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Determination of Factors Affecting the Cumin Production Decision of Agricultural Enterprises: The Case of Konya Province

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ABSTRACT

Turkey has vast agricultural lands and diverse climatic conditions, and different plant species can be cultivated. Especially, Konya province, located in the Central Anatolia Region, is an important agricultural centre in Turkey. Konya province, which has a polyculture production pattern, stands out in the production of medicinal and aromatic plants due to its favourable climatic conditions and soil structure. In Turkey, 26.33% of cumin, which is among the medicinal and aromatic plants, is produced in Konya province. This study aims to determine the factors affecting cumin production. For this purpose, 65 cumin producers determined by proportional sampling method were interviewed. The data obtained through these interviews were analysed by using the Analytic Hierarchy Process (AHP) method to determine the weights of the criteria affecting the cumin production decision of the agricultural enterprises. In the process of determining the criteria influencing the cumin production decision, the opinions of subject experts working in universities, public institutions and organizations and producers were taken. Among the criteria determined as yield, price, labour requirement, water requirement, ease of marketing, mechanisation, input costs, cultivation knowledge, soil structure and subsidies, the most important criterion was found to be price with 28.11%. Price criterion is followed by input cost 22.57%, water requirement 12.13%, yield 8.71%, cultivation knowledge 8.43%, subsidies 6.82%, ease of marketing 4.74%, soil structure 3.63%, mechanisation 2.54% and labour requirement 2.25%. It is thought that the solution of the mechanisation problem will make a significant contribution to cumin production as it will reduce the need for labour force.

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Introduction

Although medicinal and aromatic plants have an important place throughout human history, these plants were first used in the food and pharmaceutical industry. Over time, they have also found value in many areas such as spices and cosmetics. The Covid-19 pandemic, which emerged in the world in 2019, was declared as a global pandemic by the World Health Organization (WHO) in March 2020. In this process, in addition to medical treatments, interest in medicinal and aromatic plants has also increased (Oğuz & Çiftci, 2023).

Cumin (Cuminum cyminum L.), which has an important place among medicinal and aromatic plants, is a herbaceous plant originating from Egypt and the Eastern Mediterranean, and it belongs to the Umbelliferae family. The plant is widely cultivated in Iran, Japan, China and Turkey (Zolleh, 2009; Kaya et al, 2022). Cumin is a plant that is resistant to drought, has low soil selectivity, and requires 350-400 mm of rainfall (TOB, 2024). This plant is widely used due to its aroma, in addition to its anti-stomach problems, carminative, carminative, digestive, diaphoretic and milk-enhancing properties (Baytop, 1984).

According to FAO data, in 2022, aniseed, coriander, cumin and fennel have a production area of 2.315 million ha in the world and India ranks first with 1.870 thousand ha. Turkey ranks 4th in the world in the production area of these crops with a production area of 68 thousand ha. The production of these crops was 2.751 million tonnes in the world, while the production amount in Turkey was 347 thousand tonnes (FAO, 2022). The total cumin production area in Turkey is 16,494 ha. Ankara province ranks first with 5,783 ha, Kayseri province ranks second with 4,955 ha and Konya province ranks third with 4,327 ha. These three provinces constitute 91.32% of the total cumin production area in Turkey. In terms of production amount, a total of 11,480 tonnes of cumin is produced in Turkey and 26.04% of this production is realized in Konya province (Tüik, 2023).

Cumin, one of the medicinal and aromatic plants, has an important place in the world and Turkey in terms of production area and amount. It is a very important plant because it is exported and is one of the products with high added value. Since Konya province is located in a closed basin and irrigation opportunities are limited, and since cumin can be grown in lands that do not require irrigation, it is important to continue its cultivation in dry agricultural areas.

It is of great importance for the business to plan by deciding on the choice of crops, the method of planting and the amount of production (Günden & Miran, 2008). Agricultural enterprises consider many qualitative and quantitative factors such as climatic conditions, soil structure and market demands in product selection. An erroneous decision can causes businesses to incur high costs (Ustalı & Tosun, 2019). In addition, it can result in the emergence of consequences that negatively affect the sustainability of enterprises, such as loss of income and abandonment of production.

A decision is a conscious and purposeful choice to achieve a specific goal or solve a problem. Decision making is the process of utilizing past experiences and current conditions by evaluating advantages and disadvantages in line with the criteria determined in order to choose the most appropriate one among various options (Tekin, 2008). Decision making refers to the individual's determination and selection of various alternatives in line with their preferences and values (Özensel, 2023). Multi-criteria decision-making (MCDM) methods are used to obtain the best alternative among all solution paths by evaluating multiple criteria.

