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Research paper

Evaluation of Selected Varieties of a cotton in the Conditions of Fuzzy Initial Information

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Abstract

One of the applied problems of decision-making under conditions of uncertainty, called tasks of making weakly structured decisions, is considered. The essence of this task is to choose the most acceptable variety of cotton from a given set of crops, providing optimal values for agrotechnological parameters (yield, length and strength of fiber, oil content, etc.) in different initial conditions: sowing, cultivation, growing and harvesting. The initial conditions are of a non-quantitative, incomplete, linguistic nature (collectively referred to as fuzzy source information) and are represented in the form of logically interconnected linguistic expressions.

Keywords: *Decision-making, uncertainty, agrotechnological parameters, membership functions, selection varieties.*

1. Introduction

Since the late 1970s, the methods of the theory of fuzzy sets are beginning to be applied in the economy. Mention should be made of the work of J. Buckley, "The Solution of Fuzzy Equations in Economics and Finance" [1] and "Fuzzy Mathematics in Finance" [2], G. Boyadzhieva, M. Boyadzhiev "Fuzzy Logic in Business, Finance and Management" [3] and "Fuzzy sets. Fuzzy logic. Applications "[4], L. Dymova, P. Sevastyanova" Fuzzy analysis of planned capital costs. Investment project. Evaluation and optimization "[5], A.M. Hill Lafuente "Financial analysis under uncertainty" [6], H. Zimmermann's "Theory of fuzzy logic and its applications" [7].
In the 80's, software solutions and information technologies began to emerge, solving economic problems using fuzzy-plural and related descriptions. Thus, under the leadership of C. Zopounidis [8], an expert system for detailed financial analysis of corporations was developed at the Technical University of Crete. Earlier in Germany, in the late 1980s, a group led by H. Zimmerman [7] developed a strategic planning system in which the positioning of the corporation's business is based on fuzzy descriptions of the competitiveness and attractiveness of the business. As an example of such software, you can use expensive complex systems, which include fuzzy logic, which bankers and financiers use to solve the most complicated problems of forecasting financial indicators. The beginning of this process was laid by the Japanese financial corporation Yamaichi Securuties. Having set out to automate the game on the securities market, this company attracted about 30 specialists in artificial intelligence. The first version of the system, completed by the beginning of 1990, included 600 fuzzy rules - the embodiment of the experience of the ten leading brokers of the corporation. Before deciding to use the new system in real conditions, it was tested on a two-year sample of financial data (1987-1989). The system with brilliance withstood the test. A special surprise of the examiners was caused by the fact that a week before the stock market crash (the famous "Black Monday" on the Tokyo Stock Exchange in 1988), the system sold the entire block of shares, which reduced the damage to almost zero. Needless to say, after that, the question of the expediency of applying fuzzy logic in the financial sphere was no longer raised.
A number of works are devoted to macroeconomic analysis of the stock market on the basis of fuzzy representations: K. Piraeus "Fuzzy-multiple analysis of investment activities of mutual funds" [9]; R. Tryppy "Artificial intelligence in financial and investment activities" [10]. Also, fuzzy representations were put in the basis of neural networks for predicting stock indices: G.A. Gunin "Features of the practical application of artificial neural networks to the forecast of financial time series" [11].
In this paper, fuzzy approaches to constructing models for describing and evaluating alternatives, as well as developing an algorithm for selecting cotton breeding varieties under unclearly defined initial information [12-15] are considered.

2. A Generalized Model for Stating the Problem of Adopting Weakly Structured Solutions

We introduce the definitions of the basic concepts used in the problem under consideration.
An alternative is one of many possible solutions. The outcome is a possible outcome of the implementation of the alternative, i.e., the consequence (the state of the object) that comes as a result of the implementation of the decision. Criterion and indicator of effectiveness - the type and characteristics of the measure, according to which the effectiveness of outcomes and their corresponding alternatives is evaluated. DM preferences are subjective criteria based on the experience and personal assessment of the decision maker both internal and external current situation of the environment in which the analyzed objects (systems and processes of

