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Original paper

Production of Puno and Titicaca quinoa cultivars - cost benefit analysis

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Abstract The aim of the paper is to test the effect of climatic conditions and management practices on the yield of two quinoa cultivars (Puno and Titicaca) and to analyze the economic benefits of quinoa productivity. The experiments were carried out during the 2017 and 2019 growing seasons in rain-fed conditions on a Serbian farm. The results of the two-year long experiments proved that the growing of the quinoa cultivar Puno and particularly the cultivar Titicaca in the agro-ecological conditions of Serbia would be remarkably successful from the aspect of agronomy (with the obtained average yield of 2.5 t ha^{-1}) as well as from the aspect of economy (with the achieved average profit of 9,411 € ha^{-1}). The obtained profit values indicate that the quinoa production in the Republic of Serbia would be more cost-effective than the production of the field crops which are already produced, particularly in the increasingly present arid conditions.

Keywords Quinoa, Puno, Titicaca, Yield, Climatic conditions, Cost-benefit analysis

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Introduction

Climate change is one of the most serious problems facing the world today. The recent Intergovernmental Panel on Climate Change reports confirmed that climate change would have a significant impact on the global surface temperature, and the number of extreme weather events, including heat waves, storms and flooding (IPCC, 2014). Agricultural production is especially sensitive to climate changes and many countries are faced with the challenge to sustain agricultural productivity and food stability in such conditions. For instance, the sensitivity of Europe's agriculture to climate change, especially drought, has a distinct north-south gradient and many studies indicate that Southern Europe will be more severely affected than Northern Europe. The Mediterranean and South-East European regions are particularly vulnerable to the agricultural drought in Europe (JOVANOVIC and STIKIC, 2012). In such conditions the challenge is to use not only stress resistant genotypes of classical crops (maize, wheat, soybean, etc.) but also to identify and test the use of alternative crops. One of the recognized alternative crops for stress conditions is quinoa.

Quinoa (*Chenopodium quinoa* Willd.) is a pseudocereal crop belonging to the family Amaranthaceae and native to the Andean region where it has been grown for more than 7000 years (BOIS et al, 2006). Quinoa is considered to be a multipurpose agricultural crop (may be utilized for human food and in animal feedstock) because of its exceptional nutritional and health characteristics (JACOBSEN, 2006; REPO-CARRASCO et al, 2003). The nutritional values of quinoa are the result of the high content of minerals, vitamins, proteins and essential amino acids, high quality fatty acids, antioxidants and other important multiple bioactive compounds which, due to their antimicrobial, anti-inflammatory, anti-tumour and anti-cancer properties, are of special importance for human health (VILCACUNDO and HERNÁNDEZ-LEDESMA, 2017). In addition, quinoa can be grown in a variety of agro-ecological conditions due to its resistance to abiotic stress factors such as drought, temperature, salts (JACOBSEN, 2017). Quinoa can withstand temperatures from -4 °C to 38 °C (BAZILE et al, 2016a; JAIKISHUN et al, 2019) and can have satisfactory yields with precipitation of only 100 to 200 mm (VALENCIA-CHAMORRO, 2003), which gives it the ability to grow in the regions with low precipitation. Furthermore, the United Nations declared the year 2013 to be the International Year of Quinoa (FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS, 2013). Due to its exceptional nutritional and health values, the world popularity of quinoa is growing enormously and quinoa is being grown/tested in more than 90 countries other than South America (BAZILE et al, 2016b). The quinoa production is very profitable and in 2011 the average market price of quinoa per ton was $ 3,115 and some varieties were sold for as much as $ 8,000 per ton (RUIZ et al, 2014).

However, although the southern part of Europe is already faced with climate changes affecting agricultural production, the cultivation of quinoa is still limited, with the exception of Italy, Greece and Romania (PULVENTO et al, 2015; NOULAS et al, 2015). In Serbia, a country with the Southeast European agro-climatic conditions, quinoa is not yet being grown commercially. However, some previous results showed an excellent nutritional quality of both quinoa seeds and the bread prepared from the flour of quinoa plants grown under rain-fed conditions (STIKIC et al, 2012; CZEKUS et al, 2019).

The aim of this paper is to test the effect of climatic conditions and management practices on the yield of two quinoa cultivars (Puno and Titicaca) grown in Serbia, and to analyze the economic benefits of quinoa production. These results are expected to help farmers in Serbia to grow quinoa as a new crop and introduce quinoa seeds and food products to the growing domestic market in Serbia, and possibly to the markets of foreign countries.

