size** 1 ha 2.47 acre

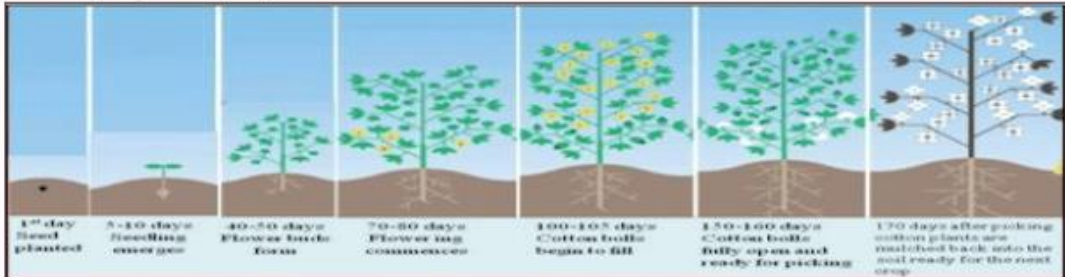
Growing season Kharif **Planting time** 16-30 June **Maturity Period (DAS)** 150-175

Planting architecture Medium

Current yield 2.3 ton 2.3 t/ha **Growing condition** Irrigated

Recommended alternative practice for cotton

Yield goal 3.25 ton 3.25 t/ha



Growth stage	DAS	Fertilizer sources	Amount (kg)	N	P ₂ O ₅ (kg)	K ₂ O
Basal	0	10-26-26 Urea	90 63	9 28.98	23.4 0	23.4 0
Early Growth	20-30	Urea Muriate of Potash	164 37	75.44 0	0 0	0 22.2
Sympodial	50-60	Urea Muriate of Potash	82.12 30.57	37.78 0	0 0	0 18.34

Fertilizer rates are adjusted to field size

Other sources of nutrients

Crop residue (soybean): low

Organic Fertilizers: 4.8 ton(s)

N: 36 kg P₂O₅: 9.6 kg K₂O: 24 kg

7. WORKING WITH THE “PROFIT ANALYSIS” MODULE

Any nutrient management programme is considered viable only when the economic returns from such strategy is superior over the existing practices. The “Profit Analysis” module allows users to estimate the economic advantage of Nutrient Expert® based recommendations over the existing generalized management.

INFORMATION REQUIRED

- Farm-gate price of seed cotton or lint
- Cost of seeds.
- Costs of fertilizers (estimated from quoted fertilizer prices as defined by the user in “Settings”)

EXPECTED OUTPUT

- Comparison of expected costs and benefits between the farmer’s current practice and the recommended practice.

In the first section of the “Profit Analysis” module, the user is asked to provide the seed rate, cost of seed and the farm-gate price of cotton for both the nutrient management options. Nutrient Expert® combines this information with the information provided in the other modules to arrive at an estimate of gross return over fertilizer cost in the SSNM based recommendation and the farmer’s practice (Figure 22). The ex ante analysis finally highlights a profit estimate of the improved nutrient management practice and builds confidence to the farmer in adopting the new strategy of nutrient management.

Press “Full Report” on the top right side corner to generate a complete report consisting information of all the modules. The “Full Report” may be saved as a pdf file or may be printed for distribution.

FIGURE 22.

Simple profit analysis

	Farmer's current practice	Recommended practice
Yield (t/ha)	2.3	3.25
Price of seed cotton (INR/kg)	77	77
TOTAL REVENUE (INR/ha)	177,099	250,250
Seed cost (INR/ha)	6,300	6,300
Fertilizer cost - Inorganic Fertilizers (INR/ha)	9,474	6,165
Fertilizer cost - Organic Fertilizers (INR/ha)	12,000	12,000
Fertilizer cost - Specialty Fertilizers (INR/ha)	0	0
TOTAL COSTS (INR/ha)	27,774	24,465
Expected benefit above fertilizer costs (INR/ha)	149,325	225,784
CHANGE IN BENEFIT (INR/ha)		76,458

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APPENDIX

Questionnaire

1. Please give the contact address of the end user for whom the recommendation is generated using Nutrient Expert-Cotton

Name: **Prajit Kamble**

Location/Address: **At. Akhatwada Tq.-Tiwasa, Dist.-Amravati**

Contact number: **7745010915**

E-mail (if available):

2. What is the planting time of cotton in your region (May 15-31, June 1-15, June 16-30, July 1-15, July 16-31, > August 1) – **June 16-30**

3. What is the name and duration of cotton hybrid - **Ajeet 155- 180 Days**

4. What is the architecture/canopy of your Bt cotton hybrid (Short/Medium/Tall)- **Medium**

5. How do you harvest cotton in your field (Manually or Mechanically) – Date of Sowing – **24/06/2018**

A. Required Information-Questions asked (Listed by module)

A.1. Current NM Practice

This refers to the nutrient management practice followed by the farmer for growing cotton in his region/farm.

1. What is the yield of seed cotton in the past 3 to 5 years? Provide total amount of harvested seed cotton yield from your field.

Field size: 1.5 acre /ha

Fresh weight: **15 qt./1.5/acre** (seed cotton yield); Moisture content (if known): **20 (%)**

2. How much fertilizer (inorganic/organic) do you apply to your cotton field? Specify number of fertilizer applications (once/twice/thrice/four/five times during the growing season), timing or schedule of each application (i.e. days after sowing), fertilizer source and amount applied.

