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FEASIBILITY ANALYSIS OF THREE DIFFERENT CATCH CROPS FOR MILKING COW ANIMAL FEED

ANALIZA EKONOMSKE OPRAVDANOSTI KRMNIH MEĐUUSJEVA ZA PREHRANU MUZNIH KRAVA

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SUMMARY

The catch crops can represent a viable forage source in dry years. The aim of this paper is to present the results of the preliminary feasibility study of three different catch crops that can be used in northeast Slovenia. The Italian ryegrass (*Lollium multiflorum* Lam.), cow cabbage (*Brassica oleracea* L., convar.: *acephala* (DC) Alef. var *viridis*) and Sudan grass (*Sorghum sudannense* (Piper) Stapf) were included into the analysis. On the basis of field experiments and other available data the catch crops simulation models were derived. The models enable estimation of costs and returns of catch crops mentioned above at different input parameters. Individual analyzed catch crop was included into milking cow feeding rations which were derived with the application of a mathematical optimisation program. The estimated costs of feeding ration represent the basis for comparison of catch crops feasibility.

Keywords: catch crops, Italian ryegrass, Cow cabbage, Sudan grass, simulation models, mathematical programming

INTRODUCTION

Summer droughts have an important impact on forage yields. The main aim of catch crops is to ensure animal feed in a short period. Catch crops, sown after winter wheat also have some other environmental benefits, such as remains of organic matter in the soil after harvesting; reduced water transpiration in soil, nitrogen accumulation and erosion prevention (Kramberger, 1998). Askegaard et al. (2005) conducted field experiments with different catch crops in order to study effects of location, manure and catch crops on nitrate leaching from organic arable crop rotations. At all locations catch crops reduced the average annual nitrate concentration to meet drinking water quality standards in the crop rotation with green manure and it was found that catch crops can reduce nitrate leaching significantly, by 30-38%, on the sandy soils. Likewise, the catch crops can represent an important forage source in years with decreased rainfall and can serve as efficient nutritional supplement especially in dry years (Rozman et al., 2004). The technological features, nutritional value and benefits of catch crops in the 2000 summer drought have been analysed by Podvršnik (2001). However, the decision which catch crop to grow (if

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any) is interrelated with ecological, technological and economic factors. The data availability required for conducting feasibility analysis for selected catch crops can be a serious limitation in the planning process. Since real farm data required for cost calculations are rarely available, this problem can be solved with the use of published enterprise budgets, gross margin calculations (Lampkin and Measures, 1999) or by model calculations based upon technological economic simulation (Csaki (1985), Pavlovič (1997), Rozman et al. (2002), Pažek (2003), Rozman et al. (2005)). In fact, many successful businesses intensively use simulation as an instrument for operational and strategic planning. In the last two decades, computer simulation has become an indispensable tool for understanding the dynamics of business systems (Kljajić et al., 2000). The technological economic simulation modelling for the feasibility analysis of catch crops is described by Rozman et al. (2004). Likewise, the inclusion of a catch crop into the feeding ration for milking cows must be carefully balanced in order to ensure desired milk quantity and quality. Considerable research has been conducted over the years to determine optimal rations for different kind of cattle. The optimal ration should meet all basic nutrient requirements. Simultaneously, costs of the feeding ration should be minimized. Mathematical programming emerges as possible solution for milking cow feeding cost minimization problem (Rozman et al., 2002).

The main objective of this paper is the feasibility analysis of Italian grass, cow cabbage and Sudan grass using the technological economic modeling of catch crop production and mathematical programming technique in order to calculate feeding rations with inclusion of observed catch crops. The cost of feeding rations including different catch crops for a milking cow per day is ultimately calculated and compared.