Materials and Methods

Plant material and experimental site

The experiments were carried out during the 2017 and 2019 growing seasons in rain-fed conditions, using two cultivars of quinoa (Puno and Titicaca) selected at the University of Life Sciences in Copenhagen, Denmark (JACOBSEN and MUICA, 2002) and adapted to the European climate. The quinoa was grown on a Serbian farm near Subotica in the area between the latitude of 46° North and longitude of 19.68° East. The soil type was chernozem, moderately rich in nitrogen and hummus (0.18%, 2.88%), highly rich in phosphorus (28.38 mg $100g^{-1}$) and rich in potassium (21.71 mg $100g^{-1}$), slightly alkaline (pH 7.8). The seeds were sown in the first part of April. The experiment was laid out in a split-split plot system, with four replications. The size of the main plot was 12 m^2. The distance between the rows was 50 cm and the distance between the plants in the row was 10 cm (approximately 200,000 seeds per hectare) (WANG et al, 2020). The seeds were sown at the 2-cm depth. No fertilizer was applied during the vegetative season. The sowing date was at the beginning of April and the crops were harvested in the second half of August during the phase of the seed physiological maturity according to BERTERO et al. (2004).

The data on temperature, wind speed, relative air humidity and solar radiation were obtained from the Republic Hydrometeorological Institute of Serbia for the meteorological station Palić, which is at a 13-km distance from the experimental field. The potential evapotranspiration (ETo) was calculated using the FAO Penman-Montheith method (ALLEN et al, 1998). Quinoa water requirements in the climatic conditions of Palić were expressed using the crop potential evapotranspiration (ETc). Etc was calculated as the product of the potential evapotranspiration (ETo) and the single crop coefficient (Kc). The Kc values were in accordance with FGHIRE et al. (2015). The amount of precipitation was measured on site, at the experimental field. The obtained yields per plant (200 plants for each genotype and each year) in the conducted experiments in 2017 and 2019 were used to calculate the potential yield per hectare which could be achieved in our agro-ecological conditions, taking into account the recommended crop density (200,000 plants ha^{-1}). It is extremely difficult to obtain the potential yield in the production conditions due to the fact that the production on large areas involves certain losses (inability to obtain an ideal crop density, mechanical harvesting, selection losses). On the other hand, at the experimental field all operations were conducted manually without any losses. Therefore, the potential yield was reduced by 20% in order to obtain the production yield to be used in further calculations of the economic feasibility of cultivating quinoa.

Parameters of economic assessments

The profitability assessment of the production of the two quinoa varieties (Puno and Titicaca) was made on the basis of the generated profit (KRESOVIC et al, 2014; MATOVIC et al, 2016). The amount of the profit margin generated during the two-year quinoa cultivation in Serbia reflects the net economic benefit (KENDALL et al, 2007), which is equal to the difference between the total income generated and total production expenditure.

The parameters for calculating the profit included the yield calculation and market price data for quinoa. The market price was determined on the basis of the data collected in health food stores. Since the Republic of Serbia imports quinoa, its price in health food stores includes a customs rate of 10%, a margin of 20% and a value added tax (VAT) of 20%. For the purpose of assessing the economic feasibility of introducing quinoa into mass production, and on the basis of the legislation in Serbia, the costs of customs duties (10%), margins and VAT (20%) are excluded from the full retail price and the retail price (Table 1) is calculated in (€/kg).

Table 1. Quinoa market price and prices of marketing services of the conducted agro-technical measures

ACTIVITY	**2017**	**2019**
PRICE (€/kg)		
Puno	4.16	4.27
Titicaca	4.16	4.27
AGRO-TECHNICAL MEASURE (€/ha)		
Spreading mineral fertilizers before ploughing	9.23	9.47
Ploughing at the 30-cm depth	45.16	46.33
Spreading mineral fertilizers after ploughing	10.34	10.61
Pre-sowing preparation – the operation of a seedbed tiller up to 4m	10.22	10.48
Sowing by means of a mechanical seed drill	84.06	86.24
Inter-row cultivation	11.54	11.84
Crop spraying – pre-harvest treatment	23.75	24.37
Harvesting using a combine harvester	65.93	67.64

Source: The author's calculations according to the data from health food stores and Pricelists of mechanical services, Cooperative Union of Vojvodina

