Decision Support Model for Prioritization of Cotton Plant Diseases using Integrated FAHP-TOPSIS approach

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Abstract
Cotton, the essential cash crop of India plays a predominant part in the agricultural and industrial enlargement of the world. The evolution of cotton plant begins with the germination of seed and its growth depends on the accessibility of temperature, soil moisture and oxygen. The desirable characteristics combined in cotton make no other fiber to duplicates its value. There are beyond 75 critical diseases leads to the substantial destruction and economic losses in cotton crop. Premature analysis of the cotton plant diminishes the disease, results in the significant enhancement in the superiority of the product. Massive yield of cotton crop is vanished each year due to fast incursion by insects and pests. Verticilium wilt, grey mildew, leaf spot and leaf blight are some of major cotton disease in cotton plant which extremely affects the productivity. This research discusses the multi criteria decision making evaluation tool to identify the major disease causing factors of cotton crop. Fuzzy AHP, a Multi Criteria Decision making method (MCDM) is applied to impact the disease causing risk factors by determining the weights of the criteria. Moreover, a Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), a ranking MCDM methodology has been applied to rank the alternatives. The outcomes and methods described in this research based on the derived criteria and sub criteria of risk factors will be a noble orientation in producing more perfect, active and efficient decision support tool for the farmers to identify and diagnose the risk factors during the cultivation of the cotton crop.

Keywords: Cotton Crop, Fuzzy AHP, Cotton Diseases, Risk factors, Fuzzy TOPSIS.

1. Introduction

Cotton, a unique fiber crop plant of thousand faces is renowned for its versatility, performance, appearance, natural comfort and above all its numerous usages including astronaut's in-flight space suits, towels, tarpaulins, tents, sheets and all types of apparels. Cotton is still a nature's fiber in this fast-moving world. Its distinctive evolution pattern makes it challenging to grow. Its antiquity traced to 4^{th} millennium (BC) in the Indian continent. Agriculture sector plays a dynamic role in India's economy, food safety and prospects of employment. India plays eternally vital role among world cotton market. India gained a superiority of place in the universal cotton statistics with the leading cropped area of 8.9 million in 1996-97, manufacturing the broadest variety of cotton fiber quality appropriate for spinning 6's to 120's counts yarn. The Gross Domestic product (GDP) has been diminishing progressively due to the role of agriculture for the earlier thirty years. In 1970, the agricultural sector signified almost half of the GDP of Indian, in 2006, the number descended to 20 percent. By the decade of 20^{th} century, its productivity has been supportive to the major agro-based national industry of the country. As a leading enterprise in India, Agriculture contributes nearly 60 % of the population; more than 19% to India's GDP and supports 11% to the total trades. The cotton crop contribution among this is about 14% to the trade fabrication, nearly 4% to GDP and more than 14.42% to the export earnings of the country. By July 2019, the monthly highest average was 80.75 cents per pound for the marketing year. According to USDA national agriculture statistical service, the price for the month of December 2018 was 61.50 and by January 2019 it was 65.40 per cents.

A frequently overlooked constituent of cotton crop is mass quantity of cottonseed produced along with the fiber. In 2019, the price of organic cottonseed reached from 400 to 525 dollars per ton which compares to 155 to 225 dollars per ton in conventional cotton. Annual production of cotton seed is around 6.5 billion tons and two-third is nourished entirely to livestock. The discarded seed is processed, manufactured oil for cooking of fine-quality and a protein meal for cattle and cottonseed skeletons, fibre for poultry feedstuff and dairy. A single umpteen of seed produces around 540 pounds of hull, 910 pounds of meal and 320 pounds of oil [35].Furthermore the foremost source of occupation, agricultural division supports to meet food and nutritious necessities of population and affords raw material to agro-based manufacturing in clothing, textile and commodities of agriculture for exports in particular. This article presents diagnosis and prioritization of cotton plant diseases by the remarkable progresses in qualitative and quantitative results of both FAHP and fuzzy TOPSIS.

