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Contents

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Buckwheat yields in intercropped systems of walnut and buckwheat

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Abstract

Intercropping involves combining more plant species on the same parcel of land at the same time. The significance of intercropping is in the cultivation of plant species in systems that are less susceptible to different stress conditions. The aim of our research is to investigate buckwheat yields intercropped between alleys of grafted walnuts. The field trial was conducted at two sites in eastern Croatia where on one site walnuts were four years old and on the other eleven years old. Buckwheat yields were significantly lower in intercropped 11-yr old orchard compared to the control plot without walnuts. However, in 4-yr old walnut orchard there was no significant difference between buckwheat yields in the intercropped system and on the control plot. Such results suggest that the shading effect could be the driving force controlling buckwheat yields in such intercropped systems.

Keywords: agroforestry, buckwheat, land equivalent ratio, silvoarable, walnut

Introduction

Intercropping agricultural crops with wood species, such as walnut, can have positive effects on crops. Combining permanent wood species with agricultural crops influences the microclimate conditions, which improves the plant resistance to stress conditions such as climatic extremes (drought, flooding), better use of the production area, positive influence on soil fertility, diversity of production in one vegetation, protection against plant disease, pests and weeds, better use of nutrients and water in soil as well as increased biodiversity. However, the question is how profitable or productive intercropped system can be i.e. how would such combined cultivation affect the yields of agricultural crops?

At the same time, this kind of cultivation can promote allelopathic relationships between plants. In intercropping systems with walnut, it is desirable to choose orchards with grafted plants since the walnut tree secretes juglone that may have a toxic effect on the germination of other plants. In the orchards of walnuts with grafted trees, the secretion of juglone is not so intense and the activity of juglone in such orchards has no significant toxic effect in the first 15 years (Scott and Sullivan, 2007). Furthermore, an introduction of organic matter or organic fertilizers is recommended because it promotes microbiological activity that enhances juglone decomposition (Schmidt, 1987). Another important factor in walnut intercroppedsystems is the selection of plants resistant to low-pH, since the walnuts can acidify the soil. By raising such systems we create stable agroecosystems resistant to negative climatic extremes (Quinkenstein et al., 2009).

Buckwheat (*Fagopyrum esculentum* Moench) is the plant from the *Poligonaceae* family. It originates from Central and Northeast Asia, Manchuria and the Himalayas (Farooq et al., 2016). It was brought to Europe at the end of the fourth century, and it is mainly produced in China, Russia, Ukraine and Kazakhstan.. Buckwheat is grown mainly in post-sowing for a short life cycle, mainly as a pre-sowing crop for vegetables, barley and wheat, it is rarely grown as a main crop. The intensity of buckwheat production at the Mediterranean level is in line with the increased search for healthy food with low environmental impact (Small, 2017). Since buckwheat has short vegetation period and low demand for agrotechnical operations, it was chosen in our filed trial as a crop to be intercropped in walnut orchard. The aim of our research is to investigate possibility of intercropping buckwheat between alleys of grafted walnuts and to determine its yields in two orchards of different age. In addition, we wanted to examine the productivity of such systems by calculating the *land equivalent ratio* (LER).

Material and methods

The field trial was set up in eastern Croatia on two sites: Ivankovo with 4-yr walnut orchard and Đakovo with 11-yr old walnut orchard. Alleys in Đakovo were 8m wide while in Ivankovo 10m. Within the alleys a 6m strip of buckwheat was sown in Đakovo and an 8m strip in Ivankovo. Each of two sites consisted of three plots; a) control plot of buckwheat without walnuts, b) walnut orchard with intercropped buckwheat and c) sole walnut orchard without intercropped wheat. Soil and climatic parameters were measured and monitored during the vegetation period.

Land equivalent ratio

From the crop and walnut fruit yields, land equivalent ratio (LER) was estimated. The land equivalent ratio is defined as the ratio of the area under monoculture production to the area under intercropping needed to give equal yields at the same management level (Ong & Kho, 2015). It is calculated as the ratio of tree yield from intercropped system to the tree monoculture yield plus the ratio of crop yield from the intercropped system to the crop monoculture yield, as shown in Equation 1:

eq. 1
$$LER = \frac{\text{walnut intercropped } yield}{\text{walnut pure orchard } yield} + \frac{buckwheat \text{ intercropped } yield}{buckwheat \text{ monculture } yield}$$

When LER ≤ 1, there is no agronomic advantage of intercropping over sole cropping, but when LER is >1, production in the intercropped system is higher than in the separate sole crops.