METHODOLOGY

The simulation model (SM) was used in order to conduct the feasibility analysis of catch crop production. The model is a simplified representation of a system observed (in this case catch crop production). The relationships between elements of the system are usually represented by some kind of formal language (usually mathematical equations). In the case of catch crop production the technical parameters of production (such as machine and manual labor used, material, etc.) are expressed with a series of technological equations and incorporated into a computer spread sheet program that is used for preparation of enterprise budget at different input parameters. The technical coefficients such as input usage (for instance machine hours) per unit of area (ha, etc.) are put into spreadsheet input tables. Using these data, costs of machine operations, costs of labor operations and material costs are calculated and transported into enterprise budgets. The enterprise budget also contains capital costs and adequate share of farm fixed costs. This approach is known as technological economic simulation (Csaki, 1985) since it captures only the technological and economic dimensions.

The main indicators of the enterprise budget are the costs per unit of output (CU), calculated as a ratio between total production costs and yield quantity (TC/Y) and measured in monetary unit per kilo. The expected yield quantity is derived deterministically. The CU indicator can be used for comparison of production costs of different catch crops. However, due to different nutritional values of individual catch crops, the CU indicator alone is not representative enough in order to estimate feasibility and to choose optimal solution (best catch crop for individual farm). The CU indicators for every feedstuff produced on the farm are used in order to determine costs of a daily feeding ration at known milking cow weights and desired milk production. It was assumed that the basic feedstuff was maize silage and that catch crops were used in order to adjust the feeding ration. For feed components that were not produced on the farm (for instance mineral additives) the purchase price was used. It was assumed that the basic feeding ration consisted of maize and grass silage mixture. The nutritional value used in the simulation was derived from field experiments conducted at the University of Maribor, Faculty of Agriculture (Kramberger (1998), Topolovec (1999), Podvršnik (2001)). The feeding rations were calculated using mathematical programming optimization method with minimization of total feeding ration costs as

objective function. The mathematical model can be described with the following equation:

min CU* X
C*X > = N
C*X <= K*N
X >= 0

Where:

CU – price matrix for individual components of feeding rations

C – matrix of contents for each ingredient in the individual feeding component

X – matrix of quantities of indiviual components of feeding ration

N – matrix of normatives for individual components in the feeding ration at desired milk quantity and quality

K – tolerance coefficient for the maximum allowed surplus of individual component in the feeding ration

Additional constraints and nonlinear relationships (such as Ca:P ratio) were additionally used in order to find optimal feeding rations. The model operates in *Visual basic for Excel* (simulation model) and *What's best Industrial for Excel 4.0* (calculation of feeding ratios) optimization environment which is able to solve nonlinear mathematical programs. Both models (simulation and optimization) can be used for costs estimation at different farm input parameters (yields, nutritional values). The model is described in the flowchart in Figure 1.

RESULTS

The main results of the simulation model are the enterprise budgets for individual catch crops. The estimation was made for 1 hectare of every catch crop produced (table 1).

Figure 1. Flowchart of catch crops simulation model

Slika 1. Dijagram toka simulacijskog modela za proračun troškova proizvodnje krmnih usjeva