In the literature, there are a large number of studies in the agricultural sector, as in different sectors, that deal with product selection using MCDM methods. When the studies in the literature are examined, it is seen that AHS-VIKOR and SAW methods have been used to determine the agricultural production technique and the suitability of the use of existing agricultural land (Pourkhabbaz et al., 2014). A hybrid model was created by using Fuzzy Analytic Hierarchy Process (B-AHS) and VIKOR methods from MCDM methods together and a decision support system was developed to propose a sustainable solution to the crop selection problem obtained by agricultural methods (Özdemir & Savalan, 2022). B-AHS and geographic information system approach was developed to determine the suitability of agricultural land for wheat and maize production (Pilevar et al., 2020). In a study for local organic agricultural development in Indonesia, the B-AHS method was used to identify a strategy for the development of organic agriculture (Firdaus et al., 2021). In another study, the AHP method was used to identify and weight the decision priorities of producers in deciding on dry bean production, and suggestions were made on the reasons for the decrease in production area and quantity (Çiftci et al., 2023).

In a study on target market selection for companies using AHP and TOPSIS methods, appropriate market targets were determined by evaluating the alternatives (Aghdaie & Alimardani, 2015). With the criteria of population, GNP per capita, fertiliser consumption, fertiliser production, fertiliser trade balance and ease of doing business, distance to countries and logistics performance, 10 candidate countries were evaluated with AHP-TOPSIS methods and the most suitable target market was determined (Ünal & İpekçi Çetin, 2019).

In this study, AHP method, which is one of the CRM methods, was used to obtain the weights of the factors determined in agricultural enterprises producing cumin in Konya province. Factors affecting cumin production were identified and the weights of decision criteria were determined. By determining the decision priorities, predictions for the expansion of cumin production as an alternative crop in Konya province, where water constraint is intense, were put forward and a solution proposal was presented.

Material and Method

Primary data were used in the study. In Turkey, cumin is produced on 164,944 decares of land in total, with Ankara province ranking first with 57,825 decares, Kayseri province ranking second with 49,550 decares and Konya province ranking third with 43,266 decares. These three provinces account for 91.32% of the country's production. Konya province accounts for 26.23% of the total production area in Turkey and was selected as the research area since it is among the important provinces in terms of production area and quantity. In order to determine the factors affecting the decision of agricultural enterprises in Konya province while deciding on cumin production and the impact rates of these factors, a face-to-face survey was conducted with the enterprises on a voluntary basis and the data obtained were analysed by the AHP method.

The proportional approach was used to determine the sample size (n) that would best represent the population. The proportional approach is calculated according to formula 1 below (Miran, 2003).

$$n = \frac{N \times p \times (1-p)}{(N-1) \times \sigma_{px}^2 + p \times (1-p)} \quad (1)$$

In the formula 1; N is the number of agricultural enterprises in the population; σ_{px}^2 is variance of the ratio; p is the rate of agricultural enterprises cumin production.

In this study, the sample size was obtained as 65 with a 5% margin of error and a 90% confidence interval according to the proportional approach.

In order to determine the decision factors that are important for cumin production, the opinions of subject experts working in universities, public institutions and organisations and producers were taken. Ten criteria were determined as yield, price, labour requirement, water requirement, ease of marketing, mechanisation, input costs, cultivation knowledge, soil structure and subsidies.

AHP Method

The AHP method, developed by Thomas L. Saaty in 1971, is one of the MCDM methods used in a wide area (Wind and Saaty, 1980). This method is an approach that ranks the decision alternatives according to the level of importance among many options based on the criteria determined by the decision maker (Erdal & Akgün, 2014).

The application steps of the AHP method are given below.

Step 1. Establishing a hierarchical structure for decision making

In the AHP method, determining the objective is the basic condition. Using a scale of 1 to 9, a hierarchical structure showing the relationship between the main criteria, their sub-criteria and alternatives is created (Yang and Lee, 1997).

Step 2. Constructing the binary comparison matrix

The binary comparison matrix was obtained using the binary comparison scale (Saaty, 1994) in Table 1. In AHP, binary comparison is made primarily between the main criteria, sub-criteria, if any, related to these main criteria and alternatives.

