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ECONOMIC PERFORMANCE OF SPECIALIZED FIELD CROPS FARMS PRODUCING SWEET CORN

Abstract

Sweet corn is not commonly produced at Serbian family farms, although it has a significant economic potential. Besides, there is a lack of research related to economic performance of the sweet corn production. Therefore, the goal of this research was to determine economic effects of introducing sweet corn in the sowing structure of specialized field crops farms in Serbia. The analysis was performed on the model of family farm specialized in the field crops production. Determination of average gross margin for appropriate field crops was followed by the optimization of farms' sowing structure (by applying linear programming approach). Authors analyzed three variants depending on sweet corn participation in the sowing structure. It was determined that the optimization itself increases the use of labor force and positively influences the level of farm gross margin. By combining the optimization with the introduction of sweet corn in the sowing structure even better results are achieved. Therefore, family farms specialized in the field crops production should be encouraged to extend their sowing structure by producing sweet corn. The paper offers an important insight into the combination of crops which can improve an overall economic performance of family farms.

Key words: *sweet corn, specialized field crops farms, sowing structure, labor productivity, gross margin*

JEL classification: *Q12, J53*

ЕКОНОМСКЕ ПЕРФОРМАНСЕ СПЕЦИЈАЛИЗОВАНИХ РАТАРСКИХ ГАЗДИНСТАВА КОЈА ПРОИЗВОДЕ КУКУРУЗ ШЕЋЕРАЦ

Апстракт

На породичним газдинствима у Србији производња кукуруза шећерца није уобичајена, иако он има велики економски потенцијал. Поред тога, не постоји

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довољан број истраживања која се баве економским перформансама производње кукуруза шећерца. Због тога је циљ овог истраживања утврђивање економских ефеката увођења кукуруза шећерца у сетвену структуру специјализованих ратарских газдинстава у Србији. Анализа је спроведена на моделу породичног газдинства специјализованог за ратарску производњу. Након утврђивања просечне бруто марже за одговарајуће ратарске усеве, извршена је оптимизација сетвене структуре газдинстава (применом линеарног програмирања). Аутори су анализирали три варијанте, зависно од учешћа кукуруза шећерца у сетвеној структури. Утврђено је да се оптимизацијом увећава употреба радне снаге и да се позитивно утиче на висину бруто марже газдинства. Још бољи резултати су остварени комбиновањем оптимизације са увођењем кукуруза шећерца у сетвену структуру. Због тога је потребно охрабрити породична газдинства специјализована за ратарску производњу да прошире своју сетвену структуру преко увођења кукуруза шећерца. Ово истраживање пружа важан увид у комбинацију усева која може унапредити укупне економске перформансе породичних газдинстава.

Кључне речи: кукуруз шећерац, специјализована ратарска газдинства, сетвена структура, продуктивност рада, бруто маржа

Introduction

Sweet corn, as well as other types of corn, originates from Central America (Latković et al., 2012, p. 91). In comparison to wheat or rice, corn does not have an obvious wild relative (Babić et al., 2012, p. 92). Besides, sweet corn does not have a long history of breeding, and it is considered that this type of corn is generated by genes mutations (Gadžo et al., 2017, p. 45). According to the authors, its sweetness is caused by a recessive gene, which slows down the transformation of sugar into starch. Sweet corn is rich in fibers, minerals and vitamins, having at the same time antioxidant effects.

Sweet corn is "a high input, high value seasonal vegetable crop that can command high prices, especially when produced under organic conditions" (Revilla et al., 2021, pp. 25-26). Above authors also stated that it is necessary to apply "high levels of fertility, irrigation, and intensive pest management techniques" in the production of sweet corn, while it could be produced in different cropping systems (as the main crop, catch crop or in intercropping systems). Sweet corn is a type of corn which does not tolerate low temperatures or high soil humidity (Bekavac, 2012, pp. 9-10). On the other hand, availability of sufficient amounts of water during some development phases significantly influences the level of yield, as well as its quality. According to the author, one of the most important challenges in the sweet corn production is the harvest (the optimal time frame for successful harvest is only 4 to 5 days), while harvested sweet corn should be immediately stored in adequate cooling facilities (which prevents the loss of quality).

