ARRANGING ALTERNATIVES FOR THE SOWING STRUCTURE BY RANKING METHOD AND FUZZY SETS

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Abstract
The selection of agricultural plants for sowing and planning the economic success in production is done in conditions of uncertainty and high risk. The farmer plans crops for sowing on the basis of available data and experiences. Yield in the next year is determined by quality and farmland size, the structure of husbandry production, machinery supply, possibility to provide necessary working capital under favorable conditions, adequate labor and climatic conditions. The factors, which cause the biggest uncertainty in achieving returns in agricultural production, can be quantified by the valuation method. This paper presents the valuation method at planning the structure of sowing: wheat, chamomile and mint.
Keywords:
Uncertainty factors, ranking method, fuzzy sets

Introduction

The concrete yield of some crop depends on crop rotation, depth of plowing, quantity of (mineral) fertilizer consumption, herbicide, crop-dusting, seed (grain) sort and quality. The cited factors can be quantified. Weighted indexes for some factors can be determined on the basis of data from the previous years. Starting from it, a general model can be designed to determine optimal conditions for husbandry production and expected yield.

Husbandry yields also depend on the climatic conditions as rainfall amount, temperature, the depth of the snow, storms, and so on. The cited factors cannot be easily predicted and quantify in advance. Decisions on crop sowing are made under conditions of uncertainty and high risk caused by:

- Many relevant factors that cannot be measured,
- Instability and nonlinearity of relevant factors,
- Lack of information for quantifying and measuring relevant factors influence,
- Insufficient exactness and information unavailability.

The criteria, limitations and performances of measures of alternatives bear in themselves some aspects of indefiniteness: in determinativeness, multiple aspects of meaning, incompleteness and fuzziness (Sedlak et al., 2013). The method based on the unique evaluation of criteria will be applied for solving the cited uncertainties in husbandry. The evaluation method can be applied if the criterion values can be treated as estimates or it can be transformed into them.

This paper will present the decision analysis process both for decision making under different decision criteria, type, and quality of available information. Basic elements in the

analysis of decision alternatives and choice were described as well as the goals and objectives that guide decision making.
The evaluation method is similar to R. Jain's method of arrangement (Jain, 1977) that is based on the weighted estimate aggregating. As estimate processing can be described with the help of many rules, the method forms the fuzzy set of extra estimates using aggregation based on the rules, and it can be also programmed as a fuzzy system.

1. Literature review

Making decision in agriculture is almost always accompanied by conditions of uncertainty wrote Ben-Haim. More information the decision maker has, the better the decision will be. Treating decisions as if they were gambles is the basis of decision theory. This means that the decision makers have to trade off the value of a certain outcome against its probability. To operate according to the canons of decision theory, must compute the value of a certain outcome and its probabilities; hence, determining the consequences of choices. The origin of decision theory is derived from economics by using the utility function of payoffs. It suggests that decisions be made by computing the utility and probability, the ranges of options, and also lays down strategies for good decisions (Ben-Haim, 2001). Richards thought that there are many selection criteria that have been proposed to increase drought resistance of our crops have had little, if any, impact on improving crop yields in dry environments. In this paper the author gave three different examples to emphasize the considerations and which show substantial promise in targeting traits to improve yield under drought (Richards, 1996).
Some authors used game theory to work out an optimal plan least sensitive to weather variations, and used sensitivity analysis to obtain the information for production planning (Qingzhen et al., 1991).
In several papers Sedlak and coauthors used experts estimate logic rules, based on experience, previous knowledge, and depending on the location, climate, agricultural and technological equipment, as well as the development of national agriculture (its place and role in the economy of the country) (Sedlak et al., 2010).
There are many hazards that affect agricultural production (Mihailovic, et al., 2014). These dangers come mostly from nature and may affect a large area and cause great damage. Man himself is sometimes the cause of these events. It is known that Serbia is among the countries that have extremely good natural conditions for this production. (Birovljev et al., 2015).

