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OPTIMIZATION OF VEGETABLES FOR CONSUME IN FRESH CONDITION PRODUCTION STRUCTURE

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Abstract

Vegetables production has important role in rural development. The real hypothesis for it, are: Production time of vegetables is relatively short, what give opportunity for 2-4 seeds by year; return of the capital is faster; high economic effectiveness and efficiency; vegetables is very important “healthy food”; there are a 20-30 sorts of vegetables for production in our conditions; vegetables production is very intensive.

In this paper the vegetables production structure was optimizing. Only production of vegetables for consume is optimizing. The method of linear programming is applied, by using the LINDO program. In the model for optimization, 26 of sort of vegetables are planned. Depends of vegetables position in the sowing structure, in model was included 55 independent variables, in total. For objective function, the gross margin is used (difference of total value of production, and direct variable costs (material, and external services).

The standard technologies in irrigation and actual prices of outputs and inputs are used in calculation. In the model are included next grope of constrains: agro-technical, bio-technical constrains, limitations of land capacity (first, second and third sowing), market limitations, while, limitations of manpower and machinery capacity in the months of the intensive works are not included.

The results of optimizing are showed that 41 independent variables are included in optimal structure of production. The index of soil usage is 276 %. Structure of soil usage is next: 100 % in first sowing, 98 % of second sowing, and 78 % of third sowing. Gross margin in that, optimal structure of vegetables production for consume in fresh condition is 37.500 euro per hectare of farm, per year.
Key words: vegetables, production, optimization

Introduction

The main objective of this paper is to define, solve and analyze the general model for optimization sowing structure of vegetable for consume in fresh condition. On the problem of optimal vegetable production structure works Novkovic, Radojevic (2002), and Krasnic (2004), who is defined optimal models of industrial vegetables production, and vegetables for consuming fresh condition, in agricultural enterprises, and farms. Novkovic (1990, 2003), and Novkovic, Somogyi (1991) defined models for multi/criteria optimization of agricultural production.
From the aspects of using operational research methods in vegetable production, Mutavdzic et. al. (2010), and Novkovic et. al. (2009) gave contribution.

The model for optimization of vegetables for consume in fresh condition production structure, is classical model of linear programming. The Objective function is maximal economic effectiveness, as the absolute measure of economic success, expressed in money. Category which is used for express economic effectiveness is gross margin, as a difference of total

value of production, and direct variable costs (material, and external services) in vegetables production.

Method of Research and Data Source

For optimizing of vegetables production for consume in fresh condition, based on maximal effectiveness, the classical model of linear programming is used. In the concrete model, is included 26 different kinds of vegetables. Some kind of vegetables can be included for a few times in the model, depend of sowing order (first, second, third sowing), so the total number of independent variables in concrete model is 55.

In the model is defined soil capacity on 10 hectares, and limits for second and third sowing. For that limitations the important was earlier crop (vegetable kind), and period of production, and time of sowing. That needs to define large number of agro-technical limitations. Total number of limitations in the model is 58.

The coefficient of objective function criteria is planned gross margin per hectare. Planned coefficient is accounted based on modern agro-technology of production, and actual prices of direct inputs of production, and vegetables for consume in fresh condition. Criteria function is maximal planned gross margin (value of production minus direct variable costs), what means that gross margin consist of: fix cost, indirect cost, farmers labor cost, and profit.

Result of research

Definition of mathematical model of linear programming

The general model for optimizing of vegetables production for consume in fresh condition has a next structure:

Independent variables:

$X_{ijk} > 0$

X_{ijk} – area of vegaetables from group „i“, kind „j“ in sowing order „k“ in ares.

i = 1(1)6; j = 1(1)15; vegetables king k = 1(1)3;

i=1 root vegetables
i=2 bulb vegetables
i=3 tubers vegetables
i=4 fruit-bearing vegetables
i=5 pulses vegetables
i=6 leafy vegetables

k=1 first sowing
k=2 second sowing
k=3 third sowing

Matrix of limitations:

1. Limitation of soil capacity in the first sowing (10 hectare, or 1000 acres)
2. Limitations of soil capacity for the second sowing (limitations from 2, to 15)
3. Limitations of soil capacity for the third sowing (limitations from 16, to 26)
4. Biotechnical and agro-technical limitations – limitations of maximal and minimal areas of certain kind of vegetables (limitations from 27 to 58).