Disease-ridden cotton plants can reveal a change of symptoms and creating diagnosis was really difficult. Collective symptoms include stunted growth, unusual leaf growth, rots, colour falsification and scratched pods. This research study comprises of six sections. Section one provides the motivation of the research. Second section discusses the literature study and the third section describes the methodology of the paper and the fourth section deals with the implementation of the framework, section five discusses the theoretical framework and section six presents the conceptual framework of the research and section seven discusses the conclusion.

2. Research Motive

India, the only country in cultivating all the species of cotton covering 85 – 89 lakh hectares and since 1995 the cotton area stayed static on commercial state. Indian economy is agronomics based and its growing demand for cotton as a result of interruption of estimation of government, the necessity of cotton has been estimated at 35.0 million bales by 2010. India ranks first in universal scenario (almost 20 % of the cotton area in world) and with respect to the production, ranked second next to china. The crop planning decisions are intricate due to the several restrictions, the need to protect crop, broadening and the involvement of several affected factors. Burden is increasing on farmers. National crimes Records Bureau released the latest figures saying that in 2015, the suicide committed by farmers is 88 per cent occurred in the states that cultivate cotton passionately.

The cultivation of cotton crop desires to be shifted from contribution based to knowledge based evolution. During this hypothesis change the propagation of knowledge becomes vital. The quantitative and qualitative conversion needs to occur to improve the low productivity of cotton crop due to several disease causing factors. Suitable efforts and right policies to be enhanced to improve the production technology of Indian cotton to persist in an esteemed position in the international level. This research examines the disease causing factors of cotton plant which affects the growth and productivity of a cotton plant. The goal of this research is to classify the cotton plant diseases based on the disease causing risk factors to help the farmers to produce a good yield. The objective of the research is to recommend a novel methodology to identify the diseases based on the criteria climatic factors, physiological factors, management factors and nature of variety and various sub criteria with four alternatives are evaluated in ranking the type of disease in the cotton crop cultivation.

3. Literature Review

In this section, we deliver a brief review of some of the literature based on FAHP and Fuzzy TOPSIS which are utilized for various problem solving techniques. The world needs an organized and inclusive methodology to provide effective decision support to the problems rise to it [16].Many multi-criteria decision making methods such as ANP, AHP, GRA, ELECTRE, PROMETHEE are exists in the Literature [34]. The MCDM method Analytic Hierarchy Process (AHP) was introduced first by Satty in 1977 [5, 40]. The Fuzzy Analytic Hierarchy Process (FAHP) has attained fascination of the researchers due to the accurate mathematical properties and the essential information are easy to acquire relatively. The determination of comparative value is obtained by the expert opinion or judgment to synthesize a solution. The uncertainty belonging to the natural language in demonstrating the crisp number for human decisions is considered by AHP [42, 46].

FAHP was developed to provide solution to the classified fuzzy complications where the pairwise evaluations of the decision matrix are triangular fuzzy numbers (TFN). TFN is instinctive, useful in processing the information and useful in supporting the representation in uncertain environment. It was conveniently realistic to solve the problems of Fuzzy MCDM in which the criteria principles are represented by the TFNs. Therefore, the decision making preferences can be stated in natural language expression providing the significance of the criteria [51, 53]. The TFNs is used in the fuzzy augmentation method on the conception of ideal and anti-ideal points to handle FMCDM problems [13]. The qualified weights of the criteria measures troubling the agronomic performance were calculated by using the fuzzy AHP method and the measures are analysed by the VIKOR method [14, 17].