2. Characteristics of the method for evaluating uncertainty factors

To apply the method, it is necessary to arrange alternatives described by many criteria, where the values of criteria are fuzzy sets. To treat the problem simpler, we chose the unique, five-degree way of criteria description. The same fuzzy set given by a triangular fuzzy number was associated to every estimate. This way of a unique criterion description enabled to evaluate variants in the way usual in education. This evaluation considers every criterion, with all possible values, and the result can be used as a basis for variant evaluating.

2.1. The characteristics of the ranking method appear in the following way: The characteristics of the method appear in the following way:

1. We describe different criteria by the same estimates, but the identical, gradual evaluation is not necessary in all criteria.

2. Estimates are defined by fuzzy sets where their belonging functions show the middle estimates of the estimates set in the belonging degree. Besides, they must point to the fact that the middle estimates and values, being in their immediate environment (for example, 1.5; 2.5; 3.5, and so on) belong to two neighboring sets. The estimate set (supp) can be determined by the interval which is, for example, the estimate -0.6, the estimate +0.6. From the interval **p**, the neighboring ones have the mutual part. The belonging function of fuzzy estimate set is the symmetrical function which in the middle of the interval takes the value 1, and from the middle in both directions, it is monotonous falling. The choice of the appropriate function can be found on the basis of a poll or on the basis of looking for an approaching function. We made the choice on the basis of looking for an approximate function. So, to describe the belonging function, we chose the triangular fuzzy number (we chose the triangular for the belonging function for every estimate).
3. To realize the average which can be considered to be the estimate, the result is given to **p**-estimates. The **p** value determines the highest degree of evaluation, which is applied with criteria. Let's call this set, consisting of **p** estimates, the set of results. In that case, the sum of weighted estimates will be some subset of the set of results (let's call it the set of extra estimates). The center of gravity of this subset corresponds to the average.
4. To consider the center of gravity the estimate, we have to determine the rule by which the estimates describing alternatives will be copied on the estimates in the set of results.

The following rules are necessary:

- One subset of the same estimate in the set of results is associated to every estimate. The belonging function of the subset is also the triangular fuzzy number.
- Every estimate exerts influence on the result to the degree corresponding to the gravitational value of criteria that belongs to it (maximal gravitational value is 1). However, it should be noted that only criteria with higher gravitational values can exert influence on the final result (Yager's level set method assumes the same). We can attain if we multiply the height of the subset by the square of the gravitational value.
- If more criteria get the same estimate, we associate different subsets in the set of results of the same estimate to the estimates multiplied by different weighted indexes.

Let us assume $x=\{a_1,a_2,...,a_n\}$ is the final set of alternatives, and then take $K=\{k_1,k_2,...,km\}$ as the final set of fuzzy criteria. Let $g_1,g_2,...g_m$ be the weights belonging to criteria, where the maximal value of the weight is 1.

Let every K_j fuzzy criteria be over x a linguistic variable ($1\leq j\leq m$), also letting $K_1=\{S_1,S_2,...,S_{p1}\}$ where S_1, S_2,…, S_{p1} are the values of the linguistic variable. The functions of belonging (μ) $S_1,S_2...,S_{p1}$ to fuzzy sets are determined on the basis of marks:

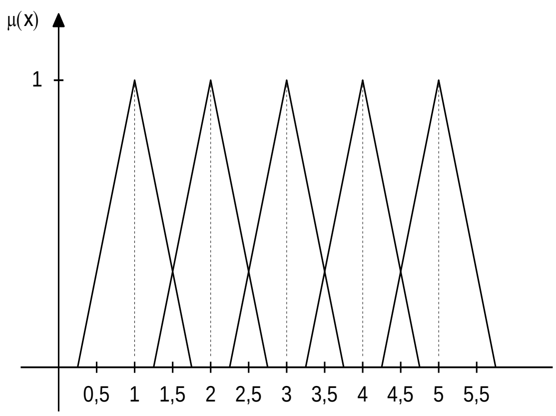
$$\mu S1(x) \quad \text{supp } S1 = [0,4;1,6] \tag{1}$$

$$\mu S2(x) \quad \text{supp } S2 = [1,4;2,6] \tag{2}$$

...

