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PRODUCTIVITY OF WINTER RYE IN ORGANIC VS. CONVENTIONAL CROPPING SYSTEM

Snežana I. Oljača*, Željko K. Dolijanović, Đorđe N. Glamočlija, Snežana S. Đorđević and Jasmina M. Oljača

Faculty of Agriculture, Nemanjina 6, 11080 Belgrade-Zemun, Serbia

Abstract: Rye is a cereal which is very much demanded at the market, for making a special kind of bread, but it is little grown in Serbia. The aim of this paper is to investigate possibilities of organic growing of winter rye, comparing with the conventional one, in agroecological conditions of Valjevo hilly region during 2008/2009 and 2009/2010 cropping seasons. The trial was set up in a village of Kotešica, on soil which had not been used for agriculture for 7 years. In organic cropping system three combinations of microbiological fertiliser baktofil with zeolite and hydrogel were used prior to sowing. Half of each plot was treated with foliar microbiological fertiliser Slavol during crop growing period. In conventional cropping system three variants with mineral fertilisers were included: NPK, NPK+zeolite, NPK+hydrogel. Results of the yield obtained in the experiment showed a significant difference between two seasons, 2008/2009 and 2009/2010. In comparison with the control, the treatments in an organic cropping system resulted with statistically insignificant differences for mean values in both years, while the mean in conventional cropping system has significantly higher yield of winter rye. Organic cropping system under conditions of Valjevo hilly region did not give significantly lower rye yield compared with the conventional one in a moderate growing season such was 2008/2009. The combination of soil microbiological fertiliser (Baktofil) with foliar fertiliser (Slavol) and zeolite gave the highest winter rye grain yield in all other treatments in the second year of investigation. In a very wet season (2009/2010) mineral fertiliser NPK showed an advantage, especially in combinations with zeolite, and this treatment can be recommended.

Key words: winter rye, productivity, organic cropping system, conventional cropping system.

Introduction

Rye is very cold tolerant and is the hardiest and most disease resistant of the winter cereals. Winter rye has an extensive fibrous root system, it can scavenge

*Corresponding author: e-mail: soljaca@agrif.bg.ac.rs

nitrogen very effectively, and it utilises early spring moisture to grow very rapidly. Winter rye is earlier and faster growing in the spring than the other winter cereals, including wheat, barley and triticale (Malešević et al., 2008). It heads earliest of all these autumn-seeded cereals, enabling an earlier forage harvest and more 'double crop' options. Winter rye is a traditional winter cereal cover crop grown on lighter soils to control wind erosion and build organic matter (Glamočlija, 2004). It is an excellent source of organic matter, growing in marginal soils, reducing erosion and having an allelopathic action that suppresses weeds (Teasdale et al., 1991). Rye is one of the best cool season cover crops for outcompeting weeds, especially small-seeded, light-sensitive annuals such as *Chenopodium album* L., *Amaranthus retroflexus* L., *Abutilon theophrastii* Medik., *Stellaria media*, and *Hordeum murinum* L. Rye also suppresses many weeds allelopathically (as a natural herbicide), and has been shown to inhibit germination of some triazine-resistant weeds (Przepiorkowski and Gorski, 1994; Bugg, 1995).

Autumn rye can also be used successfully as a forage crop, by grazing in the autumn and spring, or by harvesting as haylage in May. If livestock are part of the operation, rye can provide early spring forage, before cool or warm season grasses are available for grazing. Rye fields provide forage for pastured pork or poultry, as well as ruminants (Bach Knudsen et al., 2003). Livestock can utilize the nutrients, deposit manure, and help prepare the field for subsequent plantings. Rye grain has a feeding value of about 85% to 90% that of maize, and contains more digestible protein and total digestible nutrients than oat or barley. (Eppendorfer, 1977) Rye is most satisfactorily used when mixed with other grains at a proportion less than a third, because it is not highly palatable and is sticky when chewed. Rye makes excellent forage, especially when combined with red or crimson clover and ryegrass. For the best quality, cut rye between early heading and the milk stage of growth. Yields and quality of rye harvested as forage are compared to winter wheat and winter triticale. Rye matures earlier than wheat or triticale and has the highest crude protein levels. However, forage yields are lower than for the other two small grains, resulting in somewhat lower crude protein yields and overall lower relative feed values. Thus, the main advantages winter rye has as forage compared to winter wheat or winter triticale, is that it is more winter hardy and reaches optimum harvest maturity 7 to 10 days earlier.

