

Biblid: 0350-2953 (2019) 45(4): 163-170
UDK: 631.4;

Originalni naučni rad
Original scientific paper

**SELECTION OF AN OPTIMAL CROP PRODUCTION MODEL BASED ON
LAND RECLAMATION OF SALINE SOILS
IZBOR OPTIMALNOG MODELA PRELAZNE POLJOPRIVREDNE
PROIZVODNJE, ZASNOVANE NA KOMPLEKSNIM MELIORACIJAMA
SLANIH ZEMLJIŠTA**

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SUMMARY

Selection of the reclamation crop production optimal models have been based on:

- A. Production economical analysis of chosen crops tolerant to high salts content.
- B. Economical analyses of Land Cultivation (Mechanical Reclamation), technology varieties applied.
- C. Economical-financial analysis of the irrigation methods applied during the reclamation crop production period.

After the 2nd stage of land reclamation completion, all soil classes might be included in the regular, stable production where all crop varieties could be cultivated, i.e. that the fundamental task of the Land Reclamation Process has been attained.

Key words: Reclamation production, ameliorative crop, initial salt leaching, crop rotation models

1. INTRODUCTION

The problem of desalinization of highly saline soils has drawn significant attention of researchers, not only in past, but at present time, too. Having in mind the wide area of “unproductive” lands, it’s obvious that only the minor part has been reclaimed.

The majority of scientific researchers have been realized within the territory of Republic of Iraq (South-East Mesopotamia), where the most of the investigations has been organized.

Besides Iraqis, Dutch, Russian and American, a research activity has been dominantly established by the Serbs.

Halomorphic soils of Serbia, the same as the equivalent once in the world, engrossed the significant vigilance of Serbian science. Part of examinations has escorted in field of chemical amelioration by gypsum and lime and their influence to chemical characteristics of “Slatine”.

Following 2 year Land Reclamation period the physical-chemical and biological soil properties are considerable improved, providing their transfer toward the “Normal Soils”, were cultivation of sustainable agriculture production may take place.

Regardless the significant scientific results attained in field of Land Reclamation all over the world where experimental examination took place, it's quite obvious that only the inconsiderable researchers have engaged economical dimension as a fundamental basis for the final selection of certain reclamation methods.

The subjective analysis, obtained and presented results referred to applied models of reclamation production, represents the integral part of the complete experimental investigations.

Having in mind the above mentioned, the Final Selection of the reclamation crop production optimal models has been based on:

A. Production economical analysis of chosen crops tolerant to high salts content as a basis for Crop Rotation Models Selections.

B. Economical analyses of Land Cultivation (Mechanical Reclamation), technology varieties applied.

C. Economical-financial analysis of the irrigation methods applied during the reclamation crop production period.

In accordance to the objective analyses, within 9 reclamation crops economically evaluated, three Crop Rotation Models, based on a three reclamation crops (Barley, Sweet clover and Sudan grass), have been emphasized and recommended.

Basically, the obtained and presented analysis results represent integrative input components estimation-gross expenses per ha, for each defined and selected reclamation production crop rotation model.

2. MATERIALS AND METHODS

Setting of II stage of Land Reclamation models investigations are denoted as reclamation-temporary production, realized at the same experimental plots where initial salt leaching process has been finalized in continuation, depending on the achieved soil salinity level. 3 experimental plots, representing different textural, physical-chemical soil properties including initial salt content, have been selected. The chosen experimental fields were 20 ha area, 60 ha, in total (Žeželj, B., 2013).

Prior to optimal reclamation models selection, the following integrative input-parameters of the analysis have been evaluated, subliming the kind, volume and costs of measures, goods or materials applied (Table 1).

Table 1. Integrative input variables evaluation analysis

No	Kind of inputs-evaluated	Inputs variables
1	Soil Type	Clay, Clay loam, Sandy clay loam
2	Crop Type	Barley, Wheat, Horse bean, Berseem, Alfalfa, Sweet clover, Potato, Sudan grass, Green grain
3	ECe-Salinity before sowing to 60cm depth (mmhos/cm at 25 ⁰)	2, 2-4, 4-8 8-16, 16-30 and > 30
4	Soil samples for laboratory analyses, at 0-30, and 30-60 cm depths	1 to 3 groups of analyses, before, during and after leaching and after harvesting
5	Kind of land preparation and technology measures applied	Sub soiling, disk harrowing, fine leveling, ploughing, pre sowing soil preparation, sowing, organic matter applic., embankments and irr.infrastructure constr. Crop care and protection, harvesting.
6	Nitrogenous and phosphate fertilizers application	Ammonia sulphate (21% pure N) Super phosphate (42% P ₂ O ₅)
7	Average underground water depth below the surface (cm)	50,60,100,110,148 and 156 cm
8	No. of monthly irrigation rates, over the differ system operation	From 10 to 200 applications
9	Drainage system incl. pumping station operation	Field drainage, open drain collectors, sub main and main drainage canals
10	Irrigation method-equipments applied	Surface: Border strip and basin Sprinkler: Self driving machines, with and without rain ramps