Results and discussion

The walnut orchard in Đakovo has 10 equally long rows of walnuts. However, so far, walnut yield of first five rows was always around 30% of the total walnut yield, while the last five rows had around 70% of total walnut yield i.e. higher productivity. Walnut orchard in Ivankovo is still too young and it has not produce any walnut yield so far. In Đakovo, we have decided to sow buckwheat in the 4 alleys in between first five rows of trees to increase the productivity of this low productive area. After growing buckwheat in the alleys of first five tree rows the system had walnut yield of 378 kg/ha and buckwheat yield 1.8 t/ha. However since only 75% (6m out of 8m) of area in alleys was covered with buckwheat (the rest 25% was walnut rows) the actual buckwheat yield per ha in intercropped system was actually 1.35 t/ha. Walnut control plot had walnut yield of 746 kg/ha and buckwheat control plot had buckwheat yield of 2.5 t/ha. In relative numbers, the walnut yield in intercropped system was 51% (0.51) of the walnut yield in the walnut control plot and buckwheat yield was 54% (0.54) of the buckwheat yield in the buckwheat control plot. Altogether, it comes out that intercropped plot had land equivalent ratio (LER) of 1.05 (eq. 2) which means that by intercropping buckwheat in between these low productivity rows of walnut we have increased the production of this area by 5% in comparison to high productive area (last five rows of walnut trees).

eq.2
$$LER = \frac{378kg/ha}{746kg/ha} + \frac{1.35t/ha}{2.5t/ha} = 1.05$$

a)

b)

Figure. 1 – Đakovo site: a) intercropped walnut orchard, b) buckwheat control plot

Even though the buckwheat yield in intercropped system in Đakovo was significantly lower than in agricultural field (Table 1.), such lower yield still increased the total productivity of the area (eq. 2). In younger orchard - Ivankovo there was no significant difference between buckwheat yields grown in the walnut alleys and on the agricultural control plot (Table 1).

Analysis of soil parameters indicated that in Đakovo there were significantly higher levels of available potassium as well as significantly higher percentage of soil organic matter (SOM) in intercropped orchard than in agricultural field (Table 1.). However, the buckwheat yields were still lower. Such results indicate the importance of light and shading effect, which are more important than soil properties (Dufour et al., 2013; Talbot et al. 2014). In Ivankovo, where the shading effect was negligible due to young trees with small canopy area, there was no significant difference between buckwheat yields in intercropped system in comparison to agricultural field.

Table 1. Soil parameters and buckwheat yields on two sites

		ĐAKOVO		IVANKOVO	
		n		n	
pH	Orchard	8	5.9^{ns}	8	7.3^{a}
	Agri. field	16	5.7^{ns}	4	6.0^{b}
AL-P_2O_5	Orchard	8	7.9^{ns}	8	16.1^{ns}
mg/100g	Agri. field	16	9.3^{ns}	4	13.4^{ns}
AL-K_2O	Orchard	8	17.1^{a}	8	18.2^{a}
mg/100g	Agri. field	16	11.9^{b}	4	21.9^{b}
SOM	Orchard	8	2.2^{a}	8	1.5^{a}
%	Agri. field	16	1.7^{b}	4	1.7^{b}
Buckwheat Yield	Orchard	8	1.8^{a}	8	2.5^{ns}
t/ha	Agri. field	16	2.5^{b}	4	1.7^{ns}

n-number of samples, ^{ns} indicates no significant differences, ^{a} and ^{b} indicate significant difference between orchard and agricultural field for each site separately, SOM –soil organic matter

Further economic analysis is necessary to investigate the economic aspect of such production, i.e. profitability. For how long can intercropping be profitable in walnut orchards? Previous research that conducted investigating effect of light on crop yield has shown that crop yields in agroforestry system usually drastically drop around year 8-10 from planting (Talbot et al. 2014).

