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Original scientific paper

SMALL BERRY FRUIT FARMS AND DIVERSIFICATION POTENTIAL ON REDUCTION OF PRODUCTION RISK

Emir Bećirović[1*], Sabahudin Bajramović[1], Ivana Janeska Stamenkovska[2], Jaka Žgajnar[3]

[1]University of Sarajevo, Faculty of Agriculture and Food Science, Bosnia and Hercegovina
e.becirovic@ppf.unsa.ba (*corresponding author)
[2]Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food - Skopje, Republic of North Macedonia
[3]University in Ljubljana, Biotechnical Faculty, Slovenia

ABSTRACT
A significant number of small farms in Bosnia and Herzegovina (BiH) produce berry fruits. Some of them achieve good economic results, however many have significant potential for further improvement. Due to several beneficial factors, many farms decide for cultivation of a single berry fruit activity, however this decision implies a potential risk in case of unfavourable production or market conditions for that crop. The aim of this analysis is therefore to observe the extent of risk reduction by application of different diversification strategies, using two types of berry fruits; and the most efficient production plans for such a farm from a risk perspective. A linear program was utilized to prepare an optimal production plan, while quadratic risk programming served to analyse risk. Results show that diversification could be a significantly important possibility for risk reduction on such farm type. It is possible to reduce risk with capital and labour less intensive production activities. Production of the highly intensive strawberry variety *Clery* has highest Estimated Gross Margin (EGM), but is also associated with very high risk. If one includes raspberries or blueberries into the production plan, it is possible to significantly reduce risk while almost keeping EGM at the same level. On the other hand, if the farmer is risk averse, the highest opportunity cost for risk reduction on such a farm type is in production of raspberry and blueberry, where it is necessary to give up 3.25 EUR on average for decreasing risk for one EUR. In the other two scenarios, production of strawberry – blueberry and strawberry – raspberry, risk gradient values are almost the same with amount 2.57 EUR sand 2.56 EUR, respectively.

Key words: risk management, optimal plan, diversification, berry farms.

INTRODUCTION
Agriculture is the fourth most important sector in Bosnia and Herzegovina (BiH), considering its share in total GDP (ASBH, 2016). Taking into consideration the entire BiH agricultural sector, during the past period the production of fruits, especially raspberries and strawberries, revealed most intensive development (MAWF, 2014). There are several reasons why fruit growing has spread faster compared to the other agricultural sub-sectors over the past years (Becirovic & Zgajnar, 2019). Namely, the average farm size in BiH is very low, indicating that the production should be intensive in order to generate higher income per unit of production. Additionally, BiH has favourable climate conditions for production of continental fruits and Mediterranean species (Kurtović *et al*., 2004). The market for these products has also developed during the last decade, which is not the case for most of the other agricultural products. Another reason supporting the expansion of fruit production in BiH relates to the availability of family labour, i.e. a significant number of small family farms

provide all necessary labour by family members, thus positively impact the farm income. Berry fruit production supports these preconditions, i.e. the berry farms in BiH utilize modest land area and have potential for achieving sufficient economic results. Due to these beneficial factors, many farms decide for the cultivation of only one berry fruit enterprise, which on the other side represents a potential risk in case of unfavourable production or market conditions.

In the process of production planning, farmers have to choose among different alternative activities associated with different risk levels. Alternatives with minimal risk usually generate a smaller profit. However, the alternatives with higher risk could generate higher profits, but they may be riskier than the farmer is willing to accept. The desired and optimal choice needs to balance the potential for profit and the risk of loss (Crane *et al*., 2013). On the other hand it is also important to determine the opportunity costs resulting from the decision, i.e. how much does it cost to decrease the risk to a certain level. Numerous studies have shown that farmers are in general risk averse (e.g. Binswanger, 1980, Zgajnar & Kavcic, 2016), commonly choosing less risky activities resulting in lower profits. This opens a number of challenges for effectively organization of those holdings and decisions about which activities to select in the optimal production plan, such as: (i) to reduce risk or (ii) at given level of risk, to achieve better economic result (Zgajnar, 2017). Zgajnar & Becirovic (2019) have analysed the possibility of risk reduction on small, semi-large and large farms, and have found out that regarding risk reduction efficiency considering diversification of production plan, the small family farm is the most efficient.