The Fuzzy AHP method is used to handle the various measures included for the selection of the agricultural approach for turkey [33].Two fuzzy methodologies, AHP and ideal point has been compared for land suitability evaluations and fuzzy AHP was considered as better than ideal point [2, 30]. As the application areas are growing enormous, the FAHP become an impressive research area for many researchers [18]. This approach has been applied successfully in different applications like job selection, producer selection, personnel selection, measuring instrument selection, project selection, supplier selection [1, 3, 4, 11, 15, 23, 24, 28, 29, 32, 39, 41, 45, 52] and other applications[19, 25]. The Fuzzy AHP is a best decision making and dominant tool in providing both quantitative and qualitative decisions [8, 9].

Fuzzy set theory was developed to deal the fuzziness, qualitative, unstructured problems and uncertainty of the expert's judgement which is the outstanding component of vagueness governed by the human decisions [7, 43, 44, 51]. A novel methodology for handling AHP for synthetic extent values is the use of extent analysis method and pairwise comparison scale of fuzzy AHP for triangular membership functions [10, 37, 38]. Fuzzy numbers are used as elements of comparison matrices proposed by Chang and the core problem in using the fuzzy numbers was calculating the weights as eigenvectors of the matrices [6, 35, 36]. To measure the relative weights in pairwise comparisons logarithmic scale was used by Wang and Chin [49, 50]. The fuzzy AHP is linked with fuzzy TOPSIS and other methodologies of MCDM by various researchers in decision making problems [12, 25, 26, 27, 48].

The foremost goal of this research is to categorize and prioritize the disease causing risk factors of cotton crop by means of fuzzy – AHP and fuzzy TOPSIS to rank the alternatives. Several researches investigates the work related to this research in the literature Survey and numerous dimensions of effort on fuzzy AHP and TOPSIS has been measured for the judgement and none of the work was related to the classification and prioritization of cotton plant diseases. In this research, a decision support model to categorize and prioritize the cotton plant diseases was carried out with integrating FAHP and TOPSIS. Fuzzy AHP is proposed for classifying the disease causing factors of cotton plant. To attain the objective, the criteria and alternatives are weighed to define the risk factors in the cotton plant.

4. Research Methodology

This study will use both analytical tools and domain knowledge from the expert in conducting the research. Several environmental parameters are analysed to identify the strength and weakness of the cotton crop cultivation. The Analysis of the risk factors of diseases helps the farmers in accessing the challenges and opportunities in the cultivation of cotton crop. This research comprises of two methodologies which concluded that Fuzzy AHP, a multi criteria technique is considered as a hopeful framework for aggregate preference to attain a group decision [20, 21, 22]. Fuzzy AHP method is a quantifiable system that does not allow the decision makers to handle the complications directly when they may be indefinite about their level of priority due to lack of knowledge or information and ambiguous in decision making scale. The decision making in this scenario will be done by using the linguistics values like “Very Strong importance”, “Equal importance”, “Strong importance”, “Extreme importance” or “Moderate importance”, rather than by definite values to conclude the relative significance. In order to select adequate cropping pattern in common irrigation area, FAHP affords multiple objectives, understanding the choice of the problem efficiently, growth transparency and creditability in decision making.

In multi criteria problems, the parameters will be in the form of irrational dimensions which leads to raise problems in the assessment. To overcome this scenario, fuzzy TOPSIS is used for analysing the criteria which makes the assessment modest and simple. Fuzzy TOPSIS methodology is able to deal with MCDM by transforming the Linguistic ideals into fuzzy quantities leads to permit the decision makers to handle unattainable and partial information in to a decision model. It is a convincing technique of handling the alternatives by including or excluding based on the rigid endpoints. This paper recommends fuzzy AHP and fuzzy TOPSIS based framework for classifying and identifying the risk factors for cotton diseases. The FAHP technique is used to determine the weight the criteria by identifying the disease causing factors from the experts and TOPSIS is used to rank the alternative diseases. This research conveys a new insight of MCDM process to classify and identify the disease causing risk factors of the cotton diseases.