Inorganic fertilizers

Application no.	Days after sowing	Fertilizer (s) source	Amount applied (kg/ha)
First/Basal	0 DAS	Urea	
		DAP/SSP	
		MOP	
		Others	(Specify names of fertilizers)
First top dress	????	Urea	2 Bag
Second top dress	????	DAP/SSP	3 Bag
Third top dress	????	MOP	
Fourth top dress	????	Others-10:26:26	3 Bag

Please specify the details of any secondary and micronutrients applied by the farmer to his cotton crop

Organic fertilizers:

Applied either cart load or using tractor trolley. Please specify the weight of cartload/tractor trolley in kg)

Manure/Organic Fertilizer (s)	Amount applied (kg or q or ton applied per ac/ha)
FYM/Vermicompost/Poultry manure etc.)	
FYM	3 Trolley/1.5 Ac

Specialty Fertilizers:

Name of specialty fertilizer source	Rate of application (kg/ha)	Time of application (DAS)	Method of application (Foliar spray/soil application/Drip fertigation etc.)	Price of specialty fertilizer (Rs./kg)

A.2. SSNM Rates

Calculation of the attainable yield (t/ha) target of cotton for your location

1. Please mention the value of attainable yield (t/ha) target if known.
2. If the attainable yield for the location is not known, answer the questions in the box below.
(tick ☒ or highlight the appropriate options)

Describe the growing environment:

1. Source of water availability
 - (a) Irrigated (b) Fully rainfed (c) ☒ Rainfed with supplemental irrigation
 - 1a. Do you have an estimate of K input in irrigation water ____ (kg K₂O/ha/crop)?
2. Drought problems
 - (a) ☒ often (b) seldom (c) never [often = 2 or 3 out of 5 times; seldom = 1 of 5 times]
3. Soil-related problems or constraints (note: answer can be more than one)
 - a. acidity Soil pH: 5.0-5.3 (If pH is below 5.3, liming is recommended)
 - b. deficiency of secondary and micronutrients (highlight the deficiency if any from the given list: boron, copper, iron, magnesium, manganese, sulfur, zinc)
 - c. problem soils (select from a list: acid sulfate soils, degraded soils, saline soils)
none

3. What do you do with cotton residues after harvest (this question refers to the current cotton crop to be planted)? (tick ☒ or highlight the appropriate options)

- ☒ remove all the above ground residues from the field
- ☐ retain all the above ground residues in the field and incorporate
- ☐ retain all the above ground residues in the field and burn
- ☐ if none of the above, please specify the residue retention (%) _____

4. Will you apply organic fertilizers (e.g. manure) to current cotton crop to be planted?
☒ Yes ☐ No If Yes, name the organic manure source (e.g. FYM/chicken manure etc.) and amount to apply for a given field size.

Manure/organic Fertilizer (s)	Amount applied (kg or q or ton applied per ha)
FYM	2 Trolley

5. Have you grown any crop previous to planting the current cotton crop?
☐ Yes ☐ No
 If yes, then
 - a. What crop did you grow in the previous season? (tick ☒ or highlight the appropriate options)
☐ maize ☐ rice ☐ wheat ☐ chickpea ☐ tomato ☐ others
 (Please specify the name of other crop)
 - b. What is the source of water availability for previous crop (tick ☒ or highlight the appropriate options)
 (a) Irrigated (b) Fully rainfed (c) **Rainfed with supplemental irrigation**
 - c. What was the yield of your previous crop? ____ (t/ha), please specify the moisture content (%) _____ if known.

6. Please answer the following questions in the box to determine cotton yield response to application of N, P and K nutrients. (tick ☒ or highlight the appropriate options)

- 1) Soil type/texture: (a) clayey (b) ☒ loamy (c) sandy
2. Soil color and organic matter content:
- (a) reddish or yellowish color (indicates low organic matter content)
- (b) grayish or brownish (indicated moderate organic matter content)
- (c) ☒ Black or very dark soil (indicate high organic matter and high fertility)
3. Has your soil been analyzed for Organic C, available P and available K in the past 3-5 years? (a) Yes (b) ☒ No
- If Yes:
- 3a. Choose the level of soil organic C: (a) low (b) medium (c) high
- 3b. Choose the level of soil P: (a) low (b) medium (c) high
- 3b. Choose the level of soil K: (a) low (b) medium (c) high

A.3. Sources and Splitting

(This section will use a list of available fertilizer sources in the area/ location, identified by the user through the settings section of the software.)

Select an option for fertilizer N splitting:

- ☐ two times (50:50) ☐ three times (33:33:33) ☐ Four times (10:30:30:30)

Select an option for fertilizer P and K splitting:

- ☐ two times (50:50) ☐ one Time (100)

Select an option for fertilizer source

- ☐ Single-element fertilizer ☐ Compound fertilizers

A.4.Profit Analysis

7. What is the seed rate (kg/ha) and price of cotton seed (Rs. /kg) used for planting?
2 pkts. /acre
8. What is the selling price of seed cotton after harvest in your region: ___ (Rs./kg) – 4500rs./qt