The aim of this analysis is therefore to observe the risk on small family farms and how much it can be reduced, by application of different diversification strategies. The analysis is done in context of using two types of berry fruits instead of one. In addition, we also analyse which are from risk perspective the most efficient production plans for such farm type.

MATERIAL AND METHODS

The main objective of this study is to analyses risk reduction efficiency on small family farms specialized in berry fruit production, as well as to identify the main production challenges on small-scale farms in production planning. This is a classical problem of the optimal allocation of production resources considering risk. Microsoft Excel has been used as a basic platform, which enables relatively simple integration, complementarity and adjustment of the model-tool to any analysed farm (Zgajnar, 2017). To solve the allocation problem, mathematical programming concept has been applied, utilizing MS Excel Solver for linear and non-linear problems (Powell & Baker, 2009). Optimization is carried out on the basis of maximizing the expected gross margin (EGM).

The developed model-tool consists of three sub-models. The first sub model consists of 60 statistical simulation models (budgets) that enable calculation of different economic indicators at the level of berry fruits production activities. In addition to the economic indicators its main purpose is to calculate technical parameters for different production activities. Therefore, for each production activity technology cards have been defined.

The tool is further based on linear (second sub-model) and quadratic constrained programming (third sub-model) to support the production-planning analysis considering risk. Linear programming (LP) is used to prepare an optimal production plan maximizing the expected gross margin (EGM). This is also the starting point (value) for parametric constraints in the third sub-model that enables efficiency risk analysis. In this part, sensitivity analysis was also done by observing reduced cost and shadow price[1].

[1] Reduced cost represents amount by which an observed activity must be improved to be included in an optimal production plan. Shadow price on the other hand shows how much we can pay for an additional unit of scarce resource (binding constraint) not to deteriorate economic result.

The third sub-model is based on quadratic risk programming (QRP) that considers also riskiness of activities. It enables calculating the optimal solution at a given level of risk that in a set of optimal solutions forms efficient production frontier. The expected value and variance (E-V) criterion considers that farmers choose between alternative farm plans based on EGM and related variance (V). With suggested approach, it is possible to formulate the set of farm plans laying on the E-V efficient frontier and enables analysis of which activities to include to either, (i) reduce the risk at a certain level of gross margin or, (ii) increase the gross margin at a certain level of risk.

Production activities

The model-tool includes 60 baseline production activities that are further divided into three production sub-groups: raspberry (R), blueberry (B) and strawberry (S). Within each sub-group there are different production activities considering different fruit varieties, each with own specific production technology, yield, etc. The specific fruit varieties require different production conditions and therefore in terms of mathematical programming different technical coefficients are determined. Hence, in this analysis we considered 11 different activities as possible to enter into the farm production plan. These are most common varieties on small family farms in BiH. In this context, four different varieties of raspberry are included (*Willamette*, *Meeker*, *Tulameen* and *Polka*), two different varieties of blueberries (*Duke* and *Bluecrop*), and four varieties of strawberry (*Clery*, *Zenga*, *Arosa* and *Maja*). Regarding the production technology, all activities included in the analysis have intensive production. Nevertheless, as an additional activity, the high-intensive strawberry *Clery* production is included. Highly intensive production implies growing in high plastic tunnels, which is from technological perspective the main difference comparing to an intensive production. *Clery* is chosen as a high-intensive production option because as an early fruit variety with production in plastic tunnels, it enables achieving higher price as a first strawberry on the market. Therefore, the costs of the plastic tunnel are calculated in the total variable costs (VC), and considered at the level of EGM.

The majority of farms in BiH cultivate small amount of arable land utilising mostly family labour. The model is therefore applied on hypothetical farm as a representative of berry fruit producers, whereas the main assumptions are that it cultivates 0.5 ha of arable land, and whole labour is provided by family members (8,800 h). Three different scenarios are considered, focusing on different diversification strategies. In this context, each scenario combines two different crops with their crop varieties. In the first scenario (S1-B/S), the possibility of combination of blueberries and strawberries was observed, in the second scenario (S2-R/S) the production of raspberries and strawberries was tested, while the third scenario (S3-R/B) enables different combinations of raspberries and blueberries varieties.