The following Crops are analysed: Barley, Wheat, Horse bean, Alfalfa, Sweet clover, Green grain, Potato, Sudan grass, Berseem (Mikšić, M., at al., 2010).

In order to simplify an objective variable crop production costs analysis, all the crops have been grouped into: Cereals (Barley, Wheat, Green grain and Berseem), Fodders (Alfalfa, Sweet clover, Sudan grass,) and Vegetables (only Potato is analysed, as the low salt tolerant crop as referenced one). Barley was analysed as winter season crop, Sudan grass and Green gram as summer crop, while Alfalfa and Sweet clover represented long year crops (Dieleman, P.J., 1973).

The following table (Table 2) represents the variable costs of different production inputs applied to the representative crop groups above anticipated.

Table 2. Cover Variants Costs (Gross margin) analysis per group of crops (Euro/ha)

Variables	Cereals	Fodders	Vegetables- (Potato)
<i>Seed material</i>	60	190	1.390
<i>Agrotech.operatins</i>	400	750	600
<i>Fertilizers application</i>	310	340	530
<i>Crop care and crop protection</i>	140	80	380
<i>Field and laboratory analyses</i>	450	900	450
<i>Irrigation system cost during the vegetation</i>	300	500	200
<i>Drainage system cost during the vegetation</i>	250	300	200
<i>Field irrigation infrastructure costs</i>	400	200	100
<i>Irrigation equipments</i>		550	
Total/ha	2.310	3.810	3.850

The above costs represent the groups of fixed prices involved, such as:

- Costs of repro-materials (seeds, fertilizers, fungicides, pesticides).
- Costs of ordinary agro technical operations applied.
- Costs of side and laboratory analyses (the most important one, i.e. soil salt salinity control by taking the samples separate from depths. 0-30 cm and 30-60 cm, before, during and after the crop production period. The no. of analyses depends on crop type, soil texture class, salt content, etc).
- Operational fixed cost, at the area of experimental plots of 60 ha, including Skilled and unskilled labours power, engaged in regular exploitation and maintenance, spare parts, oil and fuel, (belongs to irrigation and drainage system, already executed).
- The group of field irrigation infrastructures ordinary costs, related to the kind of crops (vegetation period duration) and irrigation methods applied (Border strip-over flooding and structures required, as well as Sprinkler irrigation and structures required).
- The group of cost that covers designed –“up to date “irrigation technology-machines, parts and elements (Popović, N., Vasiljević, Z., Todorović, S., 1989).

The following table presents inter relation between designed land reclamation criterions (salinity and soil classes in accordance to reclamation measures to be applied) and total input cover variant costs (Gross Margin Costs) for two crop groups (Cereals and Fodders). The vegetables (herewith Potato, used only as referenced), have been excluded from further analyses, as the shallow roots plants, showing low soil salt tolerance-resistance (Pearson, C.H., at al., 1989., Zdravković, M., Benkova, M., 2006).

Table 3. Total cover variant costs in relation to designed reclamation criterions (Eur/ha)

Salinity class	Class of Reclamation measures	Selected reclamation crop groups	
		Cereals	Fodders
I. < 20 mmhos/cm	I. Small	10.395	17.145
II. <ECo<40 mmhos/cm	II. Medium	20.790	34.290
III. ECo> 40 mmhos/cm	III. High	38.115	62.865
Total for Experimental field of 60 ha	I.II.III.	69.300	114.300

As the results of the presented analyses the final choice of 3 optimal reclamation production crop rotation models has been introduced (Tables 4, 5 and 6):

Table 4. Model A (Soil Salinity Class I, ECo < 20 mmhos/cm)

Crop Production Year	Growing season during the year	
	Winter: (October-May)	Summer: (April-September)
1	Barley	Fallow
2	Sweet clover	Fallow
3	Regular Crop production	

Table 5. Model B (Soil Salinity Class II, Eco >20<40 mmhos/cm)

Crop Production Year	Growing season during the year	
	Winter (October-May)	Summer (April-September)
1	Sweet clover	Sweet clover
2	Barley	Sudan grass
3	Regular Crop Production	

Table 6. Model C (Soil Salinity Class III, Eco > 40 mmhos/cm)

Crop Production Year	Growing season during the year	
	Winter: (October-May)	Summer: (April-September)
1	Barley	Fallow
2	Sweet clover	Fallow
3	Regular Crop Production	

3. RESULTS AND DISCUSSIONS

Reclamation crop production analyses and optimal models selection have been realized at the experimental fields of 60 ha area (20 ha each plot). Prior to the mentioned analyses, the measuring, notification and escorting of the suggested models emphasizing the II desalinization stage-Reclamation crop production.