Step 3. Creation of a normalized decision matrix

In this step, each value in the binary comparison matrix obtained in Step 2 is normalized by dividing it into the sum of the columns, and the total of each column in the normalized matrix is equal to 1.

$$c_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \quad (3)$$

Step 4. Creation of a weighted normalized decision matrix

The criterion weights of the normalized decision matrix obtained in step 3 are calculated using the formula in equation 4 for w_i.

$$w_i = \frac{1}{n}\sum_{j=1}^{n} c_{ij} \quad (4)$$

i=1,2,...,n and j=1,2,...n,n is the criterion value.

Step 5. Calculating the vector of eigenvalues $(\lambda_{max}())$

$d_i$vector is obtained by multiplying the matrix A obtained as a result of binary comparison with the importance weights w_i. The resulting vector is given in Equation 5.

$$d_{i=}\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \quad (5)$$

The base (P_i) value for the values obtained by mutually dividing the d_i vector by each element of the w_i vector is found as in Equation (6) (Bakan, 2013).

$$P_i = \frac{d_i}{w_i} i = 1, \cdots, n \quad (6)$$

n number of criteria

Vector of eigenvalues $(\lambda_{max}())$ was obtained by utilising Equation (6).

$$\lambda \frac{\sum_{i=1}^{n} P_i}{n}_{max}. \quad (7)$$

i=1,⋯,n n is the criterion value.

Using Equation 6, the vector of eigenvalues (λ_{max}) is obtained according to Equation 7.

Step 6. Calculation of the consistency index and the consistency rate

It is important to ensure the consistency of the binary comparison matrix. If the matrix is not consistent, weights are not used. Many methods are used to determine whether the binary comparison matrix is consistent.

Consistency index (CI) is needed to obtain the consistency ratio (CR). Consistency index (CI), one of the frequently used methods, is given in Equation 8 and consistency ratio is given in Equation 9.

$$CI = \frac{(\lambda_{max})}{(n-1)} \quad (8)$$

$$CR = \frac{CI}{RI} \quad (9)$$

In Equation 8, (λ_{max}), the vector of eigenvalues and n is the criterion value.RIexpressed in Equation 9 shows the random consistency index. The RI consistency index is calculated according to different n values and shown in Table 2. When the CR consistency ratio is less than 0.10, the comparison matrix is considered consistent (Macit, 2023).

Table 1. AHP Method Comparison and Importance Scale Importance

ID	Importance	Probability	Preference	Description
1	Equally important	Equally likely	Equally preferable	Two judgements have the same degree of importance.
3	Partly more important	Partly possible	Partly preferred	One of the two judgements is of moderate importance compared to the other.
5	More important	More likely	More preferable	One of the two judgements has a strong degree of importance compared to the other.
7	Very important	Very possible	Very preferable	One of the two judgements is more strongly significant than the other.
9	It's very, very important	It's very, very possible	Very very much preferred	One of the two judgements is extremely important compared to the other.
2,4,6,8	Intermediate values	Intermediate values	Intermediate values	These are the values preferred in cases where there is indecision between two judgements and the preference values are very close to each other.

Importance Degree; Source: Saaty, 1994

Table 2. AHP Method Randomness Indicators

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.0	0.0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Source: Saaty, 1980

Table 3. Comparison of Factors Affecting the Decision on Cumin Production

Cumin	WN	LR	P	M	CN	IC	SS	Y	EM	S
WN	1	5	0.22	4.9	2.73	0.2	3.7	2.3	3.3	2.9
LR	5	1	0.14	0.8	0.28	0.18	0.43	0.2	0.43	0.27
P	0.22	0.14	1	6.2	5.1	2.1	5.5	4.8	6.1	4.3
M	4.9	0.8	6.2	1	0.27	0.21	0.54	0.25	0.36	0.19
CN	2.73	0.28	5.1	0.27	1	0.2	4.2	1.12	2.6	2.1
IC	0.2	0.18	2.1	0.21	0.2	1	5.9	4.3	4.7	4
SS	3.7	0.43	5.5	0.54	4.2	5.9	1	0.26	0.35	0.9
Y	2.3	0.2	4.8	0.25	1.12	4.3	0.26	1	2.4	2.15
EM	3.3	0.43	6.1	0.36	2.6	4.7	0.35	2.4	1	0.34
S	2.9	0.27	4.3	0.19	2.1	4	0.9	2.15	0.34	1

WN: Water Needs; LR: Labour Requirement; P: Price; M: Mechanisation; CN: Cultivation Knowledge; IC: Input Cost; SS: Soil Structure; Y: Yield; EM: Ease of Marketing; S: Subsidies