Input and output price changes have been analysed at an average annual level for the period 2008-2017 (ASBH, 2018).

RESULTS AND DISCUSSION

Three different scenarios for small family farms are analysed. Each of them includes results for the optimal production obtained through the LP sub-model by maximizing EGM, as well as for the efficiency of risk reduction strategies for the observed farms obtained with the third sub-model (QRP).

Table 1. Optimal solutions and economic indicators for all three scenarios by maximizing EGM

Description	S1-B/S	S2-R/S	S3-R/B
Economic indicators (EUR)			
Revenue	17,514	17,514	11,984
Variable costs (VC)	6,857	6,857	1,968
EGM	10,656	10,656	10,017
SD of EGM	3,996	3,996	2,982
EGM/ha	21,322	21,322	20,034
EGM/h*	5.02	5.02	4.40
Share of SD in EGM (%)	37.50	37.50	29.77
Land Area			
Blueberry *Duke* (ha)	0.00	0.00	0.50
Blueberry *Bluecrop* (ha)	0.00	0.00	0.00
Strawberry *Clery* (ha)	0.50	0.50	0.00
Labour input			
Family labour (h)	2,124	2,124	2,277
Utilized family labour (%)	24.14	24.14	25.88
Post optimal analysis			
Reduced costs (EUR)			
Blueberry *Duke*	0	-	0
Blueberry *Bluecrop*	-1,693	-	-1,693
Strawberry *Maja*	-5,575	-5,575	-
Shadow prices (EUR)			
Arable land	20,033	14,260	14,260

As it is apparent from table 1, the first (S1-B/S) and the second (S2-R/S) scenario, result in optimal production plan with highly intensive production of strawberry *Clery* on total area. At the same time, such production is also the riskiest production on the farm (Figure 1 and Figure 2). The farm would achieve 10,656 EUR of EGM, whereas revenues are 17,514 EUR and total variable costs comprise 39.15% of the total revenue. The production of highly intensive strawberry *Clery* requires a significant amount of capital comparing to the other productions covered with this model. Hence, the total variance, measured as standard deviation (SD), is 3,996 EUR, i.e. 37.5 % of EGM showing relatively high variability. Regarding the use of family labour, only 24.14% of the total available labour is utilised, resulting in 2,124 h. EGM per ha is 21,322 EUR, while EGM per h of utilised labour is 5.02 EUR. The post-optimal analysis for the first scenario (S1-B/S) shows that blueberry *Bluecrop*, as less productive activity, is the next closest alternative to optimal plan for this farm. However optimal EGM at farm level would be reduced for 169 EUR per each additional 0.1 ha included in the production plan instead of strawberry *Clery*. Due to the relatively intensive production on such a family farm, the shadow price for the arable land is 20,033 EUR, which means considering the given circumstances, that for each additional unit of arable land the EGM would theoretically increase by 20,033 EUR.

In the second scenario (S2-R/S), strawberry *Maja*, as less productive activity, is the next closest alternative to the optimal plan for this farm, where the optimal EGM at farm level would be reduced for 575 EUR per each additional 0.1 ha included in the production plan instead of strawberry *Clery*. The shadow price for the arable land is calculated at the level of 14,260 EUR, which is almost 30% less compared with the first scenario. The use of family labour is also very low (25.88%), or in total it amounts for 2,124 h. EGM per ha is 20,034 EUR and EGM per h of utilised labour is 4.40 EUR.

The last case scenario (S3-R/B) reveals that the optimal production plan comprises only raspberries and blueberries. In such a case, the optimal solution would be cultivation of the blueberry variety *Duke* on an area of 0.5 ha. EGM is 10,017 EUR, and it is 6% lower than in the first two scenarios (S1-B/S and S2-R/S). However, on the other hand, the riskiness of such production plan is lower (SD is 2,982) for 25%. Variable costs cover only 16.42% of the total revenue, significantly lower when compared with the first two scenarios.

