

Research Article

Evaluation of different cotton types with analytical hierarchy process

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Abstract

There are significant differences in terms of price formation between cotton growers and yarn producers. While cotton growers prioritize the average yield per hectare and ginning yield in price formation, yarn producers pay attention to properties such as fiber fineness, fiber length, tensile strength, etc. Therefore, even if a cotton grower produces a large amount of cotton per hectare, the monetary value may be lower. This study aimed to determine the most suitable type of cotton for optimal profitability and quality yarn production for both producers, using the Analytic Hierarchy Process (AHP) for decision-making. AHP is a method that analyzes decision-making processes in an analytical and hierarchical structure. AHP helps to determine the best selection by evaluating the factors of a decision, assessing their relationships and priorities. In this study, among the 13 cotton types registered by the Eastern Mediterranean Agricultural Research Institute, the most suitable cotton selection based on criteria such as fiber fineness, fiber length, tensile strength, average yield per hectare, and ginning yield was determined using AHP.

Keywords: Cotton, Analytic Hierarchy Process, Fiber Properties

1. Introduction

Cotton is an important fiber crop among agricultural products, creating high added value, generating numerous employments, playing a leading role in the integration of agriculture and industry, and considered as an important component of world agriculture and trade [1].

The main objectives of cotton production today are to improve the technological properties of the fiber, to increase yield and ginning efficiency, to develop early maturing

varieties, to enhance resistance against diseases and pests, and to reduce production costs [2].

In the textile industry, fineness is the measure of the thickness (or thinness) of the fiber. Finer fibers have larger surface-to-weight ratios [3]. Fineness is one of the three important fiber properties and contributes not only to high strength of the fiber bundle in transverse section but also to better distribution in the yarn. Fineness determines the number of fibers in the transverse section of a given thickness of yarn [4].

The importance of fiber fineness plays a critical role in determining the quality of the end product. Fiber fineness is an important factor that determines the stiffness or, conversely, the softness retention quality and drape quality of a fabric [5]. Finer fibers result in a smoother and softer fabric, a more homogeneous appearance, and improved durability. In addition, finer fibers have a higher degree of luster and sheen and can be used to produce lighter and more delicate fabrics.

In the production of thread, cotton fiber length is another important factor that determines the quality and performance of the final product. As longer fibers are used, they tend to produce stronger and more durable thread, as well as fabrics that are more resistant to wear and tear. Fiber length is considered a critical factor in the production of high-quality thread and fabric.

Fiber tensile strength is a measurement that determines a fiber's resistance to breakage under stress or strain. In thread production, fiber tensile strength is an important factor that determines the quality and durability of the final product. Higher fiber tensile strength results in stronger and more durable thread and fabrics that are more resistant to wear and tear. Additionally, thread made from fibers with higher tensile strength can improve production efficiency since they are less likely to break during fabric production processes.

In the textile industry, average bale yield and ginning efficiency are measures that determine the amount of fiber that can be converted into usable thread. In thread production, average bale yield is an important factor that determines cotton producer efficiency and profitability. The price formation in the bale cotton market is determined by factors such as ginning efficiency, foreign matter content, color, and moisture level [6]. Higher average seed cotton yield and ginning efficiency mean more fiber can be converted into usable thread, increasing productivity. This makes each unit of thread produced more profitable for the textile operation.

In the study, fiber fineness, fiber length, fiber tensile strength, and average bale yield and ginning efficiency were identified as the main criteria in cotton variety selection, and the process for determining the most suitable cotton variety based on the selected criteria using the AHP method was explained. The conclusion briefly discusses what can be done in future studies.

2. Materials and Methods

Table 1, obtained from the website of the Eastern Mediterranean Agricultural Research Institute, presents 13 cotton varieties according to criteria of fiber fineness, fiber length, fiber tensile strength, average yield, and ginning efficiency.