Whole-grain foods such as rye provide significant digestive health benefits that refined grain products fail to provide (Anderson et al., 2000). The fiber from rye appears to be more effective than that from wheat in overall improvement of digestive health. Rye is a very good source of dietary fiber, phosphorus, magnesium, manganese, protein and vitamin B1 (Oelke et al., 1990). Rye is also a rich source of lignans, one of the major classes of phytoestrogens, estrogen-like chemicals that also act as antioxidants. Rye's high fiber content, higher than the wheats, also aids in fighting heart disease. In one study reported in the December,

1966 edition of the American Heart Association's Journal, the high fiber content in grains, and especially rye, decreased the incidence of heart disease by 17% in 22,000 Finnish subjects (Jensen et al., 2004).

Materials and Methods

The aim of this paper is to investigate possibilities of organic growing of winter rye, compared with conventional one, in agroecological conditions of Valjevo hilly region during 2008/2009 and 2009/2010 cropping season. The trial was set up in Kotešica village on soil which had not been used for agriculture for 7 years. A randomised complete block design with four replications was employed. Plot size was 6 m^2 (5 x 1.2 m). Characteristics of soil were: acid soil reaction 4.34 pH (0.1 N KCl), moderate soil humus content (2.6%), very poor in phosphorus (1.2 mg P_2O_5 100 g-1 soil), poor in potassium (9.5 mg K_2O 100 g-1 soil after AL method), and rich in available mineral nitrogen 25.2 mg kg-1 (nitrate 10.5 mg kg-1, ammonium 14.7 mg kg-1), as measured in the soil layer from 0-20 cm before sowing. The rye grain yield was calculated to the content of 14% moisture.

In organic cropping system three combinations of microbiological fertiliser baktofil with zeolite and hydrogel were used prior to sowing. Baktofil was applied with 1.5 l/ha, zeolite with 2.67 t/ha and hydrogel in the amount of 20 kg/ha. In conventional cropping system three variants with mineral fertilisers were included: NPK, NPK+zeolite, NPK+hydrogel in the amount of 50 kg/ha NPK. In both cropping systems, half of each plot was treated with foliar microbiological fertiliser Slavol in concentration of 50 ml per 10 l of water, during growing period.

Analysis of variance (ANOVA) among years and treatments was conducted using Statistica 5.0 package for factorial experiments and the significance of factor effects, determined at $P \leq 0.05$. Significant differences in the mean values were determined using the LSD test at significance level $P \leq 0.05$ and $P \leq 0.01$.

Results and Discussion

The winter rye grain yields are presented in Table 1, where a significant difference is visible between two seasons, 2008/2009 and 2009/2010. The second season, 2009/2010 had weather pattern more favourable for the winter rye production with mild and moist winter and warm but rainy spring and summer. Precipitation sum was 1,007 mm in 2009/2010 season compared with 641 mm in 2008/2009. In the first vegetative season, a short period of drought appeared in April and May 2009 and contributed to lower grain yield in that season (Figure 1).

Table 1. Rye grain yield (t ha^{-1}) in organic and conventional farming system.