different nature) function. A problem situation is a set of alternatives, their outcomes, that is, the states of the analyzed objects, as well as the corresponding types and values of the estimates of performance indicators. The environment is a set of types of uncertainties, under which conditions an assessment of the problem situation under analysis and decision-making is carried out. In this paper we consider a fuzzy environment.
The decision-making task is formulated as follows. There are many variants of solutions (alternatives), the implementation of which leads to the onset of some outcomes: one - under conditions of certainty, and several possible ones - in conditions of uncertainty. The outcome can be characterized, for example, by the value of the state to which the object will move as a result of the implementation of this alternative. There are further indicators and performance criteria, and, importantly, subjective preferences of decision-makers. Evaluation of outcomes based on selected performance criteria determines the degree to which alternatives are suitable for these outcomes. It is required to construct a strategy for choosing an alternative that is best in accordance with the criteria for the effectiveness of outcomes and the preferences of decision-makers.

3. Formal Statement of the Decision-Making Problem

The quality of cotton is determined by a number of biological and technological characteristics. For textile workers, the most important technological properties of cotton fiber are: length, metric number, strength, breaking length, maturity and others. These properties largely depend on the characteristics of the variety, its ability to absorb and use elements of nutrition on this type of soil, etc. The need for selection variety in nutrients is determined by the interaction of variety and fertilizers in the "variety - soil - fertilizer" environment. The result of this interaction is reflected not only in the amount of cotton harvest, but also in the technological properties of the fiber.
Many researchers have studied the effect of fertilizers on the yield of some varieties of cotton. However, these studies were conducted only for one type of soil and one variety. The results of such studies are insufficient to judge the responsiveness of different types of cotton to different doses and the ratio of fertilizer application to their yield in different types of soil. The fact is that each variety responds in its own way to those nutritional conditions that are created in a specific soil difference after fertilization as a result of their specific interaction. Naturally, each soil creates its own system of "soil - fertilizer". Consequently, the responsiveness of cotton varieties to fertilizer should be judged only for each particular soil.
The study of changes in the technological properties of cotton fiber, depending on the variety, soil conditions and fertilizers, makes it possible to determine the optimal doses and ratios of fertilizer application on a particular soil, in which the corresponding variety yields a high yield of fiber with the best technological properties. In real conditions, the parameters of the sowing regimes and the agrotechnics of cotton cultivation are set approximately (fuzzy) according to expert conclusions. This necessitates the construction of a fuzzy mathematical model describing this relationship between the input and output parameters being investigated. Such a model is the basis for solving the problem of decision-making (DM) in choosing an acceptable variety.
The main goal of the present work is to develop an algorithm for selecting breeding varieties of cotton with the best biological and technological indicators in conditions of indistinctly given initial information. In the baseline, alternatives are not clearly dominant in any of the quality indicators alone, nor on their totality.
And under such initial conditions, it is required to choose the most acceptable alternative: variety for given seeding conditions, cultivation (agrotechnological regimes, fertilizer dose components, irrigation, boundary conditions for these varieties and soil types).

Suppose given:
-set of alternatives (selection varieties of cotton depending on soil type and fertilization regime) - $X = \{x_1, x_2, ..., x_n\}$;
- sets of characteristics (biological and technological characteristics, by which the acceptable variety is selected) - $P = \{p_1, p_2, ..., p_k\}$;
- the degree of fuzzy ratio of the preference of the characteristics $p_j \in P$ on the set of alternatives X, described by membership functions $\mu_{R_j}(x_{i_1}, x_{i_2})$;
- degrees of importance $p_j \in P$, described by membership functions $\mu_R(p_j, p_l)$, $p_j, p_l \in P,\ j \neq l$, in the alternative $x_i \in X$;
- fuzzy ratio of preferences of alternatives (x_i, x_l) on the basis of p_j - R_j;
- fuzzy relation of preferences of signs in alternatives R.
The degrees of fuzzy ratio of non-dominant preferences, non-dominated alternatives according to the relevant characteristics in the alternatives are asked by experts.
It is required, in the formulated conditions of fuzzy nondomination of alternatives and attributes, to choose the most acceptable alternative for the totality of all characteristics.
This is achieved using the following algorithm [12]:

4. Algorithm for Solving the Problem

Matrices of preferences are constructed R_k, taking into account only the characteristic p_k.
2. Assuming that the features in question have a different degree of importance: some of them are the most significant, others - play a secondary role, the importance of the characteristics is characterized by a fuzzy relation of the preference for the characteristics of R.
3. There is an intersection of fuzzy relations $R_1, ..., R_k$, which is denoted by Q_1:

$$Q_1 = R_1 \cap R_2 \cap \cdots \cap R_k .$$

3.1. For Q_1 there is a non-dominant set of alternatives $Q_1^{НД}$.
3.1.1. The inverse matrix Q_1^{-1} is determined.
3.1.2. From each element of the matrix Q_1^{-1}, the corresponding element of the matrix Q_1 is subtracted. In this case, if the result is a negative number, then it is replaced by zero. The result is a matrix Q_1^0.
3.1.3. In each row of the matrix Q_1^0 is the maximum value $r(x_i), i = 1,2,..., n$.
3.2. The values obtained are subtracted from unity. As a result, the required membership functions $\mu_{Q_1^{НД}}(x_i)$ of the obtained non-dominant alternatives $Q_1^{НД}$ are calculated.

Thus, a set $Q^{НД}$ a collection of elements $x_1, x_2, ..., x_n$, each of which has its own degree of belonging $\mu_{Q_1^{НД}}(x_i)$ to a fuzzy set $Q^{НД}$.

4. Similarly, there is for R the non-dominated set $R^{НД}$. The obtained degrees of affiliation $\mu_{R^{НД}}(p_1), \mu_{R^{НД}}(p_2), ..., \mu_{R^{НД}}(p_k)$ are denoted by $l_1, l_2, ..., l_k$, respectively, using which the weights $\lambda_m, m = \overline{1,m}$ are calculated for each of the characteristics.

5. A matrix Q_2 is constructed whose elements are calculated by the formula:

$$\mu_{Q_2}(x,y) = \sum_{m=1}^{k} \lambda_m \mu_{R_m}(x,y).$$

6. It is based $Q_2^{НД}$ on the algorithm described above.

7. The intersection $Q = Q_1^{НД} \cap Q_2^{НД}$ is constructed.

The choice of an alternative having the maximum degree of membership in Q is considered rational.

5. Computational Experiment

The experiment was carried out for the selection problem of four selection varieties: C-4727, Tashkent 1, 108-F, 159-F cotton ($X = \{x_1, x_2, ..., x_4\}$) better in the following characteristics ($P = \{p_1, p_2, ..., p_5\}$): yield, fiber length, fiber strength, absolute seed weight, seed oil [14].

1. According to the proposed scheme for setting and solving the problem under consideration, fuzzy information about the initial data is represented in the form of the following preferences matrices $R_1, R_2, ..., R_5$:

$$R_1 = \begin{bmatrix} 1 & 0{,}78 & 0{,}66 & 0{,}61 \\ 1 & 1 & 0{,}87 & 0{,}80 \\ 1 & 1 & 1 & 0{,}92 \\ 1 & 1 & 1 & 1 \end{bmatrix},$$

$$R_2 = \begin{bmatrix} 1 & 1 & 0{,}99 & 0{,}98 \\ 0{,}98 & 1 & 0{,}98 & 0{,}97 \\ 1 & 1 & 1 & 0{,}99 \\ 1 & 1 & 1 & 1 \end{bmatrix},$$

$$R_3 = \begin{bmatrix} 1 & 1 & 0{,}99 & 0{,}99 \\ 1 & 1 & 0{,}99 & 0{,}99 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix},$$

$$R_4 = \begin{bmatrix} 1 & 1 & 0{,}96 & 0{,}95 \\ 0{,}98 & 1 & 0{,}94 & 0{,}93 \\ 1 & 1 & 1 & 0{,}99 \\ 1 & 1 & 1 & 1 \end{bmatrix},$$

$$R_5 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 0{,}98 & 1 & 0{,}97 & 1 \\ 0{,}99 & 0{,}98 & 1 & 1 \\ 0{,}95 & 0{,}97 & 0{,}96 & 1 \end{bmatrix}$$