5. Theoretical framework

5.1. Fuzzy logic

Fuzzy Logic is a methodology to handle numerous values to be sort out through the same variable. It solves difficulties with an indefinite range of information by making it probable to attain a group of accurate results. It is intended to find solutions by make an allowance of all available data and gives the finest decision based on the input. This methodology comes from the mathematical learning of fuzzy concepts which comprises fuzzy sets of information.

5.2. Algorithm for fuzzy AHP

Chang’s extent analysis system is used for the ranking of numerous disease causing characteristics for the classification of diseases in cotton plant.

Let $x = \{x_1, x_2, x_3, x_4, \dots \dots, x_5\}$ an object set and $G = \{g_1, g_2, g_3, \dots \dots, g_n\}$ be a goal set. Each criterion is occupied and extent analysis for each goal g_i is accomplished. Consequently, m extent analysis standards for each criterion can be achieved using the succeeding notation (6) , $M^1_{gi,} M^2_{gi,} M^3_{gi,} M^4_{gi,} \dots \dots \dots \dots, M^m_{gi,}$, where g_i, is the goal set $i = (1,2,3,4,5, \dots, n)$ and $M^j_{gi} (j = 1,2,3,4,5, \dots, m)$, All are TFNs. The Chang’s extent analysis phases are illustrated as follows:

The fuzzy synthetic extent value (Si) in respect of the i[th] condition is defined as

$$Si = \sum_{j=1}^{m} \mathrm{M}_{\mathrm{gi}}^{\mathrm{j}} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \qquad (1)$$

The fuzzy addition process of m extent analysis values for a certain matrix is performed as

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \qquad (2)$$

Where *l* is the lower limit value, *m* is the most promising value and *u* is the upper limit value and to obtain

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \qquad (3)$$

As $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two TFNs, the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as

$$\sup_{y \geq x}\left[min\left(\mu_{M1}(x), \mu_{M2}(y)\right)\right] \qquad (4)$$

x and y are the ideals on the axis of association function of each criterion. The above equation can be equally written as below:

$$V(M_2 \geq M_1) = \begin{cases} 1, & if \;\; m_2 \geq m_1, \\ 0 & if \;\; l_1 \geq u_2, \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \qquad (5)$$

For comparing M_1 and M_2, both the values of $V(M_1 \geq M_2)$and $V(M_2 \geq M_1)$ are required

The grade opportunity for a curved fuzzy number to be larger than k curved fuzzy numbers $\mathrm{M_i}$($\mathrm{i} = 1, 2, 3, 4, 5, \ldots., \mathrm{k}$) can be defined by $V(M \geq M_1, M_2, M_3, M_4, M_5, \ldots\ldots, M_k) = V(M \geq M_1)$ and $(M \geq M_2)$ and $(M \geq M_3)$ and $(M \geq M_4)$and……….and $(M \geq M_k) = \min V(M \geq M_i)$, $i = 1,2,3,4,5, \ldots., k$

Assume that $d'(C_i) = \min\ V(S_i \geq S_k)$ for $k = 1, 2, 3, 4, 5, \ldots\ldots, n\,; k \neq i$, then the weight vector is given by

$$W' = [d'(C_1), d'(C_2), d'(C_3), d'(C_4), \ldots\ \ldots d'(C_n)]^T \qquad (6)$$

Where $C_i = (i = 1,2,3,4,5, \ldots\ldots, n)$ are n elements.

The normalized weight vectors are given in following equation via normalization

$$W = [d(C_1), d(C_2), d(C_3), d(C_4), \ldots\ \ldots d(C_n)] \qquad (7)$$

5.3. Algorithm for TOPSIS

TOPSIS was first proposed by Hwang and Yoon and a Fuzzy TOPSIS method was offered by Chen and Hwang in future. This technique is the efficient for resolving MCDM problems. This method works on the source of the preferred alternative by finding the positive ideal solution which is close to the alternative and as far from the negative ideal solution.