Analyzing industrial production and processing of peas and sweet corn in Serbia, Marković et al. (2003) determined that there are several reasons for a decrease in such a production, such as the lack of modern harvesters, small areas which are irrigated, inappropriate equipment used in processing and freezing facilities, etc. Therefore, authors assume that the most important factor for the improvement of the peas and sweet corn

production is modernization of equipment and technology (not only in the agricultural production but also in industrial processing), increasing capacity levels at the same time. It was suggested that the reconstruction of existing processing facilities is preferred comparing to the investments in new premises. Vešnik (1997) states that sweet corn is a valuable product for industrial processing, while positively influencing the agricultural production in many ways. This author mentioned various ways of sweet corn processing, discussing, in more details, processing by deep freezing using temperatures of -18 °C and -21 °C (which provides that its sensory characteristic will not change during the period of 12 months i.e. 24 months). Some of the conclusions in this research indicated that the production process of sweet corn is very similar to the production of mercantile corn, while the sweet corn production should lead to a higher profit comparing to the usual corn production practices.

As mentioned earlier, there are various ways of sweet corn use. It could be used for consumption as a fresh product, but also for industrial based processing – by conservation or freezing. Therefore, Pajić et al. (2008) suggested that various uses of sweet corn require different quality measures. This is why breeding of sweet corn for different consumption purposes should be based on an adequate selection process. Authors also stated that the selection process of sweet corn is primarily performed in private companies, while the production of sweet corn seed is one of the most profitable enterprises. According to Srdić at al. (2016), it is not only important to have high sweet corn ear yields, but also to provide other important traits. Analyzing eight sweet corn hybrids (two commercial and six experimental hybrids), authors determined that their ear yields are "significantly influenced by genotype, meteorological conditions in different years and the interaction of those two factors", while analyzed hybrids "had nice physical appearances, such as uniformity of shape and size of the ear". Similar research was conducted by Srdić at al. (2019). The analysis included 12 sweet corn hybrids; three of them were commercial, while the other nine hybrids were experimental. The results indicated that the level of correlation between yield and quality of sweet corn hybrids was mainly low. On the other hand, both of the mentioned traits are important. So, authors concluded that "through the breeding process, both of those characteristics need to be improved".

There is also research oriented towards some issues of the sweet corn production technology. Bajkin and Žigmanov (2000) analyzed effects of seeding cucumber and sweet corn over foil. It was determined that such a way of production leads to earlier harvesting, higher yields and higher quality. Authors discovered that the use of degradable foil proves more effective in the sweet corn production. Šimić et al. (2010) accented an importance of sweet corn fertilization for some of its production characteristics. It is especially important for the sweet corn production technology to apply an adequate amount of potassium fertilizers. On the basis of results of their research, authors determined that (comparing to control level of fertilization) an increase in potassium application resulted in bigger diameter of cobs (20%) and cob weight (11%). The analysis revealed that the differences are statistically significant.

There is small number of research dealing with economic aspects of the sweet corn production, not only in Serbia, but also on the international level. Potkonjak and Mačkić (2010, pp. 258-259) analyzed economic efficiency of irrigation on small scale areas. Authors determined certain economic indicators for sweet corn, as well as for 23 other agricultural products. The production value of sweet corn was calculated, as well as the production costs and profit. Subić et al. (2021, pp. 105-109) determined that material costs

dominate within variable costs of the sweet corn production, while majority of labor costs are related to harvesting process. Authors also determined that gross margin in the sweet corn production is very sensitive to changes in sweet corn yield or its market price.

Williams (2012, pp. 55-61) tried to determine an effect of sweet corn plant population density on various agronomic and economic indicators. Author determined that the plant population for maximal sweet corn yield depended on the hybrid to a large extent. The use of certain hybrids and their adequate population densities could improve economic performance of sweet corn producers and processors. Similar research which tackled processors profit and grower returns conducted by Dhaliwal and Williams (2020, p. 12) concluded that "processors should decide plant densities tailored to the local growing conditions".

Having above mentioned in mind, the goal of this paper is to determine economic performance on introducing sweet corn in the sowing structure of specialized field crops farms in Serbia. The following hypothesis will be tested in this research: Introduction of the sweet corn production in the sowing structure of specialized field crops farms could increase gross margin of the farms, as well as improve the level of employment of available labor force.

Material and method

Economic performance of introducing sweet corn into the sowing structure of specialized field crops farms is examined on the model of family farm situated in the Autonomous Province of Vojvodina (which is primarily lowland region). The model is based on data from researchers' database which has been created as a result of an annual survey on a representative sample of farms in that region. It is assumed that:

- utilized agricultural area is 12.9 hectares (the farmer is owner of the entire cultivated land),
- there are three family members, while two of them are active family members,
- only one active family member works exclusively on the farm and
- the analysis is performed on the basis of data covering a five year period (from the production year 2016/2017 to the production year 2020/2021) – the goal of such an approach is to avoid the influence of significant price fluctuations (of inputs and outputs) and various weather conditions on the results of the analysis.