***Objective function**:*

Maximizing of effectiveness (gross margin):

$$\sum_{i=1}^{6} \sum_{j=1}^{15} \sum_{k=1}^{2} gm_{ijk} X_{ijk} = GM_{max}$$

gm_{ijk} = planned gross margin per acres of independent variables X_{ijk} (RSD/a)

GM_{max} = Maximal total gross margin (RSD).

Solution of the model

Optimal solution, or defining of optimal sowing structure of vegetables intended for consume in fresh condition was achieved after 37 iterations, and it is presented in **table 1**. From the potential 55 independent variables in optimal solution (optimal sowing structure) is included 41.

In the model are not included limitations of direct man labor in the periods of seasonal works, because it is presumption that it is possible to provide enough good seasonal workers. Also, limitations of certain kinds of machinery are not included, too. The presumption is that, those limitations are not real limitations of production, considering the farm size (1000 acres, or 10 hectares).

In the optimal sowing structure are included: 3.99 ha (14.5%) of root vegetables, 2.51 ha (9.1%) of bulb vegetables, 1 ha (3.6%) of tubers vegetables, 1.99 ha (7.2%) of fruit-bearing vegetables, 4.77 ha (17.3%) of pulses vegetables and 13.34 ha (48.3%) of leafy vegetables.

Optimal sowing structure in sowing order (first, second, third sowing) is presented in **table 2**. Based of table data it is possible to see that for second sowing is 97% of soil and for the third sowing 78% of area of first sowing.

Maximal gross margin in optimal sowing structure of vegetables for consume in fresh conditions 42.8 millions of RSD. Converted in euro it is about 350 thousand. Calculated per hectares of farm size (10 hectare), it is 4.3 million RSD/ha, or 35 thousand euro/ha. The real indicators were obtained when calculate gross margin on hectares of used soil in all three sowing, what is 276 ha. In that case, maximal gross margin per unit of land of the farm, per year is 1.55 million RSD/ha, or 12.900 euro /ha.

Table 1 Optimal solution of model (optimal sowing structure)

Label i j k	Vegetables	Area (a)	Label i j k	Vegetables	Area (a)
X 1 2 2	Carrot, after kale	22	X 4 6 2	Eggplant, after peas	11
X 1 5 2	Celery, after radish	111	X 4 7 2	Pickles after green bean	11
X 1 8 1	Spring radish	133	X 4 8 2	Early cucumber, after spring lettuce	22
X 1 9 3	Winter radish, after early cucumber	22	X 4 9 2	Late cucumber, after spring lettuce	22
X 1 10 3	Winter radish, after eggplant	11		**Fruit-bearing vegetables**	**199**
X 1 11 2	Autumn daikon, after green bean	33	X 5 1 1	Peas	377
X 1 12 1	Early chard	67	X 5 2 1	Green bean	33