In the Table 1, the results of integrative inputs variable as a basis for economical cover variable costs, related the different reclamation crop groups analyzed (Cereals, Fodders and Vegetables (only Potato as referenced non salt resistant crop at the area of only 1 ha), are shown. Different kind of Inputs variable are analyzed due to the aim of Land Reclamation Concept to be implemented.

Out of 9 selected reclamation production crops, the 3 groups are listed and registries: Cereals (Wheat, Berseem, Barley, Grain green), Fodders (Alfalfa, Sweet clover, Sudan grass) and Vegetable (Potato).

Table 2 represents the cover variant-variable costs per group of crops in euro/ha. So beside the regular expenses of repro material and agro technical measures-operation including the man power applied the specific costs such as side and laboratory analyses, Irrigation and drainage operational costs and irrigation technology applied are separately an additionally classified and analyzed. The results shows the highest cost of Vegetables-Potato as reference crop (3.850 euro/ha), than the Fodders (3.810 euro/ha) and finally the Cereals (2.310 euro/ha).

Table 4 shows total cover variant-variable costs in relation to designed reclamation criterions in euro/ha. The results are presented for each group of reclamation crops including a total area of 60 ha of experimental fields. The higher estimated cost are estimated for Fodders (114.300 euro/ha), the crops group with longer vegetation duration, bearing in mind the most of the inputs involved in analyses and lower for the Cereals (69.300 euro/ha), as one seasonal crops (winter or summer). In accordance to the above mentioned analyses, the final choice of 3 optimal reclamation production crop rotation models has been introduced and presented by the tables 5, 6 and 7.

4. CONCLUSIONS

1. Land Reclamation process has been realized upon two fundamental stages within 2 years period, upon the stages of initial salt leaching and salt leaching during the reclamation crop production, designed within the areas where the initial salt content is <4 mmhos/cm.
2. Regardless the significant scientific results attained in field of Land Reclamation all over the world where experimental examination took place, only the inconsiderable researchers have engaged economical dimension as a fundamental basis for the final selection of certain reclamation methods.
3. The selection of the reclamation production optimal model has been realized in accordance to the cover variable cost analyses (Gross Margin Costs), including the: a. Production economical analysis of chosen crops tolerant to high salts content. B. Economical analyses of land cultivation technology varieties applied. C. Economical-financial analysis of the irrigation methods applied during the reclamation crop production period.

4. The integrative input-parameters of the analysis have been evaluated, subliming the kind, volume and costs of measures, goods or materials applied in relation to groups of reclamation production crops (Cereals, Fodders and Vegetables).
5. Inter relation between designed land reclamation criterions (salinity and soil classes in accordance to reclamation measures to be applied) and total input cover variant costs (Gross Margin Costs) for two dominant crop groups (Cereals, Fodders). Potato is excluded, showing low soil salt tolerance-resistance.
6. The final choice of 3 optimal reclamation production crop rotation models is based on the high salt tolerant crops: Barley, Sweet clover and Sudan grass.

5. LITERATURE

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REZIME

Izbor optimalnog modela prelazne poljoprivredne proizvodnje je baziran na:

A. Ekonomskoj analizi izabranih kultura, tolerantnih na visok sadržaj soli u zemljištu.

B. Ekonomske analize diferentnih tehnoloških mera kultivacije zemljišta.

C. Financijsko-ekonomske analize primenjenih metoda navodnjavanja u toku perioda prelazne poljoprivredne proizvodnje.

Nakon finalizacije 2 faze kompleksnih melioracija zemljišta, sve klase zemljišta se uvode u regularnu, stabilnu proizvodnju svih biljnih vrsta i varieteta, što znači, da je fundamentalni zadatak kompleksnih melioracija, ostvaren-postignut.

Ključne reči: Reklamativna proizvodnja, meliorativna kultura, inicijalno ispiranje soli, model rotacije useva.

Primljeno: 23. 11. 2019. god.

Prihvaćeno: 30. 11. 2019. god.