The main criteria for economic evaluation of the sweet corn production are the level of gross margin of the entire family farm. The following options (variants) are discussed and compared in the research:

- variant 1 – the optimization of existing (usual, the most common) sowing structure (without the introduction of the sweet corn production),
- variant 2 – the introduction of sweet corn (while optimizing the existing production structure at the same time) and
- variant 3 – the introduction of sweet corn (while optimizing the existing production structure at the same time), assuming that sweet corn is limited to a maximal area of 0.25 hectares (due to market and organizational challenges).

To perform the optimization of the sowing structure (which leads to the maximization of gross margin at the farm level), authors used a linear programming method (Microsoft Excel Solver is used to solve formulated linear programming problems). Gross margin maximization is an equivalent to profit maximization (or minimization of potential losses). Having in mind that fixed costs are constant, every change of gross margin at the farm level in short term directly influences the level of profit (Ivkov et al., 2008, p. 237). When it comes to the specialized field crops farms, linear programming method is used to – increase the existing capacity use of family farms (family labor and machinery) (Munćan et al., 2008), as well as to optimize the sowing structure of family farms in unstable business conditions (Todorović and Munćan, 2009).

Results and discussion

Variations of gross margin are a solid base for the estimation of present and future economic status of family farms. Therefore, an average gross margin (representing 5-year period) for crops involved in usual sowing structure (corn, winter wheat, sunflower and soybean) and sweet corn as optional crop are presented in table 1.

Table 1: Gross margin for the observed crops (an average for the period from 2016/2017 to 2020/2021)

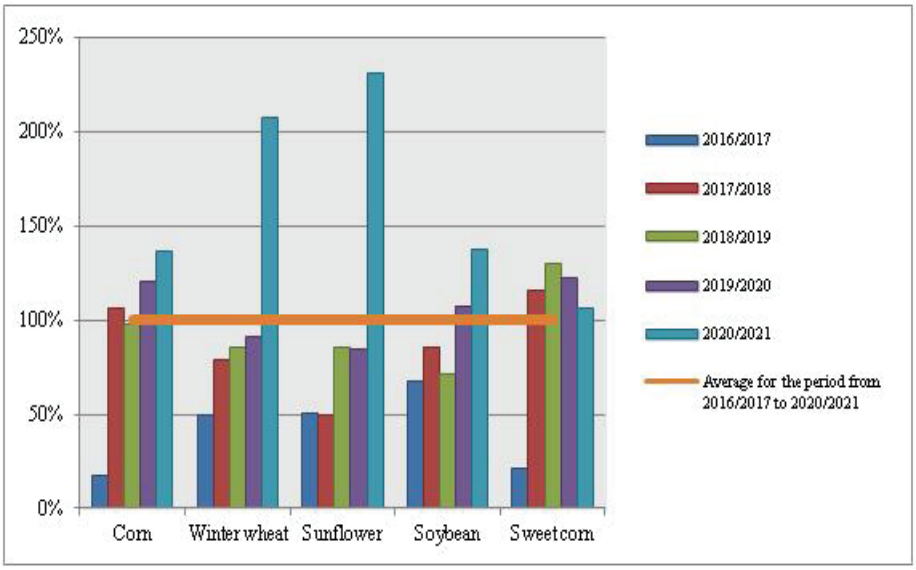
Crop	Amount (RSD per ha)	Index (Corn gross margin=100)
Corn	56,780.85	100.00%
Winter wheat	34,601.19	60.94%
Sunflower	34,230.38	60.29%
Soybean	64,122.43	112.93%
Sweet corn	327,109.20	576.09%

Source: Authors' calculation

While sweet corn had the highest average gross margin, the lowest value of this indicator was recorded for winter wheat and sunflower.

Nevertheless, the value of gross margin varied during the observed period (Graph 1). The reasons for such variations are not only market conditions (considering the observed commodities, as well as inputs necessary for the crop production) but also weather conditions influencing the crop production. The biggest gross margin variations are determined for the sunflower production, while the most stable gross margins are recorded in the soybean production. Each gross margin increase is perceived as a positive change, while its decrease indicates negative tendencies and an indication of a possible crisis.