$$\mu Sp_j(x)\ ) \quad \text{suppSp}_j\ [p_j\text{-}0,6;p_j+0,6] \tag{3}$$

Let every function of belonging be over the sets of the same form of a triangular fuzzy set. The degree of marking (p) can be any whole number, but the exactness and possibilities of expression differ from case to case (Figure 1 represents the fuzzy sets of the criteria K, in the case p=5). The alternative a_1(IS i S_n) with S_1,S_2,... S_{p1} fuzzy sets of criteria can be evaluated.



Source: Sedlak, O., Cileg, M., Kis, T. (2013). Decision Support System with Mark-giving Method. *ICORES 2013 – International Conference on Operations Research and Enterprise Systems (Conference).* 338-343.

Fig. 1 Fuzzy sets of the criteria K

The mark-giving method assigns every alternative a_1 one fuzzy set R_i, i.e. extra marks, which will appear in one E fuzzy set of results. The set E will enable the set R_i to be compared, as well the set R not to be defined. The set E is a fuzzy set identical with the set of criteria:

$$E = \{S_1,S_2,...,S_p\} \quad (4)$$

where K = max P_j (j=1,2,...m), and every R set will be formed on the basis of partly activated subsets of the E set.

Copying and aggregations of fuzzy sets are necessary for forming R_1 sets. In the program package of fuzzy logic, which is applicable, these operations can be performed only with the help of such program blocks.

Aggregating obtained subsets with the estimate copying (t-konorma) in the set of results, we get the set of extra estimates. The center of set gravity of extra estimates, i.e. the projection on the x-axis can be considered as an estimate.

3. The choice of sowing crop by the evaluation method

Three crops are planned for sowing: chamomile, mint and wheat. But, it is necessary to select only one taking into consideration factors exerting influence on yield, therefore on our decision about the choice of crop for sowing. Based on the long-range research of experts, and farmers' working experiences (considered experts in this field), we chose 15 most important factors enabling yield planning in relation to immeasurable criteria.

These factors represent the limitations; therefore we called them the main criteria and relating to the strength of their possible influence, we added them the weighted indexes. Weighted indexes are determined on the basis experts' experiences. To their opinion, yield of some crops depends on different factors, in different extent. Table 1 includes criteria and their assumed weighted indexes.

Table 1 Criteria and their weighted indexes

Criteria	Weighted index
1. Forming market prices of agricultural crops	1,00
2. Crop rotation	0,90
3. Condition of land	0,80
4. Work safety of machines and connecting machines	0,70
5. Choice of plant sort (sort or hybrid)	0,50
6. Seed germination and seedling quality	0,31
7. Prompt execution of technological operations	0,25
8. Quality of mineral and organic fertilizers	0,24
9. Quality of protective measures	0,22
10. Disease of plants and pests	0,21
11. Air and land temperature	0,19
12. Reliability of wether forecasts	0,16
13. Precipitation (rain, snow, fog, hail, hoar frost, dew, freezing rain, and so on)	0,15
14. Climatic conditions	0,14
15. Labor costs	0,11

Table 2 includes the description of yield of some crops with the help of estimates regarding to the criteria. The estimate points to the influence of some criteria (1-15) on crop yield; it ranges from five (big influence) to zero (no influence). For example, suppose that labor costs for soil cultivation (criterion 15) has no influence on any considered crop, while the policy of market pricing, as one of factors having influence on sowing, is evaluated by the highest estimate with all tree crops (Vasilescu et al., 2010).

Table 2 Yield relation of some crops under influence of different criteria

Crop criterion	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Chamomile	5	5	4	4	4	4	4	3	3	1	3	3	3	4	0
Mint	5	5	3	4	4	5	4	3	3	2	3	3	3	4	0
Wheat	5	5	4	5	5	4	3	3	3	3	3	3	3	3	1

The obtained results are processed according to the advance established rules, which are cited in detail at the beginning of the work (according to the rules of the evaluating method). These results represent the estimate of crop uncertainty. The better result is, the bigger uncertainty in realizing the planned yield, and reversely.