	Root vegetables	**399**	X 5 2 2	Turnip green bean, after early cabbage	45
X 2 1 1	New onion	22	X 5 2 3	Turnip green bean, after early cucumber	22
X 2 3 1	Spring garlic	22		**Pulses vegetables**	**477**
X 2 4 3	Winter garlic, after pepper from seed + celery	95	X 6 1 1	Spring lettuce	67
X 2 6 2	Leek after early chard	34	X 6 4 3	Autumn lettuce, after carrot	22
X 2 7 2	Winter leeks, after early cauliflower	45	X 6 5 3	Winter lettuce, after pepper from seeds & seedlings + tomato from seedlings	66
X 2 8 2	Autumn leek after early potato	33	X 6 6 1	Spring spinach	67
	Bulb vegetables	**251**	X 6 6 3	Јесењи спанаћ, after early tomato from seedlings	45
X 3 1 1	Early potato	67	X 6 7 3	Winter spinach, after carrot+ cauliflower +kale + turnip green bean	500
X 3 2 1	Potato	33	X 6 8 1	Early cabbage	45
	Tubers vegetables	**100**	X 6 8 2	Late cabbage, after spring garlic	11
X 4 1 2	Pepper from seed, after spring radish peppers from seed	22	X 6 9 1	Early Kale	22
X 4 2 2	Pepper from seedlings after spring garlic	22	X 6 10 2	Late kale, early potato	67
X 4 3 2	Tomato from seed, after spring lettuce	22	X 6 11 1	Early cauliflower	45
X 4 4 2	Early tomato from seedlings, after spring spinach	45	X 6 11 2	Late cauliflower, after green bean	366
X 4 5 2	Tomato from seedlings, after spring spinach	22	X 6 12 2	Late cabbage, after spring garlic	11
				Leafy vegetables	**1.334**

Table 1 Optimal sowing structure of vegetables for consume in fresh condition, in sowing order

Label	Vegetables	Area (a)	Label	Vegetables	Area (a)
X181	Spring radish	**133**	X462	Eggplant, after peas	**11**
X1121	Early chard	**67**	X472	Pickles after green bean	**11**
X211	New onion	**22**	X482	Early cucumber, after spring lettuce	**22**
X231	Spring garlic	**22**	X492	Late cucumber, after spring lettuce	**22**
X311	Early potato	**67**	X272	Winter leeks, after early cauliflower	**45**
X321	Potato	**33**	X522	Turnip green bean, after early cabbage	**45**
X511	Peas	**377**	X682	Late cabbage, after spring garlic	**11**
X521	Green bean	**33**	X1112	Autumn daikon, after green bean	**33**
X611	Spring lettuce	**67**	X6102	Late kale, early potato	**67**
X661	Spring spinach	**67**	X6112	Late cauliflower, after green bean	**366**
X681	Early cabbage	**45**	X6122	Late cabbage, after spring garlic	**11**
X691	Early Kale	**22**	X282	Autumn leek after early potato	**33**
X6111	Early cauliflower	**45**		**Second sowing**	**977**
	First sowing	**1000**	X193	Winter radish, after early cucumber	**22**
X122	Carrot, after kale	**22**	X1103	Winter radish, after eggplant	**11**
X152	Celery, after radish	**111**	X243	Winter garlic, after pepper from seed + celery	**95**
X262	Leek after early chard	**34**	X643	Autumn lettuce, after carrot	**22**
X412	Pepper from seed, after spring radish peppers from seed	**22**	X523	Turnip green bean, after early cucumber	**22**
X422	Pepper from seedlings after spring garlic	**22**	X653	Winter lettuce, after pepper from seeds & seedlings + tomato from seedlings	**66**
X432	Tomato from seed, after spring lettuce	**22**	X663	Јесењи спанаћ, after early tomato from seedlings	**45**
X442	Early tomato from seedlings, after spring spinach	**45**	X673	Winter spinach, after carrot + late cauliflower+ late kale+ turnip green bean	**500**
X452	Tomato from seedlings, after spring spinach	**22**		**Third sowing**	**783**

Conclusion

The model for optimization production structure of vegetables for consume in fresh condition is showed the next:

- From potentional 55 independent variables in first, second and third sowing in optimal sowing structure are included 41 variables from each group of vegetables: root vegetables **7,** bulb vegetables 6, tubers vegetables 2, fruit-bearing vegetables 9, pulses vegetables 4, and leafy vegetables 13 variables;
- Optimal structure of production provide from ten hectares of land gross margin of 42.8 millions RSD, or 350 thousand euro.
- Optimal sowing structure of production of vegetables for consume in fresh condition provide 276 % of land usage, the most important factor of production on the farm;
- Usage of land with 276 % in intensive production, provide to farmers gross margin of 12.900 euro//ha of used land in tree sowing, per year.

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