Graph 1: Indexes of gross margin during the observed period



Source: Authors' calculation

When creating the model of the family farm, it is assumed that there is one annual work unit available (1,800 working hours). In that regard, the average number of AWU for the entire Republic of Serbia (if family farms are cultivating 10 to 50 hectares) is presented in Table 2.

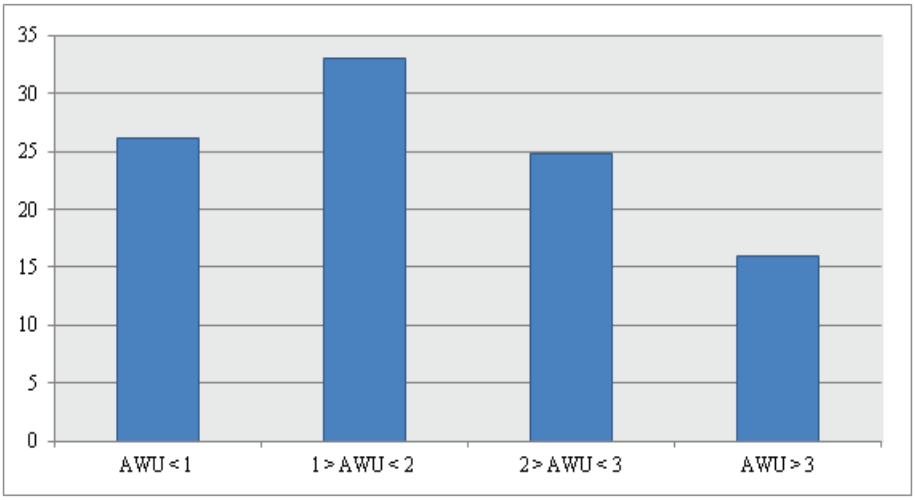
Table 2: An average number of AWU depending on the size of family farms in Serbia

UAA per holding (ha)	**Average number of AWU per family holding**	**Index (Holdings with UAA from 10.01 to 50 ha=100)**
< 1	0.6	33.33%
1.01 to 2	0.8	44.44%
2.01 to 5	1.2	66.67%
5.01 to 10	1.5	83.33%
10.01 to 50	1.8	100.00%
50<	2.2	122.22%

Source: Statistical Yearbook of the Republic of Serbia, RZS, 2021, p. 234, (based on census 2018)

On the other hand, there is a significant percentage (26.1%) of farms (having size 10 to 50 hectares) with less than one AWU (Graph 2).

Graph 2: The structure of farms cultivating 10 to 50 hectares by number of AWU (%)



Source: Statistical Yearbook of the Republic of Serbia, RZS, 2021, p. 234 (based on census 2018)

Data concerning the year 2020 (dealing with the farms involved in Serbian FADN sample) indicate the following facts – 1.3 AWU per farm is used in the region Serbia North, which is less than an average for the region Serbia South (1.9 AWU per farm). There are a few reasons for this situation, such as bigger farms, higher level of mechanization and lower presence of the livestock production in the region Serbia North (MPŠV, 2022, p. 42). According to the same source (MPŠV, 2022, p. 43), specialized crop farms and specialized swine farms have the lowest level of the used AWU among Serbian farms involved in FADN sample (in 2020)

Based on the data from Census (2018), 14% of agricultural labor force in Serbia is engaged on specialized crops farms (Bogdanov and Babović, 2019, p. 33). According to the authors (Bogdanov and Babović, 2019, p. 33), specialized crops farms are dominant in the AP Vojvodina concerning agricultural employment (specialized crops farms use 45% of the total AWU in the region).

a) Changes of the sowing structure

The optimization process (performed in variants 1, 2 and 3) and the introduction of sweet corn (in variants 2 and 3) caused changes in the sowing structure (Table 3). In Variant 1, the optimization caused a decrease of an area used for winter wheat production, while all other crops increased its participation in the sowing structure. The introduction of sweet corn in Variant 2, led to a decrease of areas used for corn and winter wheat production, while areas under sunflower and soybean enlarged. Variant 3 was characterized by a decrease of winter wheat area, while an area under other production activities increased.