Table 3 Result of arrangement

Crop	Results of the evaluation method
Chamomile	4,01
Mint	3,96
Wheat	3,51

According to this estimate, it can be concluded that (Table 3) the influence of factors that are indefinite, immeasurable are at the same time the strongest on chamomile, and it points to the fact that its sowing is with the highest risk. Risk with wheat is the lowest.

However, if the decision on the choice of crop is made on the basis of economic indicators only (Table 4), chamomile turns to be economically the most acceptable from the standpoint of realized profit per kg (Table 5) and profit rate (Table 6). The economic analysis does not quantify the influence of uncertainty which can have the decisive influence on the realized yields in agricultural production.

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Table 4 Average yield of crops and income (in €)

Crops	Yield kg/ha	Redemption price	Income
1	**2**	**3**	**4 (2 × 3)**
1. Chamomile	8.000	0,17	1.330
1.1. flower	3.000	0,26	780
1.2. herb	5.000	0,11	550
2. Mint	25.000	0,11	2.729
2.1. first year leaf	5.100	0,17	867
2.2. first year herb	9.900	0,08	792
a) First year/total	15.000	0,11	1.659
2.3. second year leaf	3.000	0,17	510
2.4. second year herb	7.000	0,08	560
b) Second year/total	10.000	0,11	1.070
3. Wheat	5.500	0,18	990

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Table 5 Direct production costs per hectare with farmers (in €)[1]

Elements	Chamomile	Mint		Wheat
		1 year	2 year	
1. Tilling and sowing	130,00	151,50	-	200,00
2. Seed – planting material	208,50	810,50	-	26,50
3. Mineral fertilizer	105,50	193,50	183,00	313,50
4. Care and crop protection	20,50	33,50	15,00	30,50
5. Crop – dusting	15,00	12,00	12,00	16,00
6. Combining (I+II)	165,50	80,00	80,00	112,50
7. Crop transport	80,00	96,00	65,00	130,00
8. Total	725,00	1.377,00	355,00	829,00

[1] Note: Account in current prices

9. Average costs per kg.	0,09	0,07	0,15
10. Selling price	0,17	0,11	0,18
11. Profit per kg (10 – 9)	0,08	0,04	0,03

Table 6 Economic production indicators per hectare in crops (in €)

Elements / Crops	Income	Costs	Profit	Engaged capital	K_e [2]	do' (%)
1	2	3	4	5	6 (2 : 3)	7 (4: 5)
1. Chamomile	1.330	722	608	6.270	1,84	9,70
2. Mint First year	1.659	1.377	282	6.770	1,20	4,17
Second year	1.070	353	717	5.760	3,03	12,45
Total	2.729	1.730	999	12.530	1,58	7,98
Average	1.365	865	500	6.265	1,58	7,98
3. Wheat	990	828	162	6.800	1,20	2,38

Conclusions

Crops planted cause economic success of farmers according to yield, costs, engaged capital and market prices. The most efficient economic sowing plan, at any level of investment and results, means the minimal realization of risk level. Crop yields depend on many measurable and immeasurable factors.

For measurable factors, it is possible to set the model for determining the optimal structure of agricultural production, but the reliability of factors causing yields in all production phases is very important.

For immeasurable factors, the fuzzy method, based on evaluation, can be applied, where fuzzy criteria can be described by estimates, or where criterion values can be considered to be estimates. This method can include many competitive and conflict criteria in a relatively simple way.

The mark-giving-method treats criteria as a fuzzy system with the rules of aggregation. It can be easy programmed by fuzzy logic software. The method is, in some points, similar to Jain's method of alternative ordering, but an ordering on the basis of weights, to assigned alternatives is a different principle in relation to Jain's method.

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[2] K_e – rate/coefficient of return; do'- profit rate.

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