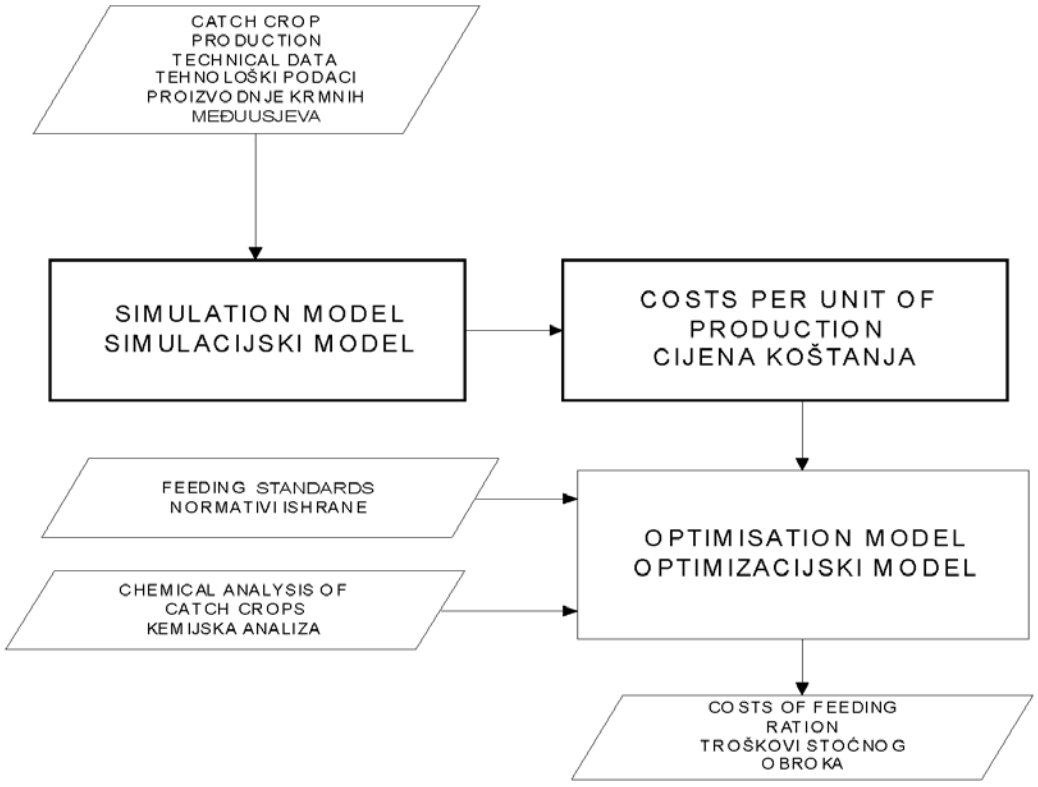


Table 1. Enterprise budgets for Italian ryegrass, cow cabbage and Sudan grass production
Tablica 1. Kalkulacije troškova za talijanski ljulj, stočni kelj i sudansku travu

Italian Ryegrass - Talijanski ljulj	1 hectare (1 ha)				
Number of mowing - Broj otkosa	1				
Expected yield - Očekivani prinos	35000 kg/ha				
1. Material costs - Trošak materijala	Units / ha	SIT / unit	SIT	€	%
Seed - Sjeme	50	458	22900	95,6	13
N:P:K 10:15:20	600	65	39000	162,8	23
KAN 27 %	200	46	9200	38,4	5
2. Labor costs - Trošak rada	35	1109	39003	162,8	23
3. Machinery labor - Rad strojeva					
Home machinery labor - Rad strojeva u domaćinstvu	1	44067,5	4406	183,9	26
Hired labor - Unamljeni rad	1	15000	15000	62,6	9
4. Capital cost - Trošak kapitala			2603	10,9	2
Total costs - Ukupni troškovi			171772	717,0	100
Costs per kg green mass - Cijena za kg zelene mase			4,9	0,020	
Cow cabbage - Stočni kelj	1 hectare (1 ha)				
Number of mowing - Broj otkosa	1				
Expected yield - Očekivani prinos	35000 kg/ha				
1. Material costs - Trošak materijala	Units / ha	SIT / unit	SIT	€	%
Seed - sjeme	5	540	2700	11,3	1
N:P:K 7:20:30	420	65	27300	114,0	15
KAN 27 %	400	46	18400	76,8	10
2. Labor costs - Trošak rada	63	1109	69779	291,3	38
3. Machinery labor - Rad strojeva					
Home machinery labor - Rad strojeva u domaćinstvu	1	59028,4	59028	246,4	32
Hired labor - Unamljeni rad	1	6000	6000	25,0	3
4. Capital cost - Trošak kapitala			2268	9,5	1
Total costs - Ukupni troškovi			185475	774,2	100
Costs per kg green mass - Cijena za kg zelene mase			5,3	0,022	
Sudan grass - Sudanska trava	1 hectare (1 ha)				
Number of mowing - Broj otkosa	1				
Expected yield - Očekivani prinos	35000 kg/ha				
1. Material costs - Trošak materijala	Units / ha	SIT / unit	SIT	€	%
Seed / sjeme	40	780	31200	130,2	16
N:P:K 7:20:30	320	65	20800	86,8	11
KAN 27 %	290	46	13340	55,7	7
2. Labor costs - Trošak rada	19	1109	21376	89,2	11
3. Machinery labor - Rad strojeva					
Home machinery labor - Rad strojeva u domaćinstvu	1	87774	87774	366,4	46
Hired labor - Unamljeni rad	1	15000	15000	62,6	8
4. Capital cost - Trošak kapitala			3362	14,0	2
Total costs - Ukupni troškovi			192852	805,0	100
Costs per kg green mass - Cijena za kg zelene mase			5,5	0,023	