The further results show how the risk can be reduced in all three different scenarios, emphasizing the main differences between all three diversification strategies. In this context, in the first scenario (S1-B/S) a combined cultivation of blueberries and strawberries is observed. Here, the analysis of the E-V efficiency curve for S1-B/S shows that with a slight reduction of the total EGM the farm would achieve a significant (16.37% – 31.47%) reduction of risk (SD) (Figure 1). If the optimal production plan includes also less risky blueberry *Duke* on 66% of the arable land and strawberries on the rest, the EGM will decrease for about 4.05%, but however SD decreases for 24.90%. In other words, to reduce risk for 1 EUR, it is necessary to sacrifice on average only 0.43 EUR of EGM. In average reducing risk for one (1 EUR) unit in this scenario (S1-B/S) will cost 2.57 EUR.

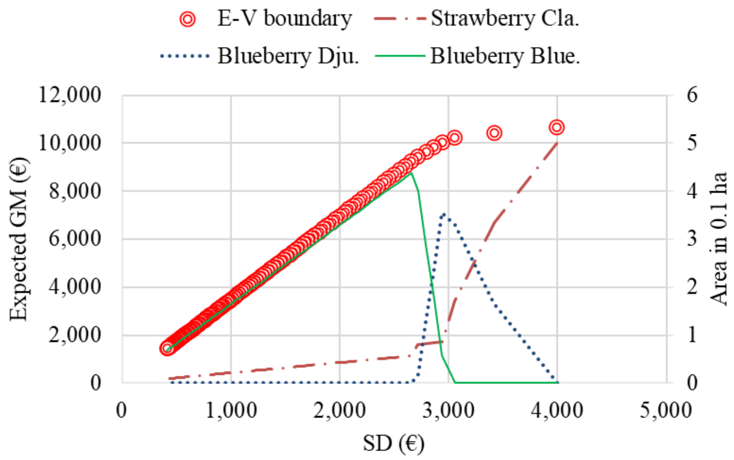

Figure 1. E-V efficient frontier for production of blueberry and strawberry (S1-B/S) at small family farm and change in optimal production plans

As analysed with the second scenario (S2-R/S), a cultivation raspberries and strawberries is considered. The results provide optimal production of strawberry *Clery*, on an area of 0.5 ha. Therefore, the starting point is the same as in the first case scenario (S1-B/S). With the reduction of riskiness of the production plan (Figure 2), the share of raspberry *Willamette* production significantly increases due to the fact that production of *Willamette* is labour and capital less intensive than the highly intensive strawberry *Clery*. The efficiency of the risk reduction is relatively lower when compared with S1-B/S. For reducing SD by 24.82%, EGM decreases for 11.42%. Therefore, raspberry *Willamette* should be produced on 29% of the total available land area and highly intensive strawberries *Clery* on the remaining. If we want to further decrease the risk, then raspberry *Willamette* has to comprise bigger share of land. So, for decreasing risk by 42%, comparing to the starting point, it will be necessary to decrease the EGM for 23.10%. In this case, raspberry *Willamette* should be on 65% of the available land. In average reducing risk for one (1 EUR) unit in this scenario (S2-R/S) will cost 2.56 EUR.

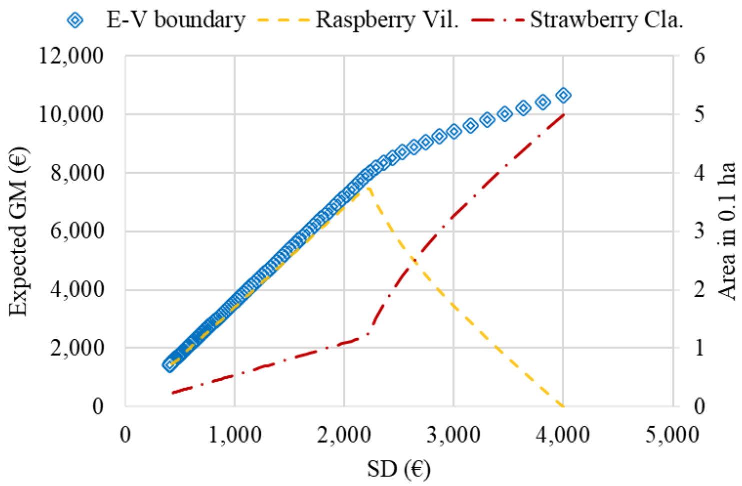

Figure 2. E-V efficient frontier for production of raspberry and strawberry (S2-R/S) at small family farm and change in optimal production plans