The total expenditure included all costs of agro-technical measures typical of quinoa production. The following agro-technical measures were considered when calculating the expenses (ĐURIĆ et al, 2015): ploughing at the 30-cm depth, pre-sowing soil preparation, sowing, fertilization, crop thinning, inter-row cultivation, pre-harvest crop treatment, harvesting, procession (selection) of crops. The expenditure for all the agro-technical measures in the process of quinoa production was obtained from the official Pricelist of mechanical services (Table 1) (Cooperative Union of Vojvodina). Thus, the costs of each agro-technical measure were taken into account. They involve the costs of the complete service, i.e. costs of workforce, fuel consumption and depreciation of the used resources. The crop thinning service is conducted manually and its value is calculated according to the number of paid wages. The value of the service of seed processing (seed selection) was determined on the basis of the current market prices and had an average amount of 300 €/ha in the observed period.

When it comes to the agro-technical measure of sowing, the costs were increased by the value of the cultivar Puno and Titicaca seed (the price based on the suppliers' invoices). The recommended quantity for the area of 1 hectare is 4 kg of seeds. Similarly, the costs of the agro-technical measure of spreading mineral fertilizers before ploughing in autumn were increased by the value of 400kg NPK (15:15:15), while in the period of the pre-sowing soil tillage the costs were raised by the value of 100kg of the UREA fertilizer. The prices for the recommended amounts of the NPK (15:15:15) and UREA fertilizers were defined according to the suppliers' invoices. Crop thinning is performed manually. The crop thinning costs were calculated on the basis of the evaluation of the required workforce and the spent working hours. In order to realize the agro-technical measure of crop thinning, 15 daily wages per 8 working hours are required, which amounts to 120 working hours. In order to obtain balanced ripening and eliminate seed moisture, i.e. hasten the crop physiological maturity, prior to sowing the crops were treated by means of a preparation called "desiccator". The crops were treated using the agro-technical measure of spraying, which requires 3 l/ha of the preparation.

Table 2. Prices of inputs in the process of quinoa production in 2017 and 2019

Year	Unit of measurement	Used unit of measurement per ha	Price of 1 unit of measurement expressed in €	
			2017	2019
NPK (15:15:15) €/kg	kg	400	0.35	0.38
UREA €/kg	kg	100	0.36	0.41
Seed Chenopodium quinoa Wildd €/kg	kg	4	30	30
Manual crop thinning – wages €/h	h	120	2	2
Desiccator	l	3	12.36	12.68

Source: Pricelists of the official suppliers

According to the given parameters, the calculation of the total income and expenditure was conducted. On the basis of the differences between these two values in terms of profit, the economic feasibility of quinoa production in the Republic of Serbia was assessed.

Profit = Total income – Total expenditure (1)

The total profit was calculated for the years of 2017 and 2019 for both genotypes. When determining the total income, the production price was used in order to calculate the profit.

Results

Climatic characteristics

The experimental field is located in the area of the city of Subotica, characterized by continental climate with the daily mean air temperature (Tmean) of 11.0 ºC and the annual precipitation of approximately 536 mm. During the growing season (April-September) Tmean is 17.8 ºC, and the total average annual precipitation is around 319 mm.

The analysis of climatic data for the period 1961-2010 shows the tendency of the air temperature rise in this area. There is also an evident increase in the minimum (Tmin) and maximum (Tmax) air temperatures (Figure 1).