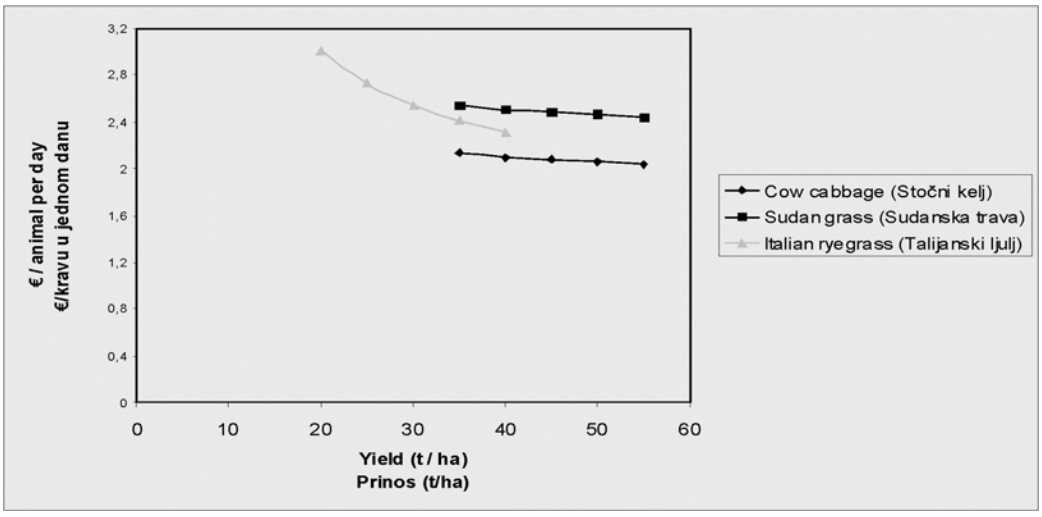
The results show that the lowest production costs estimated were for Italian ryegrass. However, as mentioned in previous section, the production costs (CU) cannot be used for direct comparison of the economic feasibility. Thus, in the next phase the costs of feeding rations were calculated by applying mathematical programming technique (where individual catch crops were included in order to adjust feeding rations).

The comparison of the three catch crops using the nutritional values and assumed model input parameters show that cow cabbage yields the lowest costs of milking cow feeding rations. In the initial analysis we assumed the same yield quantity for all the three analyzed catch crops. However, according to Kramberger (1998) and Podvršnik (2001) the yields of cow cabbage and Sudan grass can reach up to 60 t/ha, while the yield of Italian ryegrass very much depends on sowing date. The model was used to conduct the sensitivity analysis for costs of feeding at different yields of individual catch crops (graph 1).