Table 1. Cotton Type and Characteristics Used In the Study

Alternatives	Fiber Fineness (mic)	Fiber Length (mm)	Fiber Tensile Strength (gr/tex)	Seed Cotton Yield (kg/da)	Ginning efficiency (%)
AYZEK595	4,8	31	33,3	580	47,9
BOSSA159	4,6	31,8	33,7	575	42
TEKSA415	4,5	31,3	34,8	500	44
YILDIRIM63	4,7	31	34,8	500	46
ŞÖHRET	5	29	30	560	43
GAPKOT602	4,8	30,5	33,7	535	45,2
ÖNER513	4,7	29,5	30,2	547	41,7
TÜRKOĞLU	4,8	29,5	31,6	584	42,5
C92	5	29,2	31,1	550	44,1
TYA366	4,7	30,2	32,1	555	43,3
TYA193	4,8	31,5	33,5	550	43,5
CEYKOT340	4,9	30,5	31,5	575	43,5
ADN701	4,8	29,9	29,5	528	43

The Analytic Hierarchy Process (AHP) method was used in decision-making processes to select the most suitable type of cotton among different types based on factors such as fiber fineness, fiber length, fiber tensile strength, seed cotton yield and ginning efficiency. Geographical cultivation characteristics were not taken into account when evaluating the cotton types and it was assumed that they all grew under similar geographical conditions. The AHP method was applied using Super Decision software, which considers both qualitative and quantitative variables and takes into account the priorities of both groups and individuals [7]. AHP helps to make a decision more systematic, objective, and consistent by identifying the factors of a decision, evaluating the relationships and

priorities among them, and ultimately determining the best choice. AHP can be used in various decision-making processes, such as product and service selection, investment decision-making, project management, and selection.

Generally, fiber length and fiber fineness have a higher correlation with yarn properties [4]. In the study, based on the correlation between fiber properties and yarn properties, were evaluated on a scale of 1-5 according to their importance levels shown in Table 2.

Table 2. Evaluation Between Fiber Properties and Yarn Properties

Cotton Characteristics	Importance Level
Fiber Length	5
Fiber Fineness	4
Fiber Strength	3
Seed Cotton Yield	2
Ginning efficiency	2

To make the most suitable selection among different types of cotton using the Super Decision program, criteria were first identified, alternatives were defined, and a hierarchical structure was created. The hierarchical structure of the study is shown in Figure 1.

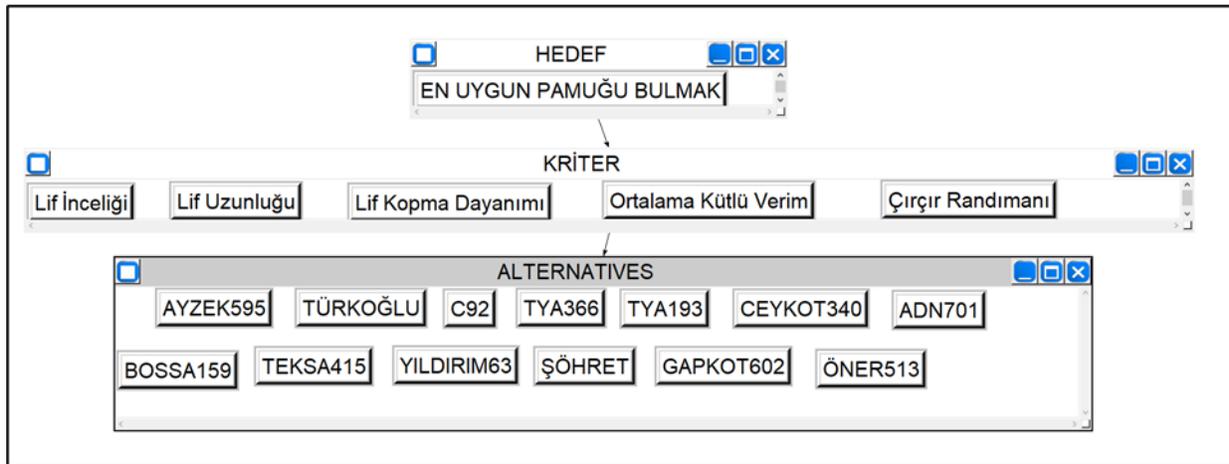


Figure 1. Hierarchical Structure

When entering criterion weights into the program, the data given in Table 1 were normalized. The normalized data is shown in Table 3. When inputting data for the fiber fineness criterion, the cotton type with the finest fibers has been assigned the highest

value in the normalized data because finer fibers in cotton are generally considered to be of higher quality than thicker ones.