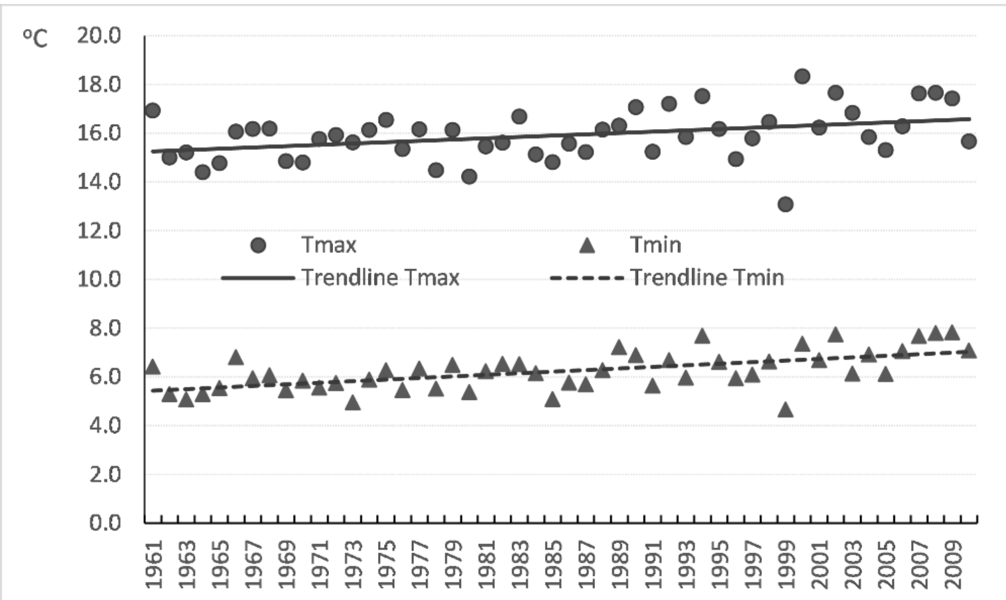

Figure 1. The tendency of air temperature rise in the area of Palić in the period 1961-2010

The growing seasons in the research years (2017 and 2019) in the area of Palić were also warmer than the long-term mean temperatures (Figure 2). Both growing seasons are characterized by the same Tmean of air which amounts to 19.3 ºC, which is by 1.5 ºC higher than the long-term average values. The differences of air temperatures in comparison to the mean values are particularly high during the summer months (June-August). Only May 2019 was colder than the mean temperature (Figure 2). When it comes to precipitation, the growing seasons of 2017 and 2019 differed significantly. In 2017 there was the total amount of 245 mm of rain, which is by 24% lower than the mean values, while in 2019 the precipitation amounted to 394 mm, which is by 23% higher than the mean values. There are also large differences in the monthly distribution of precipitation during these two growing seasons. In 2017 the precipitation was distributed in relatively equal monthly quantities which oscillated between 33 and 57 mm, while in 2019 the oscillations in the monthly precipitation were substantial – from 12 mm in April to as much as 168 mm in May (Figure 2). The uneven precipitation distribution in 2019 is reflected in the fact that 73% of the total precipitation (April-September) occurred in two months (May and June).

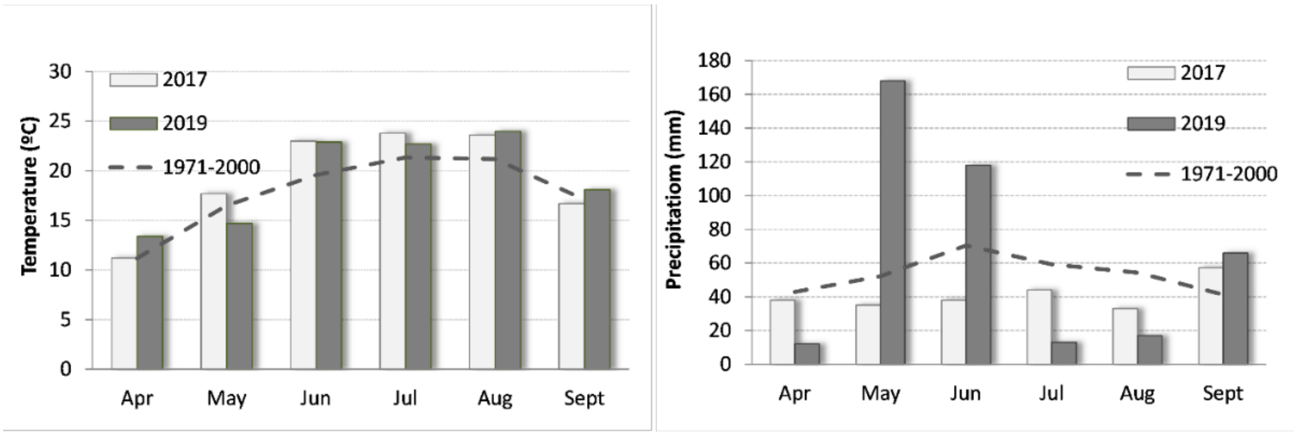

Figure 2. Monthly distribution of Tmean (left graph) and precipitation (right graph) in the research years in comparison to the mean values for 1971-2000 in the experimental field area.

Quinoa water supply

Crop water supply is represented by the decadal quinoa water requirements (ETc) and available precipitation (P) (Figure 3). The periods in which ETc is higher than P indicate the precipitation deficit. In 2017 the precipitation deficit occurred in the second half of May, while in 2019 it started at the beginning of June (Figure 3) and in both cases it continued until the end of vegetation periods. The total precipitation deficit during the growing season of 2017 amounted to around 390 mm, and in 2019 it was 250 mm.