Step 1: Construct normalized decision matrix by transforming the several quality dimensions into non-dimensional qualities, which allows comparisons through criteria. The normalized value r_{ij} is calculated as

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad i = 1, \ldots\ldots\ldots m; \;\; j = 1, \ldots\ldots\ldots n.$$

Step 2: Construct the weighted normalized decision matrix. For a given set of weights for each criteria W_j for $j = 1, \ldots\ldots, n,$ and $\sum_{j=1}^{n} W_j = 1$, Each column of the normalized decision matrix is multiplied by its associated weight. A component of the new matrix is:

$$v_{ij} = W_j . r_{ij} \qquad i = 1, \dots \dots m; j = 1, \dots \dots .. n.$$

Step 3: The positive ideal and negative ideal solutions are determined
Positive ideal solution

$A^* = \{v_1^*, \dots \dots .., v_n^*\},$ where

$$v_j^* = \{max(v_{ij})\ if\ j \in J; min(v_{ij})\ if\ j \in J'\}, \quad j = 1, \dots .., n.$$

Negative ideal solution

$A' = \{v_1', \dots \dots .., v_n'\},$ where

$$v_j' = \{min(v_{ij})\ if\ j \in J; max(v_{ij})\ if\ j \in J'\}, \quad j = 1, \dots .., n.$$

Step 4: The separation processes for each alternative is calculated. The separation from the positive ideal alternative is:

$$S_i^* = \left\{ \sum_{j=1}^{n} (v_{ij} - v_j^*)^2 \right\}^{1/2} \quad , i = 1, \dots \dots , m.$$

Similarly, the separation from the negative ideal alternative is:

$$S_i' = \left\{ \sum_{j=1}^{n} (v_{ij} - v_j')^2 \right\}^{1/2} \quad , i = 1, \dots \dots , m.$$

Step 5: The relative closeness to the ideal solution is calculated by

$$C_i = \frac{S_i'}{(S_i^* + S_i')} \quad , i = 1, \dots .., m. \qquad C_i \in \{0,1\}$$

Where C_i denotes the final performance score in TOPSIS method.

Step 6: Rank the preference order. Rank the alternatives using C_i index value in decreasing order. An alternative with largest index value (C_i) has shortest distance from positive ideal solution and farthest distance from negative ideal solution.

6. Conceptual Framework for making alternatives for cotton diseases

In FAHP, to determine the alternative diseases the criteria must be defined and the qualitative and quantitative sub criteria are considered from the judgements of the decision makers to categorize the disease causing factors. The Criteria for the diseases are Climatic factors, physiological factors, Management factors and Variety. The sub criteria in respect of each criteria and the alternatives are shown in Fig.1. The standards of linguistic variables are shown in Table 1.

Table 1. Standards of Linguistic Variable

Statement	**TFN**	**Reciprocal TFN**
Equal importance (E)	$(1, 1, 1,)$	$(1, 1, 1,)$
Moderate importance (M)	$(1, 3, 5)$	$(1/5, 1/3, 1)$
Strong importance(S)	$(3, 5, 7)$	$(1/7, 1/5, 1/3)$
Very Strong importance(VS)	$(5, 7, 9)$	$(1/9, 1/7, 1/5)$
Extreme importance(EI)	$(7, 9, 11)$	$(1/11, 1/9, 1/7)$

The comparison matrices and triangular fuzzy number with the support of the questionnaire are used to calculate the priority weights of each criteria, sub criteria ad alternative diseases. The diseases that form the alternatives are discussed below

Grey mildew ($\mathbf{A_1}$): It is a polycyclic fungal disease as it can infect crop repeatedly in single cropping season. One of the major diseases needs to be effective controlled during the cultivation at the earliest. Humidity and low temperature are conventional throughout the winter season are also the cause for the disease intensity. Cotton yield damages range between 26 to 66 per cent has stated under grey mildew epiphytotic conditions.