Conclusion

Intercropping of buckwheat in low productive rows of walnut orchard can increase the productivity of such area even if the buckwheat yields are significantly lower compared to yields in agricultural land. In younger walnut orchards (4-yr old orchard) there was no difference in buckwheat yields. However, how long can such intercropping in walnut orchards be profitable, needs to be investigated in more details. At some point the walnut trees will provide too much shade and the production of agricultural crops within walnut rows, such as buckwheat, will not be feasible anymore.

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References

Dufour L., Metay A., Talbot G., Dupraz C. (2013) Assessing Light Competition for Cereal Production in Temperate Agroforestry Systems using Experimentation and Crop Modelling. Journal of Agronomy and Crop Science 199: 217–227.

Dupraz C., Burgess P., Gavaland A., Graves A., Herzog F., Incoll L., Jackson N., Keesman K., Lawson G., Lecomte I., Liagre F., Mantzanas K., Mayus M., Moreno G., Palma J., Papanastasis V., Paris P., Pilbeam D., Reisner Y., Vincent G., Werf Van der W. (2005). Synthesis of the Silvoarable Agroforestry For Europe project. INRA-UMR System Editions, Montpellier, 254 p.

Farooq S., Rehman R., Bilal T., Dar F., Tahir I. (2016). Cultivation, Agronomic Practices, and Growth Performance of Buckwheat. In: Molecular Breeding and Nutritional Aspects of Buckwheat. (Eds. Zhou M.) 10.1016/B978-0-12-803692-1.00023-7.

Ong C.K., Kho R.M. (2015). A framework for quantifying the various effects of tree-crop interactions. Tree-Crop Interactions: Agroforestry in a Changing Climate 1–23.

Schmidt, S.K. (1988) Degradation of juglone by soil bacteria. Journal of Chemical Ecology 14 (7):

1561–1571.

Scott R. i Sullivan W.C. (2007). A review of suitable companion crops for black walnut. Agroforest Syst 71: 185–193.

Small E. (2017). 54. Buckwheat – the world's most biodiversity-friendly crop?. Biodiversity 18(2-3): 108-123.

Talbot G, Roux S, Graves A, et al (2014) Relative yield decomposition: A method for understanding the behaviour of complex crop models. Environ Model Softw 51: 136–148.

Quinkenstein A., Wöllecke J., Böhm C., Grünewald H., Freese D., Schneider B.U., Hüttl R.F. (2009). Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe. Environmental Science & Policy 12: 1112-1121.

Prinos heljde u konsocijaciji nasada oraha i heljde

Sažetak

Konsocijacija podrazumijeva kombiniranje više biljnih vrsta na istoj površini u isto vrijeme. Značaj konsocijacije je u uzgoju biljnih vrsta u sustavima koji su manje osjetljivi na abiotski i biotski stres. Kombinacija trajnih nasada s poljoprivrednim kulturama na istoj površini pozitivno utječe na mikroklimatske uvjete, što poboljšava otpornost biljaka na ekstremne klimatske uvijete suše i poplave. Cilj našeg istraživanja je odrediti prinose heljde unutar nasada oraha. Pokus je proveden na dvije lokacije. Na jednoj lokaciji orasi su stari četiri godine (Ivankovo), a na drugoj jedanaest godina (Đakovo). Pokus na obje lokacije se sastojao od tri parcele - kontrolne parcele heljde bez oraha, voćnjaka oraha s usijanom heljdom između redova i voćnjakom oraha bez usijane heljde. Svojstva tla i agroklimatski parametri mjereni su i praćeni tijekom vegetacijskog razdoblja. Prinosi heljde u 11-godišnjem nasadu oraha bili su statistički značajno niži u usporedbi s kontrolnom površinom bez oraha. Međutim, u 4-godišnjem voćnjaku oraha nije bilo statističke značajne razlike između prinosa heljde u voćnjaku i na kontrolnoj parceli bez oraha. Takvi rezultati ukazuju na to da je moguće uzgajati poljoprivredne kulture poput heljde u konsocijaciji s orahom, no takva proizvodnja je isplativa do određene starosti oraha.

Ključne riječi: agrošumarstvo, heljda, iskoristivost zemljišta, silvoarabilno, orah