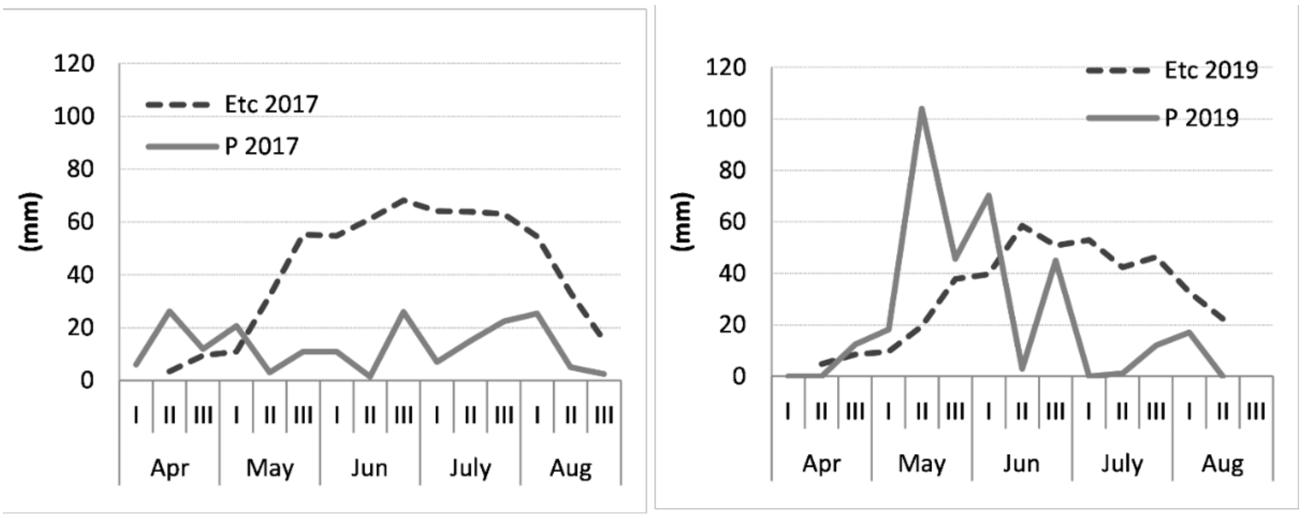

Figure 3. Quinoa water requirement (ETc) and precipitation (P) at the experimental field in 2017 and 2019.

Quinoa yield

In the experiments conducted in 2017 and 2019 the obtained average yields per plant amounted to 14.7 and 14.3 g for the Puno cultivar, and 17.2 and 15.6 g for the Titicaca cultivar (Figure 4). On the basis of the obtained yields in the experimental conditions, the production yield which would be possible to obtain per hectare in our agro-ecological conditions for the cultivar Puno would amount to 2.4 and 2.3 t ha^{-1}, while for the cultivar Titicaca it would be 2.8 and 2.5 t ha^{-1}. For both cultivars and for both research years it would amount to an average of 2.5 t ha^{-1}. The cultivar Titicaca realized the yield which was on average by 11% higher than the cultivar Puno yield. The analysis of yield during the two vegetation periods shows that the yield obtained in 2017 was higher (by 8% on average) in both cultivars than the yield realized in 2019.

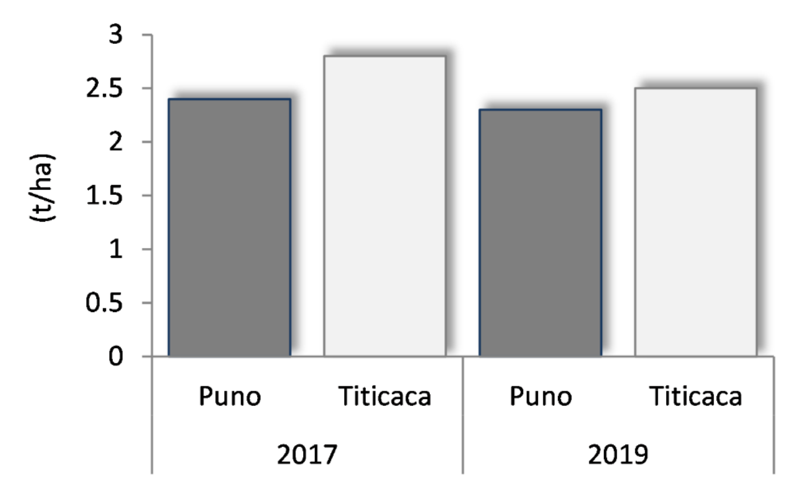

Figure 4 . The obtained yields of the quinoa cultivars Puno and Titicaca at the experimental field in 2017 and 2019