Variant (B)	Grain yield (t ha^{-1})		
	2008/09	2009/10	Average Year (A)
Control	3.83	5.76	4.80
Control+slavol	3.61	5.96	4.79
Baktofil+zeolite	3.87	6.40	5.14
Baktofil+zeolite+slavol	1.98	6.68	4.33
Baktofil+hydrogel	2.38	5.60	3.99
Baktofil+hydrogel+slavol	4.43	5.92	5.18
Average organic cropping system	3.17	6.15	4.66
NPK	3.41	6.82	5.12
NPK+slavol	2.89	6.12	4.51
NPK+zeolite	3.89	7.60	5.75
NPK+zeolite+slavol	4.08	7.20	5.64
NPK+hydrogel	2.72	6.36	4.54
NPK+hydrogel+slavol	4.24	6.08	5.16
Average conventional cropping system	3.34	6.70	5.02

LSD	0.05	0.01
A	0.049	0.068
B	0.121	0.166
AB	0.171	0.235

In comparison with the control (4.80 t ha^{-1}), the treatments in organic cropping system (4.66 t ha^{-1}), resulted with statistically insignificant differences for mean values in both years, while the mean in conventional cropping system has significant higher yield of winter rye (5.02 t ha^{-1}).

According to yield obtained in separate years, the highest value (4.43 t ha^{-1}). was obtained by the organic treatment baktofil+hydrogel+slavol and similar combinations on conventional plots NPK+hydrogel+slavol (4.24 t ha^{-1}) in 2008/2009. Different microbiological fertilisers combined with the matter which retains soil moisture, gave the maximum results in winter rye production in slightly dry season. Completely different weather pattern in 2009/2010 resulted in the highest yield, obtained in combinations with zeolite in both cropping system: Baktofil+zeolite+slavol (6.68 t ha^{-1}) and NPK+zeolite (7.60 t ha^{-1}). In agriculture, a naturally occurring zeolite is used as a soil treatment. It provides a source of slowly released K^+ and NH_4^+ ions. Zeolites can also act as water moderators, in which they will adsorb up to 55% of their weight in water and slowly release it under plant demand (Auerbach et al., 2003). Under very wet conditions in 2009/2010 season these properties of zeolite were completely expressed.

Treatment with foliar microbiological fertiliser had statistically significant higher rye yield in both seasons in organic cropping systems. Exceptionally, in conventional cropping system in 2009/2010 foliar fertilising had no positive effect on grain yield of rye. These results are in accordance with the results which were obtained by Kovačević et al. (2009) where significantly higher yields of different wheat species (*Triticum spelta*, *T. durum*, *T. aestivum* ssp. *compactum*) were obtained in the treatement with foliar microbiological fertiliser.

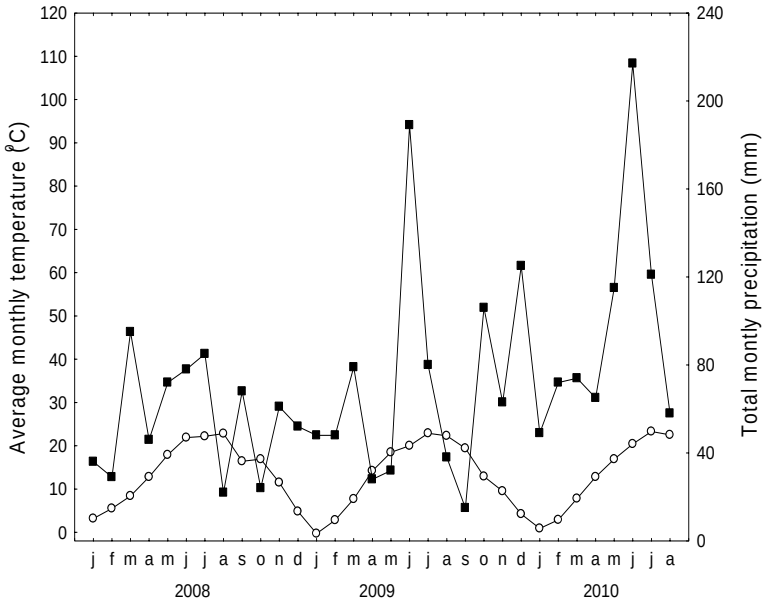

Figure 1. Total monthly precipitation and average temperature in 2008-2010 for Valjevo.