Leaf Spot (A_2): It is a cercospora fungus disease that attacks the crop which mainly occurs during the drought or nutrient deficiency. High temperature and relative humidity provides a path way for the leaf spot.

Leaf Blight (A_3): The infection is mainly through seed borne bacteria. The spread of bacteria in the field is through wind, water and other physical and biological agents, entering the host through natural openings or other wounds. The intensity of infection is based on the prevailing weather conditions.

Verticilium wilt (A_4): This disease infects the vascular cylinder of the plant which results in defoliation, stunting and yield loss. It appears in young plant and disappears when the temperature increases and reappears during the fruiting period. High temperature and heavy soil is the good environment for the occurrence of the diseases.

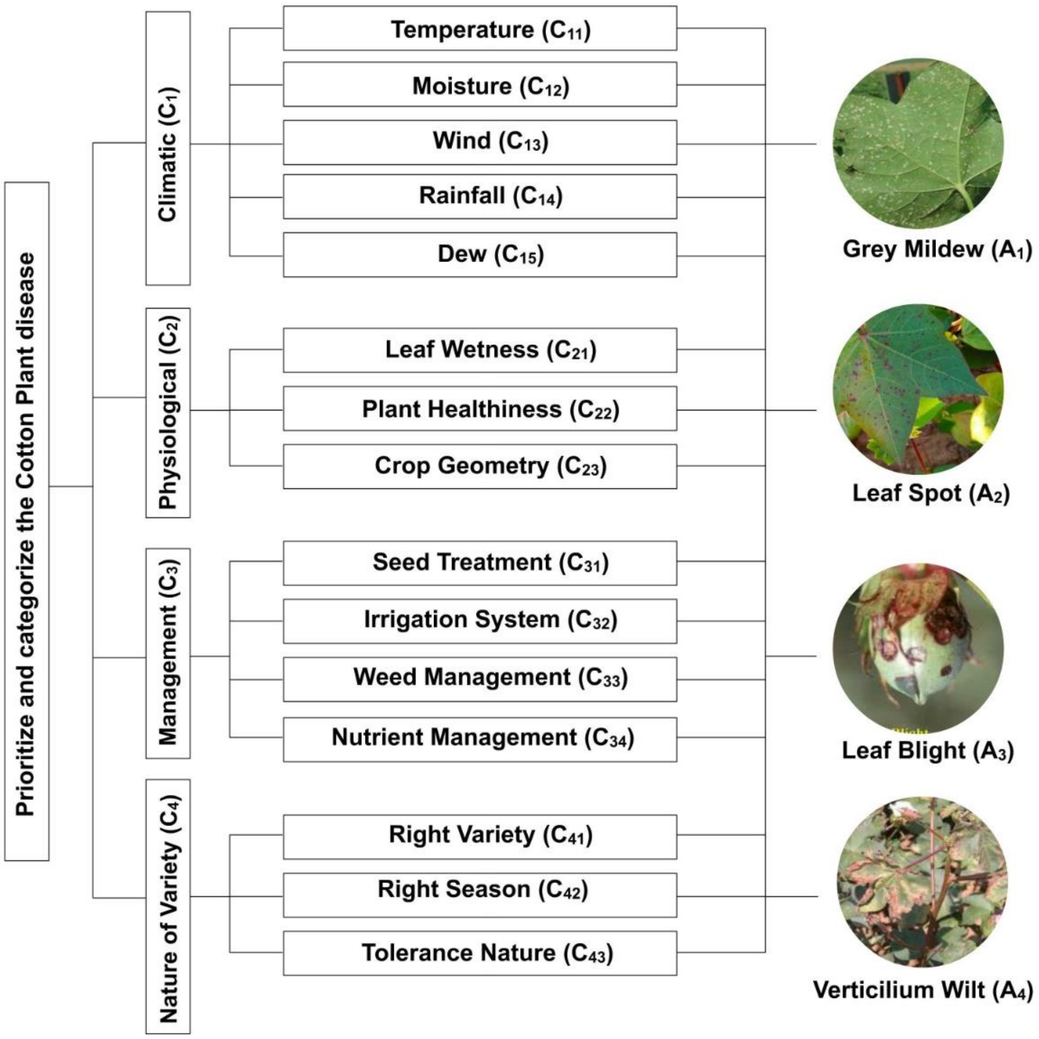

Fig.1. Categorize the cotton plant based on the criteria and sub criteria

The weights along with criteria and sub criteria are evaluated. The four alternate diseases must be evaluated in respect of each criterion. The corresponding weight vector of each disease and the evaluation matrix of alternative diseases concerning sub criteria are shown in Table 2 to 6. The weights of the alternative diseases concerning to sub criteria calculated by fuzzy AHP are used in TOPSIS to rank the alternative diseases are shown in Table 7. The priority weights of the alternative diseases with criteria are shown in Table 8. The weighted normalized decision matrix can be seen in Table 9. The closeness coefficient C_i of four alternatives is calculated and the results are represented in Table 10.