Regarding the third scenario (S3-R/B), the results show a bit lower EGM in the optimal solution (Table 1) as compared to the first two scenarios, but significantly lower risk. In this scenario, if we want to reduce the production risk, the production of blueberry *Duke* will comprise smaller share, while the intensive production of raspberry *Willamette* will dominate the optimal solution. In this context, if the risk reduction amounts for 23.07 % the EGM should decrease for 9.61%; thus the raspberry *Willamette* will be produced on 33% of arable land, while the remaining area will be cultivated with blueberry *Duke*. For larger decrease (>36%) of riskiness, the intensive production of blueberry Duke will not be included in the optimal production plan, i.e. the optimal solution will include only less risky blueberries *Bluecrop* and raspberry *Willamette*. In average the risk reduction for one (1 EUR) unit in this scenario will cost for 3.25 EUR.

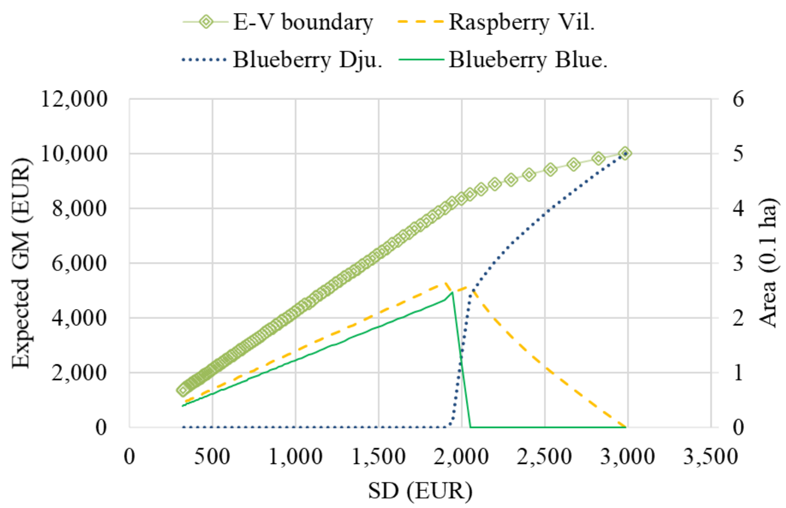

Figure 3. E-V efficient frontier for production of raspberry and blueberry (S2-R/B) at small family farm and change in optimal production plans

CONCLUSIONS

The results show that diversification of the production plan is very significant risk reduction strategy on a mix berry farm. The risk could be reduced with production of capital and labour less intensive berry fruits. Production of highly intensive strawberry *Clery* has highest EGM, but also is considered as the riskiest fruit variety. If the first two scenarios (S1-B/S and S2-R/S) include raspberries or blueberries in the production plan, it is possible the risk to be significantly reduced with relatively smaller decrease of EGM. The production of raspberries and blueberries in the third scenario have lower EGM but significantly lower risk.

From risk management perspective the most expensive is the production of raspberry and blueberry, while in the other two scenarios, the costs for risk reduction are almost the same, i.e. 2.57 EUR (S1-B/S) and 2.56 EUR (S2-R/S) respectively. In this context the production of berry fruits could be interesting for farms with favourable production conditions and available market, where the production of raspberries and blueberries could be a promising production plan for the risk averse farmer.

The developed model for optimisation of berry production on one side and diversification of the production on the other side proved to be useful when analysing farm risk management strategies. The findings reflect to a large extent the situation in practice, whereas the model revealed the seasonality of work is also quite important challenge on berry farms. The developed model is flexible, enabling different crop enterprises to be added additionally. It could be also applied for optimising the farm situation and diversification as risk management strategy in the countries in the region, considering the similar structure of their agricultural production as well as similar production technologies.

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