Conclusion

According to the presented results of the research of different fertiliser combinations in organic and conventional cropping system for winter rye during the seasons 2008/2009 and 2009/2010, the following conclusions can be stated:

Organic cropping system under conditions of Valjevo hilly region did not give significantly lower rye yield compared with the conventional one in a moderate growing season such was 2008/2009. In a very wet season (2009/2010) mineral fertiliser NPK showed an advantage, especially in combinations with zeolite and this treatment can be recommended.

Use of the combination of soil microbiological fertiliser (Baktofil) with foliar fertiliser (Slavol) and zeolite gave the highest winter rye grain yield in all other treatments in the second year of investigation, which leads to the conclusion that this treatment can be recommended as the best for the highest grain yield in organic cropping system.

This research should be continued in order to evaluate given treatments with higher confidence for different weather patterns in Serbia.

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PRODUKTIVNOST OZIME RAŽI U ORGANSKOM I KONVENCIONALNOM SISTEMU GAJENJA

Snežana I. Oljača*, Željko K. Dolijanović, Đorđe N. Glamočlija, Snežana S. Đorđević i Jasmina M. Oljača

Poljoprivredni fakultet, Nemanjina 6, 11080 Beograd-Zemun, Srbija

R e z i m e

Raž je žito, koje je veoma traženo, naročito za spravljanje specijalnih vrsta hleba, ali se malo gaji u Srbiji. Cilj ovog rada je da se ispita mogućnost organskog gajenja ove biljne vrste, u odnosu na konvencionalni u konkretnim agroekološkim uslovima valjevskog pobrđa 2008/2009. i 2009/2010. godine. Ogled je postavljen u selu Kotešica, na zemljištu koje nije korišćeno u konvencionalnoj proizvodnji 7 godina. U organskom sistemu poljoprivredne proizvodnje, korišćene su kombinacije mikrobiološkog đubriva baktofila sa dva poboljšivača zemljišta zeolita i hidrogela, kojima je tretirano zemljište neposredno pred setvu. Polovina svake elementarne parcele je prihranjena folijarno, takođe mikrobiološkim đubrivom, slavolom u toku vegetacionog perioda biljaka. U konvencionalnom sistemu poljoprivredne proizvodnje uključene su tri varijante sa kompleksnim mineralnim NPK đubrivom i kombinacija sa zeolitom i hidrogelom, kojima je tretirano zemljište neposredno pred setvu. Dobijeni rezultati prosečnih prinosa ozime raži pokazuju značajne razlike između vegetacionih sezona 2008/2009. i 2009/2010. U poređenju sa kontrolom, tretmani u organskom sistemu gajenja nisu dali značajne razlike prosečnih vrednosti prinosa u obe godine istraživanja, dok je prosečan prinos dobijen u konvencionalnom sistemu gajenja bio značajno veći. U uslovima umerene vegetacione sezone 2008/2009. godine u regionu valjevskog pobrđa u organskom sistemu gajenja nije ustanovljeno smanjenje prinosa u odnosu na konvencionalni. Kombinacija zemljišnog sa folijarnim mikrobiološkim đubrivom i zeolitom je dala najbolji rezultat i najveći prinos ozime raži u drugoj godini istraživanja, pa se preporučuje kao najbolja kombinacija u organskom sistemu gajenja. U veoma vlažnoj godini, kao što je bila 2009/2010. mineralna đubriva su pokazala prednost, naročito u kombinaciji sa zeolitom i ovaj tretman se može preporučiti u sličnim uslovima.

Ključne reči: ozima raž, produktivnost, organski sistem gajenja, konvencionalni sistem gajenja.

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*Autor za kontakt: e-mail: soljaca@agrif.bg.ac.rs