Table 2 Fuzzy comparison matrix of criteria

	C_1	C_2	C_3	C_4
C_1	(1,1,1)	(4.217,6.257,8.277)	(3,5,7)	(1,3,5)
C_2	(0.121,0.160,0.237)	(1,1,1)	(0.11,0.143,0.2)	(3.267,5.288,7.299)
C_3	(0.143,0.2,0.333)	(5,7,9)	(1,1,1)	(0.143,0.2,0.333)
C_4	(0.2,0.333,1)	(0.137,0.189,0.306)	(3,5,7)	(1,1,1)

The weight vector from table is calculated as $W' = [0.4071\ 0.1732\ 0.2347\ 0.1850]$

Table 3 The fuzzy comparison matrix of sub criteria with respect to criteria C_1

	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}
S_{11}	(1,1,1)	(0.116,0.151,0.218)	(4.217,6.257,8.277)	(3.873,5.916,7.937)	(0.116,0.151,0.218)
S_{12}	(4.592,6.618,8.631)	(1,1,1)	(4.592,6.618,8.631)	(4.592,6.618,8.631)	(4.592,6.618,8.631)
S_{13}	(0.121,0.160,0.237)	(0.116,0.151,0.218)	(1,1,1)	(4.217,6.257,8.277)	(1,3,5)
S_{14}	(0.126,0.169,0.258)	(0.116,0.151,0.218)	(0.121,0.160,0.237)	(1,1,1)	(4.592,6.618,8.631)
S_{15}	(4.592,6.618,8.631)	(0.116,0.151,0.218)	(0.2,0.333,1)	(0.116,0.151,0.218)	(1,1,1)

The weight vector from table is calculated as $W' = [0.2434\ 0.5618\ 0.1560\ 0.0052\ 0.0336]$

Table 4 The fuzzy comparison matrix of sub criteria with respect to criteria C_2

	S_{21}	S_{22}	S_{23}
S_{21}	(1,1,1)	(5,7,9)	(0.143,0.2,0.333)
S_{22}	(0.111,0.143,0.2)	(1,1,1)	(7,9,11)
S_{23}	(3,5,7)	(0.09,0.11,0.143)	(1,1,1)

The weight vector from table is calculated as $W' = [0.3418\ 0.4327\ 0.2255]$

Table 5 The fuzzy comparison matrix of sub criteria with respect to criteria C_3

	S_{31}	S_{32}	S_{33}	S_{34}
S_{31}	(1,1,1)	(4.217,6.257,8.277)	(0.199,0.251,0.330)	(0.09,0.111,0.143)
S_{32}	(0.121,0.16,0.237)	(1,1,1)	(6,8,10)	(1,1,1)
S_{33}	(3.029,3.978,4.989)	(0.1,0.126,0.169)	(1,1,1)	(3.317,4.327,5.455)
S_{34}	(7,9,11)	(1,1,1)	(0.182,0.231,0.302)	(1,1,1)

