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ECONOMICS EFFECTS OF IRRIGATION IN PLANT PRODUCTION

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Abstract: Irrigation contributes to increased agricultural yields and production volume and intensified agricultural production. Field crops double their yields in irrigation. Production value of irrigated field crops is increased 2.06 times compared with dry farming. Profit per hectare of irrigated field crops is increased 2.01 times. The economy of field crop production increases from 1.03 in dry farming to 1.18 in irrigation. Profitability of field crop production increases from 3% in dry farming to 18.4% in irrigation.

Productivity of production of irrigated field crops increases 1.6 times for wheat, 2.4 times for corn, 1.9 times for sugar beet, 2.4 times for sunflower and 2.7 times for soybean (yield/work hour).

High economy of production is achieved in vegetable production, amounting to 2. Profitability is increased by 75%. Profit per hectare of irrigated vegetable crops exceeds that of irrigated field crops.

Investments in irrigation result in higher volume and quality of food production, more economic and profitable production, and higher incomes and profits.

Irrigation has a decisive impact on yield performance, production and economic results and further development of market-oriented, certified organic production of high quality produce.

Key words: economy, irrigation, profitability, productivity, quality.

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1. Introduction

This study deals with economic efficiency of irrigation practice. The future of agriculture is based on the exploitation of water and solar energy. Irrigation is a factor of intensified agricultural production and increased production volume. It brings increased yields and allows double cropping and intercropping. In addition to increased yield of field crops, especially industrial crops, irrigation intensifies crop production by creating favorable conditions for the growing of vegetables, forage crops, planting materials, fruits, grapes and flowers as well as for seed production. The use of irrigation increases the acreage, yields and production volume of high-value crops, thus improving the economic efficiency of agricultural management.

Economic profitability of irrigation practice has been studied in the food processing company 'Bag&Deko' from Bačko Gradište. Vegetable growing predominates in the production profile of the company, with 26% of the acreage under main-crop vegetables and a considerable acreage under double-cropped vegetables. Industrial crops take 41% of the acreage, seed production 13% and cereal crops 20%. Most of the fields are irrigated.

Tight economic and technological links exist between the production and processing of vegetables, which ensure maximum economic benefits. The combination of vegetable production and processing increases the productivity and profitability of the company. It secures full utilization of processing facilities and rapid development of highly profitable consumer goods. In its turn, the wide array of consumer goods contributes to increases in company income, salaries and profits.

The company uses a range of large and small irrigation equipment - boom sprays, linears and overhead sprinklers.

2. Research Objective and Methods of Work

In this study we compared the economic efficiency of crop production in irrigation against the production in dry farming. Economic efficiency was assessed for field crops, vegetables and other agricultural produce produced under irrigation conditions.

Economic efficiency of irrigation and its contribution to increased yields and production volume were studied in individual field crops (wheat, corn, seed corn, soybean, sunflower, sugar beet) and vegetables (onion, carrot, parsnip and celery). Total financial effects of production on the irrigated acreage were also studied. Economic effects of production in irrigation were expressed in terms of realized income, profits, productivity, profitability and economy of field and

vegetable crops production. The quantitative-qualitative and comparative analysis methods were applied. The obtained results were compared against those of Dragović, Potkonjak, etc. Data from plan and analysis documentation, product calculations and book keeping records were used. The consulted literature sources are presented in references.

3. Results

Irrigation and profitability

The low and unstable yields obtained in the crop production in Serbia are the result of insufficient and unfavorably distributed seasonal rainfall. In last 60 years, 48 were dry and 30 of those were very dry. Consequences of drought are low yields, low income and large damage: the damage suffered by farmers and the country on the whole in a single year may reach several hundred thousand to one billion dollars.

Economy of irrigation

To realistically assess the economic profitability of irrigation, we studied the production structure of the company before and after the introduction of irrigation practice. The company has changed the production structure, placing emphasis on vegetables. Another objective has been to increase yield levels and productivity per unit area, i.e., to optimize vegetable production in order to maximize the use of processing capacities. Finally, the range of consumer goods was diversified and updated including into it spices and ready-to-serve meals.

Production under conditions of dry farming

A comparative analysis has been conducted in order to establish differences between yield performance and production volume achieved with and without irrigation.