2. Matrices of preferences are constructed

$$R = \begin{bmatrix} 1 & 1 & 1 & 0{,}9 & 1 \\ 1 & 1 & 1 & 0{,}9 & 1 \\ 1 & 1 & 1 & 0{,}9 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0{,}9 & 1 \end{bmatrix}.$$

3. It is found $Q_1 = R_1 \cap ... \cap R_5$, the inverse matrix Q_1^{-1} is constructed and Q_1^0 is calculated:

$$Q_1 = \begin{bmatrix} 1 & 1 & 0{,}66 & 0{,}61 \\ 0{,}98 & 1 & 0{,}87 & 0{,}80 \\ 0{,}99 & 0{,}98 & 1 & 0{,}92 \\ 0{,}95 & 0{,}97 & 0{,}96 & 1 \end{bmatrix},$$

$$Q_1^{-1} = \begin{bmatrix} 1 & 0{,}98 & 0{,}99 & 0{,}95 \\ 1 & 1 & 0{,}98 & 0{,}97 \\ 0{,}66 & 0{,}87 & 1 & 0{,}96 \\ 0{,}61 & 0{,}80 & 0{,}92 & 1 \end{bmatrix},$$

$$Q_1^0 = \begin{bmatrix} 0 & 0 & 0{,}33 & 0{,}34 \\ 0{,}02 & 0 & 0{,}11 & 0{,}17 \\ 0 & 0 & 0 & 0{,}04 \\ 0 & 0 & 0 & 0 \end{bmatrix}.$$

3.2. The matrix $Q_1^{НД}$ is found:

$$Q_1^{НД} = \begin{bmatrix} 0{,}66 & 0{,}83 & 0{,}96 & 1 \end{bmatrix}.$$

4. Using the same scheme, it is found $R^{НД}$ and calculated the weighting coefficients λ_i:

$$\lambda = \begin{bmatrix} 0{,}19 & 0{,}19 & 0{,}19 & 0{,}24 & 0{,}19 \end{bmatrix}.$$

5. Q_2 is calculated:

$$Q_2 = \begin{bmatrix} 1 & 0,95 & 0,9 & 0,89 \\ 0,97 & 1 & 0,93 & 0,92 \\ 0,99 & 0,99 & 1 & 0,96 \\ 0,98 & 0,99 & 0,98 & 1 \end{bmatrix}.$$

6. $Q_2^{НД}$ is found:

$$Q_2^{НД} = \begin{bmatrix} 0,91 & 0,93 & 0,98 & 0,93 \end{bmatrix}.$$

7. The intersection is constructed:

$$Q = Q_1^{НД} \cap Q_2^{НД}:$$

$$Q = \begin{bmatrix} 0,66 & 0,83 & 0,96 & 0,93 \end{bmatrix}.$$

Thus, the ranking results of all breeding varieties showed that variety 108-F is the best among the proposed selection varieties of cotton, since the resulting value of the degree of belonging of this variety to the fuzzy set Q is the largest (0.96).

6. Conclusion

Analysis and design of complex processes and systems, as well as their management in real conditions, usually occurs in the presence of non-stochastic uncertainties, having an indistinct, vague character. Typical uncertainties that are present in the process of evaluating the options for their structural and functional characteristics are fuzzy, vague uncertainties, for example, the incompleteness and fuzziness of many initial data, the qualitative and subjective nature of the evaluation criteria, the heuristic nature - the fuzziness of the initial models of the projected systems and processes that determine the application soft procedures for analysis, forecasting, evaluation, selection and decision-making. In these cases, the classical statistical methods of investigating operations do not provide finding and making correct decisions. To develop these methods, it is promising to use intelligent information technologies of soft

A promising area of research in this area is the development of methods for solving problems of the PSSR using a combination of "Soft Computing" technologies: fuzzy sets, neural networks, genetic algorithms, evolutionary modeling and programming.

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