The weight vector from table is calculated as $W' = [0.1762\ \ 0.2709\ \ 0.2459\ \ 0.3071]$

Table 6 The fuzzy comparison matrix of sub criteria with respect to criteria C_4

	S_{41}	S_{42}	S_{43}
S_{41}	(1,1,1)	(2.539,3.659,4.982)	(0.120,0.160,0.237)
S_{42}	(0.201,0.273,0.394)	(1,1,1)	(1,3,5)
S_{43}	(4.217,6.257,8.277)	(0.2,0.333,1)	(1,1,1)

The weight vector from table is calculated as $W' = [0.2873\ 0.2739\ 0.4388]$

Table 7 The weight of alternative diseases with respect to sub criteria

Sub Criteria	A_1	A_2	A_3	A_4
S_{11}	0.1989	0.5054	0.0538	0.2419
S_{12}	0.1644	0.1798	0.2294	0.4264
S_{13}	0.2870	0.1466	0.2742	0.2921
S_{14}	0.3836	0.3806	0.1962	0.0396
S_{15}	0.1557	0.2020	0.3336	0.3087
S_{21}	0.4476	0.0331	0.3946	0.1246
S_{22}	0.4113	0.3632	0.1138	0.1117

S_{23}	0.5993	0.1393	0.1402	0.1211
S_{31}	0.2061	0.3889	0.3129	0.0922
S_{32}	0.3893	0.2346	0.2079	0.1682
S_{33}	0.0231	0.4527	0.3923	0.1320
S_{34}	0.3284	0.2523	0.1942	0.2251
S_{41}	0.1736	0.2605	0.3173	0.2486
S_{42}	0.4195	0.2203	0.2559	0.1043
S_{43}	0.2765	0.2361	0.2591	0.2283

Table 8 The priority weights of alternative diseases with criteria

	C_1	C_2	C_3	C_4
A_1	0.1928	0.4661	0.2483	0.2861
A_2	0.2557	0.1999	0.3209	0.2388
A_3	0.1970	0.2157	0.2676	0.2749
A_4	0.3546	0.1182	0.1634	0.2002

Table 9 The weighted normalized decision matrix

	C_1	C_2	C_3	C_4
A_1	0.1519	0.1432	0.1136	0.1049
A_2	0.2014	0.0614	0.1469	0.0876
A_3	0.1552	0.0663	0.1225	0.1008
A_4	0.2793	0.0363	0.0748	0.0734

Table 10 Ranking of the Diseases

Name of the Diseases	S_i^*	S_i'	C_i	Rank
Grey mildew	0.1317	0.1180	0.4726	2
Leaf spot	0.1143	0.0921	0.4463	3
Leaf blight	0.1481	0.0627	0.2974	4
Verticilium wilt	0.1327	0.1274	0.4899	1

7. Conclusion

This research provides evaluation criteria to determine the high impact of risk factors on cotton disease among the chosen four disease causing risk factors of cotton plant. From the closeness co-efficient ratio, Verticilium wilt provides the highest risk in the cotton plant and the grey mildew are in the next level of the risk and leaf blight is less preferable among the other diseases. According to the closeness coefficient C_i the alternative disease ranked are Verticilium wilt, Grey mildew, Leaf spot and leaf blight from the most preferable to the least preferable. The most affected disease to be selected will be Verticilium wilt as having highest C_i values. Decision making is very problematic where the knowledge from domain professionals of the agriculture university is required and a strongest system is required for building important judgements. This research formulates the risk factors as a MCDM problem and FAHP based study results in precise alternative priority weights of the main and sub attributes with respect to the diseases. The outcome of this research shows that the recommended model is flexible and proficient to relate in different kinds of diseases to prioritize their risk level in cotton crop cultivation and it is a beneficial tool to farmers in the cultivation.

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