Table 4. Standardised Values

Cumin	WN	LR	P	M	CN	IC	SS	Y	EM	S
WN	0.079	0.137	0.073	0.14	0.167	0.042	0.127	0.152	0.136	0.16
LR	0.016	0.027	0.048	0.023	0.017	0.037	0.015	0.013	0.018	0.015
P	0.361	0.19	0.335	0.177	0.312	0.442	0.189	0.318	0.252	0.237
M	0.016	0.034	0.054	0.028	0.017	0.044	0.019	0.017	0.015	0.011
CN	0.029	0.098	0.066	0.105	0.061	0.042	0.144	0.074	0.107	0.116
IC	0.393	0.153	0.16	0.136	0.304	0.21	0.203	0.285	0.194	0.22
SS	0.021	0.063	0.061	0.053	0.015	0.036	0.034	0.017	0.015	0.05
Y	0.034	0.134	0.07	0.113	0.055	0.049	0.133	0.066	0.099	0.118
EM	0.024	0.063	0.055	0.079	0.024	0.045	0.098	0.028	0.041	0.018
S	0.027	0.101	0.078	0.147	0.029	0.053	0.038	0.031	0.123	0.055

WN: Water Needs; LR: Labour Requirement; P: Price; M: Mechanisation; CN: Cultivation Knowledge; IC: Input Cost; SS: Soil Structure; Y: Yield; EM: Ease of Marketing; S: Subsidies

Research Investigations and Discovery

The choice of products is very important because there is a cutting-edge production in agricultural enterprises. The negative impact of climate conditions also affects the sustainability and profitability of the business. Decisions on product choices in agricultural enterprises depend on many factors, including social, environmental and economic. In enterprises, the choice of products directly affects the profitability of the enterprise. The right product selection is also related to the operator's experience. It is critical for the entrepreneur to make the right product selection by closely monitoring the existing production capacity and market conditions of the enterprise. (Çiftci et al., 2023).

In table 3, pairwise comparisons of water requirement, labour requirement, price, mechanisation, cultivation knowledge, input costs, soil structure, yield, ease of marketing and subsidies, which play an important role for cumin production, were made.

Using the binary comparison matrix obtained in table 3, one of its criteria is compared with the others and preference levels are determined for each pair of criteria. The normalisation (standardisation) values in Table 4 were obtained by dividing each criterion value by the total value.

Criteria can be measured with different units, therefore, by using normalization as in table 4, differences between units are eliminated and thus a dimensionless classification is obtained.

Table 5 gives the importance weights of the criteria that play an important role in cumin production.

According to the results in Table 5, the most important criterion among the criteria affecting cumin production is price (0,281). If agricultural product prices are low or high, it affects the amount of agricultural production and causes increases and decreases in cultivation. Delays between these changes disrupt the biological structure of producers and agricultural production (Bulmuş, 1978). The price criterion is followed by input cost (0,226) and water requirement (0,121).

In table 6, the consistency ratio of the binary comparison matrix of the criteria was calculated as RI = 0.069. The fact that this value is less than 0.10 indicates that the results obtained are reliable.

AHP method was used to determine the importance levels of the criteria determined as water requirement, labour requirement, price, mechanisation, cultivation knowledge, input costs, soil structure, yield, ease of marketing and support. Based on the binary comparison matrix generated in table 3, line averages were taken and weights were calculated to obtain standardized values in table 4. According to the results obtained, it was determined that the most important criterion for cumin production was price with a weight of 28.11%.

Table 5. Importance Weights of Criteria

W_i	0.121	0.023	0.281	0.025	0.084	0.226	0.036	0.087	0.047	0.068
PCR	3	10	1	9	5	2	8	4	7	6
Criteria	WN	LR	P	M	CN	IC	SS	Y	EM	S

PCR: Place of criteria in ranking; WN: Water Needs; LR: Labour Requirement; P: Price; M: Mechanisation; CN: Cultivation Knowledge; IC: Input Cost; SS: Soil Structure; Y: Yield; EM: Ease of Marketing; S: Subsidies

Table 6. Normalized Factor Comparisons

Cumin	WN	LR	P	M	CN	IC	SS	Y	EM	S
WN	0.121	0.115	0.062	0.125	0.23	0.045	0.135	0.2	0.157	0.198
LR	0.024	0.023	0.04	0.02	0.023	0.04	0.016	0.018	0.021	0.018
P	0.554	0.16	0.281	0.158	0.43	0.474	0.2	0.418	0.29	0.293
M	0.025	0.029	0.045	0.025	0.023	0.047	0.02	0.022	0.017	0.013
CN	0.044	0.083	0.055	0.094	0.084	0.045	0.153	0.097	0.123	0.143
IC	0.604	0.129	0.134	0.121	0.419	0.226	0.215	0.375	0.223	0.273
SS	0.033	0.053	0.051	0.047	0.02	0.038	0.036	0.022	0.017	0.061
Y	0.053	0.113	0.059	0.101	0.076	0.053	0.141	0.087	0.114	0.147
EM	0.037	0.053	0.046	0.071	0.032	0.048	0.103	0.036	0.047	0.023
S	0.042	0.085	0.065	0.131	0.04	0.056	0.04	0.041	0.142	0.068
			CI=0.103					RI=0.069		