Table 3. Criterion Weights

Alternatives	Fiber Length	Fiber Fineness	Fiber Strength	Seed Cotton Yield	Ginning Efficiency
AYZEK595	0,400	0,71429	0,71698	0,9524	1,0000
BOSSA159	0,800	1	0,79245	0,8929	0,0484
TEKSA415	1,000	0,82143	1	0,001	0,3710
YILDIRIM63	0,600	0,71429	1	0,001	0,6936
ŞÖHRET	0,001	0,001	0,09434	0,7143	0,2097
GAPKOT602	0,400	0,53571	0,79245	0,4167	0,5645
ÖNER513	0,600	0,17857	0,13208	0,5595	0,001
TÜRKOĞLU	0,400	0,17857	0,39623	1,0000	0,1290
C92	0,001	0,07143	0,30189	0,5952	0,3871
TYA366	0,600	0,42857	0,49057	0,6548	0,2581
TYA193	0,400	0,89286	0,75472	0,5952	0,2903
CEYKOT340	0,200	0,53571	0,37736	0,8929	0,2903
ADN701	0,400	0,32143	0,001	0,3333	0,2097

3. Results

The results obtained from the AHP (Analytic Hierarchy Process) based on the desired criteria for fiber fineness, fiber length, fiber tensile strength, seed cotton yield, and ginning efficiency among alternative cotton types are presented in Table 4.

Table 4. Sorting results of alternative cotton types

Alternatives	Total	Normal	Ideal	Rank
BOSSA159	0.0636	0.1272	1.000	1
TEKSA415	0.0632	0.1265	0.9945	2
AYZEK595	0.0527	0.1053	0.8285	3
YILDIRIM63	0.0519	0.1039	0.8167	4
TYA193	0.0485	0.0970	0.7631	5
GAPKOT602	0.0421	0.0842	0.6624	6
TYA366	0.0410	0.0820	0.6452	7
CEYKOT340	0.0324	0.0648	0.5099	8
TÜRKOĞLU	0.0307	0.0615	0.4834	9
ÖNER513	0.0278	0.0556	0.4374	10
ADN701	0.0227	0.0454	0.3568	11
C92	0.0140	0.0281	0.2206	12

ŞÖHRET	0.0092	0.0185	0.1455	13
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In the AHP (Analytic Hierarchy Process) analysis, it is necessary to determine whether the comparisons made are consistent. Therefore, consistency ratio has been calculated for each comparison. The consistency ratio should not be higher than 0.10. A consistency ratio above 0.10 indicates a calculation error in AHP or inconsistency in the decision maker's comparisons [8]. The consistency ratio of the established model was calculated as 0, indicating that the comparisons made in the study are consistent.

When geographical features and resistance to diseases are not taken into account, BOSSA159 has received the highest score among the alternative cotton types. TEKSA145, AYZEK595, and others follow BOSSA159 in order. It has been determined that BOSSA159 outperforms the other 12 types in terms of fiber fineness, fiber length, fiber tensile strength, average yield, and ginning efficiency when it is grown as cotton.

4. Discussion and Conclusion

The aim of the study was to select the most suitable cotton plant for both growers and users among different types of cotton plants. Growers generally prioritize average yield and ginning efficiency, while users pay attention to characteristics such as fiber length, fiber fineness, and fiber strength. The AHP method is an invaluable tool for finding a cotton type that satisfies the desired characteristics of both growers and users. The AHP method mathematically calculates decision-making processes. By examining the results obtained, it is possible to rank 13 different cotton types according to the specified criteria using the AHP method. With the AHP method, growers can prioritize their unique criteria to obtain the best solution. It is assumed that the cotton types used in the study have similar geographic characteristics. In future studies, work can be done on cotton types that have similar geographical characteristics as a criterion, and different physical fiber characteristics, resistance to diseases, cultivation costs, and unit prices that were not used in the study can be added to future studies.

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