Table 3: The sowing structure before and after the optimization

Crop	Sowing structure before the optimization (%)	After the optimization					
		Sowing structure (%)			Change in relation to sowing structure before the optimization		
		Variant 1	Variant 2	Variant 3	Var. 1	Var. 2	Var. 3
Corn	47.58%	50.00%	43.11%	48.06%	↑	↓	↑
Winter wheat	33.33%	20.00%	20.00%	20.00%	↓	↓	↓
Sunflower	1.64%	5.00%	5.00%	5.00%	↑	↑	↑
Soybean	17.45%	25.00%	25.00%	25.00%	↑	↑	↑
Sweet corn	-	-	6.89%	1.94%	-	↑	↑
TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**-**	**-**	**-**

Note: ↑ - increasing the share of crops in the sowing structure after the optimization; ↓ - decreasing the share of crops in the sowing structure after the optimization. Source: Authors' calculation

When determining an optimal sowing structure, the priority has been given to the production activities whose minimal participation should satisfy limitations imposed by the crop rotation. Therefore, wheat participates with 20% in an optimal sowing structure (in Variant 1, 2 and 3), although it has a rather low level of gross margin. On the other hand, participation in an optimal sowing structure of the crops having the highest gross margin is restricted by some factors such as availability of labor force (for sweet corn in Variant 2) or market and organizational challenges (for sweet corn in Variant 3). Generally, higher participation of sweet corn in the sowing structure (Variant 2) led to a decrease of mercantile corn production area.

b) Changes of working hours

The optimization did not only change the production structure, but also a number of working hours necessary for the production process (Table 4). A detailed analysis revealed that, after the optimization (Variant 1), the total number of working hours spent at the farm increased for 4.39 hours per year (by 3.59%). Somewhat bigger increase of the used working hours is recorded in Variant 3 because the total number of working hours increased for 44.51 hours per year (by 36.39%). The most significant improvement of labor force use is related to Variant 2 which is characterized by the biggest area utilized for the sweet corn production. Comparing to the state before the optimization and without the sweet corn production, Variant 2 used 147.12 working hours more, which represents 120.26% improvement.

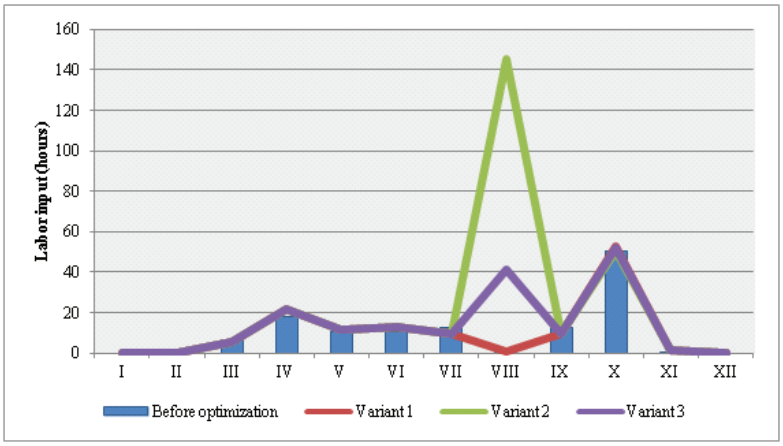
Table 4: The change of working hours per months after the optimization

Month	Variant 1		Variant 2		Variant 3	
	Change (hours)	Change (%)	Change (hours)	Change (%)	Change (hours)	Change (%)
I	0.00	/	0.00	/	0.00	/
II	0.00	/	0.00	/	0.00	/
III	-1.17	-17.15%	-1.17	-17.15%	-1.17	-17.15%
IV	3.54	19.53%	3.57	19.72%	3.55	19.58%
V	1.56	15.10%	1.56	15.10%	1.56	15.10%
VI	2.38	22.39%	2.38	22.39%	2.38	22.39%
VII	-2.81	-22.33%	-2.81	-22.33%	-2.81	-22.33%
VIII	0.36	201.00%	145.42	80,788.89%	41.14	22,856.56%
IX	-2.91	-23.63%	-2.91	-23.63%	-2.91	-23.63%
X	2.22	4.38%	-0.14	-0.28%	1.56	3.07%
XI	1.22	206.10%	1.22	206.10%	1.22	206.10%
XII	0.00	/	0.00	/	0.00	/
TOTAL	**4.39**	**3.59%**	**147.12**	**120.26%**	**44.51**	**36.39%**

Source: Authors' calculation

If the analysis is performed per months, the results indicate the decrease of labor force use in March, July, September (for all the observed variants), and in October (only for Variant 2). The highest increase of labor force use could be noted in August (for all three variants), while the highest use of labor force during August is recorded for Variant 2 (because of the highest participation of sweet corn in the sowing structure of that variant) (Table 4 and Graph 3).