The decrease in the amount of rainfall and increase in temperatures in the province in recent years have caused a decrease in cumin yield. In this period, prices are expected to increase in line with the increasing demand. Product prices have an important place for business profitability and a sustainable business. In a study on dry bean production decisions, Çiftci & et al. (2023), found that the most important criterion for deciding on dry bean production was yield (20.01%) and the second most important criterion was price (13.5%).

After the price criterion, input cost ranks second and has an impact of 22.57% in decision making. Input cost plays an important role in terms of sustainability and profitability of enterprises and in determining the product pattern. Since cumin production is carried out in dry agricultural areas in Konya province, irrigation and energy costs are quite low. Therefore, it is possible that the low input cost compared to other products ranks second among the weights of the decision criteria. Water requirement criterion ranks third among the decision criteria with a weight of 12.13%. Plant water requirement is of great importance in terms of both production efficiency and production costs. Therefore, the fact that cumin is a product grown in dry agricultural areas shows that it plays an important role in the decision of producers to produce in these areas. Yield has the fourth weight among these criteria with 8.71%. Yield has an important place as a basic criterion in terms of determining the continuity and profitability of production in enterprises.

Among the other criteria, cultivation knowledge ranked fifth with 8.43%, subsidies ranked sixth with 6.82%, ease of marketing ranked seventh with 4.74%, soil structure ranked eighth with 3.63%, mechanisation ranked ninth with 2.54% and labour requirement ranked last with 2.25%. As a matter of fact, it has been determined in the interviews with the experts and the producers during the survey that the level of mechanisation in cumin production is low and that weed cleaning and harvesting are carried out based on labour force. The fact that harvesting and weed cleaning are based on labour force has caused it not to be among the priority preferences in cumin production decision in enterprises with labour force problems. Bozdemir, (2017) in his study on determination of resource use efficiency in grain maize, determined that the most important factor in terms of criterion weight in grain maize production was labour, followed by irrigation facilities, cultivation knowledge, marketing facilities, input prices, input supply, product prices and mechanisation. The high level of mechanisation in grain maize production reduces the need for labour and directly affects the production decision. In the study conducted by Özensel (2023), the most important factor in the criterion weights of the sub-factors of agricultural factors in grain selection was mechanisation. Other factors were determined as yield, irrigation, fertilisation, soil structure and climate respectively.

It was determined that the weights of decision criteria in the selection of agricultural products in the study area varied according to product groups. As a matter of fact, it is thought that these changes are caused by the level of mechanisation, input costs, plant water requirement, and labour requirement.

Conclusion and Recommendations

The rapid increase in the world population, the continuing negative effects of climate change, and the threat of global diseases have increased the tendency towards alternative products in agricultural production. Cumin, which is considered as a food product due to its widespread use in alternative medicine and its aroma, can be produced in dry farming areas, its input costs are relatively low compared to other products, its usage areas are diversifying day by day and it is subject to export, showing the importance of the production of this plant.

In this study, the criteria affecting the cumin production decision were analysed and it was determined that price, input cost and water requirement ranked first. It is predicted that the need for labour force increases in cumin production due to the low water requirement, low level of mechanisation and limited seed diversity, and this situation leads to a change in criteria weights among agricultural products in production decisions. In order to increase and spread cumin production, extension activities should be focused on, subsidy supports should be increased and cooperative organisation of cumin producers in the region should be ensured in order to protect product prices. In addition, among the decision criteria, mechanisation and labour requirement are among the last two criteria and this situation has a negative effect on the cumin production decision. It is thought that increasing the level of mechanisation in cumin production will make a significant contribution to the production decision since it will also reduce the need for labour force. In order to solve this problem, the Ministry of Agriculture, national agencies, universities, institutes and NGOs should work together and R&D investments should be made to increase the mechanisation level.

Declarations

The study was approved by the KTO Karatay University Human Research Ethics Committee on 10.06.2024, in accordance with the principles of the Declaration of Helsinki, with Decision Number: 2024/05/13

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