Economic evaluation

The conducted economic evaluation indicates that the cultivation of the tested quinoa cultivars (Puno and Titicaca) would be economically feasible in the production of the Republic of Serbia (Table 5). The cultivar Titicaca had a higher yield and more favourable cost-effectiveness than the cultivar Puno in both observed years.

Table 3. Assessment of the economic feasibility of quinoa cultivation in the production of the Republic of Serbia on the basis of the conducted experiments in 2017 and 2019.

No.	Description	2017		2019	
	Genotype	Puno	Titicaca	Puno	Titicaca
TOTAL INCOME					
1.	Yield kg/ha	2,400	2,800	2,300	2,500
2.	Production price €/kg	4.16	4.16	4.27	4.27
I	**TOTAL INCOME CALCULATED ACCORDING TO THE PRODUCTION PRICE €/ha (1. x 2.)**	**9,984**	**11,648**	**9,821**	**10,675**
TOTAL EXPENDITURE (€/ha)					
3.	Spreading mineral fertilizers before ploughing (3.1. + 3.2.) €/ha	149.23	149.23	161.47	161.47
3.1.	*Services of mineral fertilizer spreading* €/ha	9.23	9.23	9.47	9.47
3.2.	*Fertilizer NPK 15:15:15* €/ha	140	140	152	152
4.	Ploughing at the 30-cm depth	45.16	45.16	46.33	46.33
5.	Spreading mineral fertilizers after ploughing (5.1. + 5.2.) €/ha	46.34	46.34	51.61	51.61
5.1.	*Services of mineral fertilizer spreading* €/ha	10.34	10.34	10.61	10.61
5.2.	*UREA* €/ha	36	36	41	41
6.	Pre-sowing preparation – the operation of a seedbed tiller up to 4m €/ha	10.22	10.22	10.48	10.48

No.	Description	2017		2019	
	Genotype	Puno	Titicaca	Puno	Titicaca
7.	Sowing (7.1. + 7.2.) €/ha	204.06	204.06	206.24	206.24
7.1.	*Sowing by means of a mechanical seed drilll* €/ha	84.06	84.06	86.24	86.24
7.2.	*Seed* Chenopodium quinoa Wildd €/ha	120	120	120	120
8.	Manual crop thinning €/ha	240	240	240	240
9.	Inter-row cultivation €/ha	11.54	11.54	11.84	11.84
10.	Pre-harvest crop treatment €/ha (10.1. + 10.2)	35.77	35.77	37.05	37.05
10.1.	*Spraying services* €/ha	23.75	23.75	24.37	24.37
10.2.	*Desiccator* €/ha	12.36	12.36	12.68	12.68
11.	Harvesting by means of a combine harvester €/ha	65.93	65.93	67.64	67.64
12.	Seed processing €/ha	300	300	300	300
II	**TOTAL EXPENDITURE (from 3rd to 12th)**	**1.109**	**1.109**	**1,133**	**1,133**
III	***PROFIT (I) calculated according to the production price (I-II) €/ha***	**8,875**	**10,539**	**8,688**	**9,542**

Source: Independent research by the authors

The profit calculated according to the production price in 2017 for the cultivars Puno and Titicaca would amount to 8,875 and 10,539 €/ha, respectively. In 2019 it would be 8,688 and 9,542 €/ha, respectively.