Table1 Production under conditions of dry farming

Crop	Acreage, ha	Yield, t/ha	Produced, t
Wheat	350	3,8	1.330
Corn	560	5,5	3.080
Sugarbeet	300	36,0	10.800
Sunflower	184	1,4	258
Soybean	46	1,3	60
Alfalfa	90	7,0	637
Total	1.530	-	-

Production under conditions of irrigation

Intensive crops such as industrial plants, seed production and vegetables dominated in the production structure with 80%

Table 2 Cropping structure

Crop	Acreage, ha	%-age
Small grains	300	20
Industrial crops	637	41
Seed production	201	13
Vegetables	391	26
Total	1.530	100

Table 3 Crop production scheme under conditions of irrigation

Crop	Acreage, ha	Yield, t/ha	Produced, t
Wheat	243	6.3	1.631
Commercial corn	57	13.0	741
Seed corn	131	4.5	589
Seed sorghum	49	5.0	245
Sunflower	139	3.33	459
Soybean	289	3.5	----
Sugarbeet	192	70.0	13.440
Onion	30	35.0	1.050
Potato	44	50.0	2200
Carrot	125	48.0	6000
Parsley	13	3.0	39
Parsnip	84	45.0	3780
Celery	75	30.0	2250
Seed alfalfa	21	0.300	6.3
Pea	16	8.3	132.8
Vetch	19	30.0	570
Cabbage	3	50.0	150
Leek	2	40.0	80
Total	1.530	----	----

Effects of production under conditions of irrigation

The introduction of irrigation practice has changed the cropping scheme, yield performance and total production volume. The obtained positive effects are shown in Table 4.

Table 4 Yield increases in irrigation

Crop	Difference (±) in tons
Wheat	1
Corn	-2.339
Seed corn	589
Seed sorghum	245
Sunflower	201
Soybean	944
Sugarbeet	2.640
Onion	1.050
Potato	1.760
Carrot	6.250
Parley	195
Parsnip	2.100
Celery	1.350
Seed alfalfa	31
Alfalfa	-637
Vetch	475
Pea	112
Cabbage	150
Leek	28

The large increase of the share of vegetables in the cropping structure has resulted in higher profitability and production volume. Further use of the extra amounts of vegetables in the processing sphere has increased the total turnover of the company.

Yield increases of major field crops A comparative analysis was conducted to assess the yields of field crops obtained with and without irrigation.

All crops increased their yields in irrigation. Highest effects were registered for industrial crops, forage crops and in seed production. As the analyzed year was fairly dry, high yields were registered for small grains too. The effect of irrigation on yield increases of field crops measured through the income expressed in current prices was 657 dollars per hectare or two times higher than the income obtained in dry farming. Highest effects were achieved in vegetable production and they will be treated separately.

Table 5. Yield increases of field crops in irrigation

Crop	Nonirrigated, t/ha	Irrigated, t/ha	Index
Wheat	3.8	6.3	165.8
Corn	5.5	13.0	236.4
Seed corn	2.0	4.0	200.0
Sugarbeet	36.0	70.0	194.4
Soybean	1.3	3.5	269.2
Sunflower	1.4	3.3	225.7
Alfalfa	7.0	13.0	185.6
Effect, dollars/ha	633	1.290	657

Effect of irrigation on yield performance of NS corn hybrids was assessed at Rimski Šančevi experiment field in the period 2000-2002.

Table 6. Effect of irrigation on yield of NS corn hybrids t/ ha (Dragovic, S., 2003)

Hybrid	Irrigated	Nonirrigated	Irr. effect, t/ha
NS 300	11.74	8.84	2.9
NS 540	14.11	9.97	4.14
NS 501	13.62	11.66	1.96
NS 505	13.12	10.06	3.06
NS 542	13.02	9.84	3.13
NS 640	13.23	10.89	2.34
NS 663	13.87	9.69	4.18
Ø 2000-2002	13.24	10.14	3.1

The average sugarbeet yield obtained in irrigation at the estate 'Đuro Strugar' in a three-year period was 69.0 t/ha. It was more than two times higher than the average yield obtained in dry farming. In experimental trials observed from 1966 until 1995 concerning sugar beat yield established average yield was 75.4 t ha⁻¹, whit irrigation effect 29%, which varies from 4% - 98%. Similar results of increasing root yield of sugar beat in irrigation conditions (37.3%) indicate Jaggerd i Glover (1996).

In research conducted in 2004 year found that average yield increase in irrigated conditions was 12.48 t ha⁻¹ or 14,3% compared with dry farming.

A comparative analysis of the yields of corn obtained at Rimski Šančevi and the yields of sugarbeet obtained in 'Đuro Strugar' showed that the respective yields obtained in the irrigation system of the analyzed company were similar. This

proves that the obtained research results are reliable and that yields in irrigation are indeed two times higher than those obtained in dry farming.