Table 2. Feeding rations and their costs with inclusion of individual catch crop
Tablica 2. Stočni obroci i troškovi obroka kod pojedinih krmnih međuusjeva

Catch crop included Krmni međuusjev	Italian ryegrass Talijasnki ljulj		Cow cabbage Stočni kelj		Sudan grass Sudanska trava	
Feeding component - Vrsta krme	kg	SIT/kg	kg	SIT / kg	kg	€/kg
Maize silage - Kukuruzna silaža	19,5	6,32	22,2	6,3	22,89	6,32
Catch crop - Krmni međuusjev	38,9	4,9	17,8	5,3	18,85	4,1
Grass sillage - Travna silaža	19,5	9,59	22,2	6,0	24,24	9,59
Hay - Sijeno	0,0	25,94	0,5	25,9	0,00	25,94
K12	0,0	50	0,0	50,0	0,00	50
Sunflower seeds - Sjeme suncokreta	1,1	48	2,7	48,0	2,20	48
d1614	0,1	185	0,0	185,0	0,13	185
Total costs in SIT / animal per day Ukupni trošak u SIT / krava po danu		577		509,1		583,6€
Total costs in € / animal per day Ukupni trošak u € / krava po danu		2,41 €		2,13€		2,44 €

Graph 1. Sensitivity analysis of feeding ration costs with regard to catch crop yield
Graf 1. Analiza osjetljivosti troška stočnog obroka s obzirom na različite prinose pojedinog krmnog usjeva



However, it should be mentioned here that the time when cow cabbage and Sudan grass are available can be seriously decreased by early autumn frosts. Longer summer droughts can also decrease catch crops yields. Also, nutritional value decreases as plants get older. Assuming that early frosts come at the start of November, the available quantity of cow cabbage and Sudan grass would be seriously decreased. In this case the costs of production per unit increase and the costs of feeding ration also increase. The simulation for this scenario yields with costs of feeding rations as follows: in case of cow cabbage 2,19 € for single cow per day and in case of Sudan grass 2,44 € for single cow per day. This simulation was not run for Italian ryegrass since it was available for feeding in a shorter period due to lower autumn yields. On the other hand, it should be mentioned here that Italian ryegrass can be used for another harvesting either for green mass or silage in the spring next season. In this case the yield of Italian ryegrass (green mass) can increase up to 40 – 50 t/ha. The simulation reveals that estimated yield of 45000 kg/ha of green mass, the costs of feeding ration with Italian ryegrass decreases to 2,23 € / day.

The decision which catch crop to choose on an individual farm should, therefore, be based on detailed analysis with respect to the given situation on this particular farm. The proposed model should be applied as an appropriate analytical tool in order to assist the decision maker (farm operator). Likewise, real feeding experiments should be conducted in order to properly evaluate nutritional characteristics of catch crops.

CONCLUSIONS

Three different catch crops were compared in the study, which showed that including cow cabbage into feeding ration resulted in the lowest feeding costs. However, the results should be taken cautiously since yield of catch crops can be very variable in different years. The real value of this study is the simulation model that enables evaluation of different scenarios on every single farm and can be, as such, used as decision support system on milk farms. Additional research to ensure more quality data for model input parameters and further upgrade of the model are suggested.