Disscusion

In Serbia was indicated the tendency of air temperature increase. The maximum annual mean temperature at 26 climate stations in Serbia had shown a significant rising tendency in the period 1981-2010, with the regional average rate of 0.56 °C per decade (RUML et al, 2017). The growing seasons 2017 and 2019 were warmer than the perennial average, with precipitation deficit over 250mm. However, these data were not crucial when considering the impact of climate on the crop growth and development. Special attention should be paid to the periods when the crops were in specific phenological phases, particularly in the phases of the highest sensitivity to water deficit. For quinoa, these are the phases of initial growth, as well as the flowering phase (GARCIA et al, 2015) until the phase of grain filling (PRÄGER et al, 2018). The periods coinciding with these phases were the second half of April and the month of July. In the initial phenological phase of quinoa, during the second half of April, water supply was more favourable in 2017 than in 2019 (Figure 2 and 3). On the basis of the Z-index of drought, the Republic Hydrometeorological Institute defined the moisture conditions in the area of the experimental field (Z=3.1) in April 2019 as extremely arid (Republic Hydrometeorological Service of Serbia, 2019). In July (when quinoa is in the phenophases of flowering to grain filling), water regime was also more favourable in 2017 with 44 mm of rain, in comparison to 2019 when only 13 mm of rain fell not sooner than in the third decade (Figure 2 and 3). The difference in the 2017 and 2019 yields can be explained by the more favourable water conditions in 2017 than in 2019 during the periods when quinoa is the most sensitive to water deficit (initial growth and the flowering phase until the grain filling phase). In this period drought without additional irrigation can result in lower yield, as it was the case in the study of PULVENTO et al. (2010) in Southern Italy. They obtained significant differences in the yield of the cultivar Puno (1.9 and 3.28 t ha^{-1}) in two research years (2006 and 2007) since the years differed in water regime. In the conditions of water deficit, the application of organic fertilizers can improve the yield (HIRICH et al, 2014). Moreover, irrigation can also increase the yield, as shown in the studies of TEN and TEMEL (2018) who obtained the yield of 3.5 to 4.0 t ha^{-1} in Turkey (Anatolia). According to the literature, the quinoa yield has a wide range and depends on various factors such as: soil type, climatic conditions, genotype, sowing time (MIRANDA et al, 2013; PULVENTO et al, 2010). BHARGAVA et al. (2007) reported a yield ranging between 0.47 and 6.07 t ha^{-1}, similarly to MIRANDA et al. (2013) (between 0.9 and 6.0 t ha^{-1}). Also, (VALENCIA-CHAMORRO, 2003) reported that yield of quinoa depending on the variety and growing conditions and can be in the range of 45-500 g/m^2. In Chile "Bear" is reported to produce yield of 3,000 kg ha^{-1} under field conditions, and 6,500 kg ha^{-1} under experimental conditions (DELLATORE-HERRERA, 2003). In the research in Germany, PRÄGER et al. (2018) obtained the average yields of 1.7 and 2.0 t ha^{-1} for Puno and Titicaca cultivars in two research years, without additional irrigation. Similarly to our research, Titicaca had a higher yield in their experiment. The precipitation in the vegetation period was similar, while the daily mean temperature was lower by approximately 3 ºC than in our experiment. In our agro-ecological conditions, the only studies conducted were related to the cultivar Pruno without irrigation and the obtained yield was 1.7 t ha^{-1} (STIKIĆ et al. 2012). The research was carried out at a location 150 km far from our location, and the experimental conditions were different (density and depth of sowing, amount and distribution of precipitation, content of organic matter in the soil). Results from the American and European Test of Quinoa showed that in Italy and Greece, the Danish quinoa cultivars gave the best yield, with up to 2280 and 3960 kg/ha, respectively (JACOBSEN, 2006).

The expenditure structure in both observed years during the production of both genotypes was identical. The small difference in the shares of certain cost types in the total expenditure is the consequence of the different price of inputs and machinery services in the observed period. The production expenditure was lower by 2% in 2017 than in 2019. In 2017 and 2019, the seed procession costs had the highest share in the structure of the total expenditure - 27.06% and 26.49%, respectively (Table 6). The costs of manual crop thinning had high shares of 21.65% and 21.19%, respectively, followed by the sowing costs with the shares of 18.41% and 18.21%, respectively and the costs of mineral fertilizer spreading – the shares of 18.41% and 18.21%, respectively. All other costs had a share lower than 10% in the total expenditure.

Table 4. The structure of quinoa production expenditure (%) in 2017 and 2019.