Value of production per hectare. The calculation of economic efficiency of irrigation in the production of major field crops, measured on the basis of the realized production value per hectare, indicated that production value per hectare in irrigation doubles that obtained in dry farming.

Table 7 Production values obtained in irrigation and dry farming

Crop	Nonirrigated		Irrigated		Index
	t/ha	Dollars / ha	t/ha	Dollars /ha	
Wheat	3.8	505	6.3	837	165.8
Corn	5.5	631	13.0	1.491	236.4
Seed corn	2.0	1.656	4.0	3.283	198.2
Soybean	1.3	367	3.5	919	250.2
Average	790		1.632		206.7

All irrigated crops brought higher yields and production value per hectare than the crops grown in dry farming. The average value of production of the major field crops was two times higher in irrigation than in dry farming. The realized profit had a slower rate of increase because the costs of production grew faster than the market prices of the produced commodities. In dry farming, losses were registered because of low yields. This proves that investments in irrigation facilities have an economic justification.

Realized profits per hectare. The profits realized in the production of the major field crops were two times higher than those realized in dry farming. The effects calculated on the basis of the realized profits per hectare for irrigated wheat, corn, seed corn and soybean were two times higher than the corresponding values obtained in dry farming.

Table 8 Profits per hectare, dollars/ha

Crop	Nonirrigated	Irrigated	Index
Wheat	75	124	166.3
Corn	108	213	197.1
Seed corn	671	1.404	209.1
Soybean	90	177	196.7
Average	236	476	201.5

In spite of the high yields obtained in irrigation as compared with dry farming, the realized profits per hectare were low because the rate of growth of input prices was faster than the rate of growth of market prices of agricultural commodities. In such situations, the only way to increase the profitability of production is to diversify the production of consumer goods.

Highest effects were achieved in the production of industrial crops. The profitability in the production of small grains was 1.17, in seed production 1.73 and in soybean production 1.24.

Economic effects of vegetable production in irrigation. Yield, production value, total costs and profit per hectare were calculated for the production of onion, carrot, celery and parsnip. High profitability was achieved with all vegetables grown in irrigation, from 1.64 to 2.02.

Table 9 Economic effects of irrigation in the production of some vegetable crops

Crop	Yield, t/ha	Production value, dollars/ha	Total costs, dollars/ha	Profit, dollars/ha	Profitability
Onion	35.1	3.529	2.155	1.374	1.64
Carrot	50.0	2.461	1.219	1.241	2.02
Celery	18.0	3.541	1.853	1.688	1.91
Parsnip	25.0	4.098	2.507	1.592	1.64

The profitability of vegetable production estimated on the basis of the profit to investment ratio was high, ranging from 63% for onion and parsnip to 90% for celery. Here it should be added that the production value per hectare was calculated on the basis of internal prices, which were below market prices; otherwise, the effects would have been higher. A comparison of the incomes obtained in vegetable production and field crops production demonstrated the advantages of the former.

Production	Nonirrigated	Irrigated	Effect &
Field crops	623	1.290	657
Vegetable crops	---	341	----
Average of all crops	668	2.387	1.720

The income per hectare obtained for the four vegetable crops was 2.6 times higher than that obtained for the five major field crops. The profits made in the

vegetable production were larger than the income obtained from the five field crops.

Total economic effects of production in irrigation. Total irrigation effects and effects per hectare were determined on the basis of the structure of production in irrigation and in dry farming.

Table 10 Income, costs and profit from the acreage of 1,530 ha

Indicator	Nonirrigated		Irrigated		Index
	Total	Per ha	Total	Per ha	
Total income	1.022	668	3.652	2.387	357
Total costs	990	647	3.084	2.015	311
Material costs	389		1.095		
Amortization	101		260		
Salaries	248	162	767	500	
Interests	148		525		
Insurance	20		100		
Total costs	54		6.120		
Other costs	32		237		
Profit	31	21	569	371	1806

When 18 crops were grown in irrigation at a total of 1,530 ha, the income was increased 3.6 times compared with that obtained in dry farming.

The income per hectare was increased from 668 dollars in dry farming to 2.387 dollars in irrigation. The total costs were increased 3.1 times. Evidently, intensive production incurs increased costs. The profit per hectare in irrigation was 371 dollars and it was much higher than that obtained in dry farming.

Economy of production. Economy of production was estimated on the basis of a ratio of total income versus total costs for the production at 1.530 ha.

$$Economy\ in\ irrigation = \frac{3.652}{3.084} = 1.18$$

$$Economy\ in\ irrigation = \frac{1.022}{990} = 1.03$$

The above figures show that a dollar invested in production in dry farming brings an income of 1.03 dollars while the income in irrigation is 1.18 dollars.