REFERENCES

1. Askegaard, M., J. E. Olesen, K. Kristensen (2005): Nitrate leaching from organic arable crop rotations: effects of location, manure and catch crop. Soil Use and Management 21/2:181-188(8).
2. Csaki, C. (1985): Simulation and systems analysis in agriculture, Akademiai Kiado, Budapest.
3. Kljajić, M., I. Bernik, A. Škraba (2000): Simulation Approach to Decision Assessment in Enterprises. Simulation 75:199-210.
4. Kramberger, B. (1998): Effects of seeding rate and time of cut on the yield and quality of Sudan grass (Sorghum sudanense (Piper) Stapf.). Research Reports, Biotechnological Faculty, University of Ljubljana, 71:135-139.
5. Lampkin, N., M. Measures (1999): Organic Farm Management Handbook – 3rd ed.
6. University of Wales; Aberystwyth, Elm Farm Research Centre, U.K.
7. Lisson, S.N., L.E. Brennan, K.L. Bristow, B.A. Keating, D.A. Hughes (2003): DAM EASY – software for assessing the costs and benefits of on-farm water storage based production systems. Agricultural Systems 76:19-38.
8. Pažek, Karmen (2003): Finančna analiza ocenjevanja investicij dopolnilnih dejavnosti na ekoloških kmetijah / The financial analysis of supplementary activities on organic farms. M.Sc. Thesis. University of Maribor, Faculty of Agriculture, Maribor.
9. Pavlovič, M. (1997): Systemanalyse internationaler Hopfenwirtschaft – Entwicklung des Simulationsmodells für die technologisch-ökonomische Analyse auf Hopfenanbaugebieten in Slowenien, Verlag Dr. Kovač, Hamburg.
10. Podvršnik, M. (2001): Pridelek strniščnih krmnih dosevkov in njihov pomen ter praktična vrednost v sušnem letu 2000. Graduation thesis, University of Maribor, Faculty of Agriculture.
11. Rozman, Č., Karmen Pažek, Martina Bavec, F. Bavec, J. Turk, Darja Majkovič (2005): The Multi-criteria Analysis of Spelt Food Processing Alternatives on Small Organic Farms. Journal of Sustainable Agriculture (in press).
12. Rozman, Č., Karmen Pažek, Anastazija Gselman, M. Janžekovič, J. Turk (2004): Feasibility analysis of three different catch crops in northeast Slovenia. Proceedings of the 20th General Meeting of the European Grassland Federation Luzern, Switzer-

land, 21-24 June 2004. Land Use Systems in Grassland Dominated Regions, (Grassland science in Europe, 9:1058-1060, 2004).

13. Rozman, Č., S. Tojnko, J. Turk, V. Par, M. Pavlovič (2002): Die Anwendung eines Computersimulations-modells zur Optimierung der Erweiterung einer Apfel-plantage unter den Bedinungen der Republik Slowe-nien. Berichte über Landwirtschaft 80 (4):632–642.
14. Rozman, Č., J. Nemec, M. Janžekovič, M. Repič, J. Turk (2002): Ekonomska optimizacija krmnega obroka pri pitanju volov = Economic optimisation of steer feeding ratio. Zbornik predavanj 11. posve-tovanja o prehrani domačih živali "Zadravčevi-Erjavčevi dnevi". Murska Sobota: Kmetijsko goz-darska zbornica Slovenije, Kmetijsko gozdarski zavod, 78-89, 2002).
15. Klavdija Topolovec (1999): Comparison of Italian ryegrass (Lolium multiflorum Lam.) with other summer stuble crops. Graduation thesis, University of Maribor, Faculty of Agriculture.

SAŽETAK

Suše mogu ozbiljno ograničiti prinose krmnih usjeva. Krmni međuusjevi mogu zbog toga predstavljati izvor stočne hrane u sušnim godinama. Cilj ovog rada je prikaz rezultata preliminarne studije ekonomske opravdanosti pojedinih krmnih međuusjeva u sjeveroistočnoj Sloveniji: talijanskog (jednogodišnjeg) ljulja (*Lollium multiflorum* Lam.), stočnog kelja (*Brassica oleracea* L., convar.: *acephala* (DC) Alef. var *viridis*) i sudanske trave (*Sorghum sudannense* (Piper) Stapf). Na temelju rezultata poljskih pokusa i ostalih podataka izgrađen je tehnološko ekonomski simulacijski model proizvodnje krmnih međuusjeva za procjenu troškova proizvodnje kod različitih proizvodno-tehnoloških parametara. Pojedini krmni međuusjev uključen je u teoretske proračune stočnih obroka za muzne krave, izrađene pomoću matematićkog optimizacijskog programa. Proračun troška stočnog obroka je osnova za komparativnu analizu ekonomske opravdanosti pojedinih krmnih međuusjeva.

Ključne riječi: krmni međuusjev, talijanski ljulj, stočni kelj, sudanska trava, simulacijski model, matematičko programiranje