	2017		2019	
Position	Puno	Titicaca	Puno	Titicaca
Spreading mineral fertilizers before ploughing	13,46	13,46	14,26	14,26
Ploughing at the 30-cm depth	4,07	4,07	4,09	4,09
Spreading mineral fertilizers after ploughing	4,18	4,18	4,56	4,56
Pre-sowing preparation – the operation of a seedbed tiller up to 4m	0,92	0,92	0,93	0,93
Sowing	18,41	18,41	18,21	18,21
Manual crop thinning	21,65	21,65	21,19	21,19
Inter-row cultivation	1,04	1,04	1,05	1,05
Pre-harvest crop treatment	3,26	3,26	3,27	3,27
Harvesting by means of a combine harvester	5,95	5,95	5,97	5,97
Seed processing	27,06	27,06	26,49	26,49
TOTAL EXPENDITURE	100,00	100,00	100,00	100,00

Source: Independent research by the authors

The costs of the manual crop thinning, which have a significant share in the total expenditure, are determined by the labour costs which are considerably lower in Serbia than in the EU countries. According to the Eurostat data, the hourly labour costs in Serbia in the observed period were 13 times lower than the average labour costs in the EU-28. In addition, Serbia has lower hourly labour costs than other countries in the region. In comparison to Croatia, the hourly labour costs in Serbia are approximately 5 times lower, while in comparison to Hungary, Slovenia and Romania, the hourly labour costs are 4, 9 and 3 times lower, respectively.

Compared to conventional crops, the production of quinoa in the existing agro-meteorological conditions would be considerably more cost-effective. The higher cost-effectiveness of quinoa is reflected in its price. In Serbia, the price of maize recorded in 2017 was the same as the price recorded in 2010 – 0.13 €/kg (KRESOVIC et al. 2014), which is more than 30 times lower than the price of quinoa. The average profit value of cultivating maize in the natural water regime in Serbia amounts to approximately 700 €/ha (Ibidem), while the profit value calculated according to the production price of quinoa in 2017 and 2019 for the cultivar Puno amounted to 8,875 and 8,688 €/ha, respectively, and for the cultivar Titicaca it was 10,539 and 9,542 €/ha, respectively.

Europe possesses a high potential for quinoa production (JACOBSEN, 2015; GALWEY, 1993; JACOBSEN, 1997; JACOBSEN and STØLEN, 1993). The areas cultivating quinoa in Europe increased from 0 in 2008 to 5000 ha in 2015, mostly in France, Spain and Great Britain (BAZILE et al, 2016a). The economic feasibility and potential justify the introduction of quinoa into the mass production. This is highlighted by the increasing role of quinoa in human nutrition. Shops worldwide contain a wide range of products based on quinoa – breakfast cereals, healthy snacks, pasta, drinks, and even ice cream and dietary supplements (FAO and CIRAD, 2015). In addition to importing the quinoa-based manufactured products and selling quinoa in healthy food shops, the market of the Republic of Serbia also contains the products made by domestic manufacturers. Companies in Serbia import quinoa and produce finished products such as manufactured frozen vegetable mixtures and processed baby food. These products would have a more competitive price in the market if the raw materials were produced in our country. If the producers used the production price of quinoa and not its retail price (including the customs costs, VAT and margin) when producing domestic finished products, the products' price would be more competitive and the producers' profit would be higher. The introduction of quinoa into the mass production in the Republic of Serbia would avoid the risk of its price elasticity. This is confirmed by the fact that the average price of quinoa in the period 2010-2018 ranged from approximately 1.36 €/kg (1.66 $/kg) in 2017 to 5.54 €/kg (6.74$/kg) in 2014 (STATISTA, 2019). France is a good example which can be used for the comparison with European countries. The increased demand and reduced production in South America, as a consequence of climatic conditions and limited production capacity, resulted in the quinoa import price ranging from 1.50 and 2 €/kg in 2008 and 2012, respectively, while the price for consumers was in the range from 3 to 6 €/kg (GUILLAUME, 2015).

Conclusion

The results of the two-year experiment led to the conclusion that the cultivation of the quinoa cultivars Puno and Titicaca in the agro-ecological conditions in Serbia would be very successful from both the agronomic and economic point of view. Both genotypes achieved extremely high yields in both research years with different pluviometric regimes. One should emphasize the excellent adaptivity of both genotypes to the extreme drought in the period of initial growth, the phenophase in which quinoa is very sensitive to water deficit. This is particularly true for the adaptivity of the Titicaca cultivar. The obtained results show that quinoa could occupy an important place in the sowing structure of agricultural lands in Serbia. Moreover, its production would be substantially more cost-effective than the production of the currently produced field cultivars, particularly in the increasingly present arid conditions. The introduction of quinoa into the production of the Republic of Serbia would decrease its price and encourage a more intensive quinoa consumption and production of quinoa-based manufactured products. The increased use of quinoa in human nutrition would positively affect human health, having in mind this crop's nutritive properties and the fact that it does not contain gluten which an increasing number of people are becoming allergic to both in Serbia and worldwide.

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