Profitability of production. The rate of profitability was estimated on the basis of a ratio of profit versus total costs.

$$\text{Profitability rate in dry farming} = \frac{31}{990} \times 100 = 3.13\%$$

$$\text{Profitability rate in irrigation} = \frac{569}{3084} \times 100 = 18.45\%$$

The profits rates made from the production in dry farming and irrigation ability were 3.13 and 18.45 %, respectively.

Productivity in the production of field crops. The productivity achieved in the production of field crops was estimated on the basis of a ratio of yield per hectare versus the number of man/hours per hectare.

Table 11 Production in tons per man/hour in irrigation and dry farming

Crop grown	Yield		Expended, hr/ha	Production		Productivity coefficient
	Nonirr.	Irr.		Nonirr.	Irr.	
Wheat	3,8	6,3	7,55	0,503	0,834	1,6
Corn	5,5	13,0	10,30	0,534	1,262	2,4
Sugarbeet	36,0	70,0	21,10	1,706	3,317	1,9
Sunflower	1,4	3,3	10,83	0,129	0,304	2,4
Soybean	1,3	3,5	9,90	0,137	0,353	2,7

The productivity was higher in the irrigation system than in dry farming 1.6 times in the case of wheat, 2.4 times in the case of corn, 1.9 times in the case of sugarbeet, 2.4 times in the case of sunflower and 2.7 times in the case of soybean.

4. Conclusion

Following conclusions may be drawn on the basis of the analysis of economic profitability of irrigation practice.

- Irrigation has a high positive effect of yield performance, production volume and intensity of crop production.
- In addition to increased yield of field crops, especially industrial crops, irrigation intensifies crop production through the growing of vegetables and forage crops as well as for through seed production. Implementation of irrigation improves the economic efficiency of agricultural management.
- Yields of major field crops are doubled in irrigation as compared with yields obtained in dry farming.

- Change of cropping structure in favor of vegetables, industrial and forage crops and seed production in irrigation increases yield performance and production volume.
- On average, value of production per hectare of major field crops is 2.06 times higher in irrigation than in dry farming.
- Profit per hectare in the production of major field crops was 2.01 times higher in irrigation than in dry farming.
- In the system of irrigation at 1,530 ha, the income was increased 3.6 times as compared with the cropping structure in dry farming. Profit per hectare was increased from 21 dollars in dry farming to 371 dollars in irrigation.
- Economy of production was increased in the irrigation system from 1.03 to 1.18, while the profitability rate increased from 3,13 to 18.45 %.
- Productivity was increased in the irrigation system 1.6 times in the case of wheat, 2.4 times in the case of corn, 1.9 times in the case of sugarbeet, 2.4 times in the case of sunflower and 2.7 times in the case of soybean. Productivity was measured on the basis of production per hectare per total man/hour.
- High economy of production was achieved with all vegetable crops, the values ranging from 1.6 to 2.0.
- The profitability of vegetable production ranged from 63% for onion and parsnip to 90% for celery.
- Income per hectare obtained for vegetable crops was 2.6 times higher than that obtained for major field crops. The profits made in vegetable production were larger than the income per hectare obtained for major field crops. This proves the economic profitability of applying irrigation practice in vegetable production.
- Investments in irrigation development are investments in increased production of high-quality food, more economic and profitable production and higher company income and salaries.

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ЕКОНОМСКИ ЕФЕКТИ НАВОДЊАВАЊА У БИЉНОЈ ПРОИЗВОДЊИ

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Резиме

Наводњавање има велики утицај на повећање приноса, производње и интензивирање пољопривредне производње. Поред повећања приноса у ратарској производњи, посебно код индустријског биља, интензивира се пољопривредна производња гајењем поврћа, семена и крмног биља и повећава профитабилност у пословању. Приноси ратарских усева у систему наводњавања су два пута већи у односу на приносе у сувом ратарењу. Приход и профит у систему за наводњавање је за два пута већи у односу на суво ратарење. Економичност производње у систему наводњавања је повећана са 1,03 на 1,18, рентабилност производње са 3 на 18,4% , а продуктивност рада у производњи ратарских усева је већа за 2,2 пута. Значи, да је инвестирање у наводњавање доприноси производњи квалитетне, економичније рентабилније и профитабилније хране.

Кључне речи: економија, наводњавање, профитабилност, продуктивност, квалитет.

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