Graph 3: Working hours per months (before and after the optimization)



Source: Authors' calculation

Increasing the share of sweet corn (which requires a greater engagement of the labor force compared to other crops present in the crop production due to hand picking and packing) in the sowing structure contributes to the increase in employment of labor force on the family farm especially in the case of Variant 2.

c) Changes of gross margin

Very important conclusions (concerning economic performance after the optimization and introducing sweet corn in the sowing structure) could be made by calculating various indicators based on gross margin (Table 5). Positive effects of the optimization in Variant 1 are recorded concerning all economic indicators. However, the inclusion of sweet corn in the sowing structure combined with the optimization improved two of the three observed indicators (while better results for both of these indicators were achieved using Variant 2).

Table 5: Economic effects of the optimization and change in the sowing structure

Economic indicator	Value before the optimization (RSD)	After optimization					
		Value (RSD)			Change in relation to value before the optimization		
		Variant 1	Variant 2	Variant 3	Var. 1	Var. 2	Var. 3
Gross margin	648,871.99	684,381.01	924,776.69	751,963.09	↑	↑	↑
Gross margin per used labor hour	5,304.28	5,400.87	3,432.15	4,507.05	↑	↓	↓
Gross margin per available labor hour	359.60	379.28	512.51	416.74	↑	↑	↑

Note: ↑ - increasing the value of economic indicator after the optimization; ↓ - decreasing the value of economic indicator after the optimization
Source: Authors' calculation

As a result of the optimization, gross margin on the farm level increased by 5.47% (Variant 1), causing at the same time an improvement of gross margin per used labor hour and per available labor hour (Table 6).

Generally, an increase of gross margin at the farm level means an improvement of its capacity to cover fixed costs. Therefore, short term variations of gross margin at the farm level directly influence the level of profit. The highest increase of gross margin was recorded for Variant 2, while, at the same time, the application of Variant 2 decreased gross margin per used labor hour the most (35.29%). Nevertheless, Variant 2 improves gross margin at the farm level (at the same time increasing the farm profit) and gross margin per available labor hour by 42.52%.

Table 6: Changes in economic indicators after the optimization

Economic indicator	Variant 1		Variant 2		Variant 3	
	Change (RSD)	Change (%)	Change (RSD)	Change (%)	Change (RSD)	Change (%)
Gross margin	35,509.02	5.47%	275,904.70	42.52%	103,091.11	15.89%
Gross margin per used labor hour	96.60	1.82%	-1,872.12	-35.29%	-797.23	-15.03%
Gross margin per available labor hour	19.68	5.47%	152.91	42.52%	57.13	15.89%

Source: Authors' calculation

Therefore, managerial decision of introducing sweet corn in the sowing structure is economically expectable. The same conclusion is made when market and organizational challenges are taken into account (Variant 3) although economic effects of such a decision are less significant.

Conclusion

Introducing sweet corn in the sowing structure of specialized field crops family farms results in an increase of gross margin as well as an increase of number of working hours spent on the farm (which proves the initial hypothesis). The highest gross margin is determined for Variant 2 because this variant is not related to any market limitations or organizational challenges. The sweet corn production leads to a better use of available labor force, especially during August (when it comes to the usual sowing structure, labor force in August is mostly unutilized). Having in mind that (even with the sweet corn production) capacity of labor force at family farms is not fully used, there are possibilities for family members' engagement outside the farm (or engagement related to other gainful activities at the farm).

There are not big differences between mercantile corn and the sweet corn production technologies on family farms, except for the sweet corn harvesting (sweet corn produced on family farm is handpicked, due to the lack of combine harvesters). Therefore, the results obtained in this research indicate possible directions of the sowing structure diversification (concerning specialized field crops farms). Such diversification should improve the use of available labor force, without a significant change of common production practice.

Nevertheless, it is needed to discuss some additional issues in order to reach a final decision on the sweet corn production. Some of the factors requiring further discussion are: capability of the market to absorb sweet corn quantities produced at the farm, quality of the sweet corn, premises available to store sweet corn (if the entire production cannot be sold immediately after harvest), etc. Therefore, the key challenge is how to improve and strengthen connections between sweet corn producers and processors.

There are some issues concerning the sweet corn irrigation, as well. It is impossible (in Serbian agro-ecological conditions) to produce sweet corn of satisfying quality without irrigation. Therefore, presence or absence of the irrigation system on the farm could be of the utmost importance for economic effects of the sweet corn production. If irrigation system is not already present on the farm, additional investments would increase fixed costs and possibly compromise an overall economic performance.

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