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Full Length Research Paper

Quantitative traits in wheat (*Triticum aestivum* L. cv. 'Novosadska rana 5') grown on pseudogley soil depending on lime rates

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The effect of the use of different lime rates on the pH values and subsequently on the quantitative traits in wheat (*Triticum aestivum* L. cv. 'Novosadska rana 5') was investigated on the pseudogley type of soil. Of the quantitative traits in wheat, spike length, number of spikes per m^2, grain mass per spike, number of grains per spike and 1000-grain weight, were studied as the most significant indicators of its yield. The studies were carried out during 2010 and 2011. The trial was set up following a randomized block design with four liming variants along with three replications, in which the experimental field was 70 m^2 in area. In both study years, along with the previously determined experimental conditions, the variant of $CaCO_3$, used with an amount of 2 t/ha, was found to have the highest effect on enhancing all the parameters of wheat. Based on the results obtained throughout the current research work, it could be inferred that, despite falling under a lower quality class, pseudogley soil could promote usable optimal biological potential of the wheat variety ('Novosadska rana 5'), if adequately treated with lime along with the application of cropping practices.

Key words: Pseudogley, lime rates, wheat, grown.

INTRODUCTION

Even though wheat represents the most significant farming product with respect to human nutrition, both its yield and areas of growth have been on a steady decline in Serbia for the past ten years or thereabouts (Malešević et al., 2008). It could partly be attributed to the farmers who have increasingly been passing on to others, economically, more profitable fields of activities, then partly to the global changes in temperatures being extremely unfavourable for wheat growth, but mostly to the inadequacy of soil resources engineering, due to which the soils are already becoming a long-term loss for farming production. In order to prevent wheat production and yield from further collapse and deterioration, it seems necessary to take appropriate measures in order to increase its production efficiency in the already existing production areas. One of such measures is a more massive introduction of the recently released wheat varieties (Renesansa, Pobeda, Evropa, Novosadska rana 5), which have shown a high production potential even under stressful climatic conditions, and the significant measure is to increase and improve the soil fertility level (Denčić et al., 2006).

Soil fertility is a key factor for a successful farming

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production and the ratio of soil nutrients is decisive to plant growth. In order for wheat production to reach a successful level, the soil should not only have the necessary nutrient amounts, but also neutral or a slight acid pH reaction, so that its nutrients may become available to plants (Mahler and McDole, 1987).

Unfortunately, the research results reveal more than 60% of acid soils accounting for low productivity soils and simultaneously acting as a highly limiting factor of plant production (Bošković-Rakočević et al., 2004; Djalović et al., 2010). As a typical soil of acid reaction, pseudogley is largely present in the region of *S*erbia, mostly in its central and southern parts. This soil is characterised by an unfavourable water-air and thermal regime; the reasons for this can be found in its profile structure, which is a characteristic sequence of the horizontal layers of the pseudogley type of soil. Upper horizontal layers in pseudogley are of loamy-clayey composition, whereas those underneath them are highly colloidal and clayey by composition, and this causes their weaker porosity. Under the conditions of excessive water amount in certain horizontal layers, the water becomes stagnant in some of them, aggravating the water-air regime in the soil (Resulović et al., 2008). However, under the conditions when pseudogley amendment has been performed or when the regions with deficient or unevenly distributed rainfall amounts are in question, there is a need for wheat irrigation. It was observed that the water-physical properties or the chemical properties did not prove to be satisfactory with pseudogley type of soil. These soils mainly have acid reactions (pH 5-5.5), having a small adsorption capacity and a poor availability of plant nutrients.

In order to promote plant growth, it seems unavoidable, beforehand, to adjust soil pH reaction. To achieve this, liming is most often used, which means certain rates of lime must be introduced in order to reach neutral or mildly acid pH reaction and therefore more suitable mediums must be created for nutrient uptake by the plant (Coventry et al., 1997).

This study was carried out with the following objectives. Firstly, the current study tended to achieve a better yield in wheat variety (*Triticum aestivum* L..cv. 'Novosadska rana 5') grown on the pseudogley type of soil by applying lime rates and neutralising excessive acidity. Secondly a test was conducted on how the soil pH reaction was displayed on the quantitative traits in wheat, and the most indicative ones of its yield were spike length, number of spikes per square meter, grain mass per spike, number of grains per spike, and 1000-grain weight of wheat. The studies placed emphasis on variety 'Novosadska rana 5' which is increasingly spread on the farms of Serbia.

MATERIALS AND METHODS

The studies were conducted during 2010 and 2011 in GornjiMilanovac, with wheat crops (variety *Triticum aestivum* L. cv. 'N ovosadska rana 5') sown on a pseudogley type of soil.

Prior to setting up the experiment, the soil was sampled from topsoil to establish its chemical properties. The sampling was done using a probe and the samples were packed in paper sacks and brought to the laboratory of the Faculty of Agronomy in Čačak where the following parameters were analysed: soil reaction (pH value), readily available forms of phosphorus and potassium which are the basic macroelements contained in the soil.

Soil acidity was determined by a pH meter (ISO 10390, 1994), and the content of the available forms of potassium and phosphates was determined following the Al method (Egner et al., 1960). The analysis was made to gain an insight into the soil fertility level prior to the experiment.

The analysis indicated that the soil had an acid reaction (pH_{KCl} = 5.01) with an average content of readily available phosphorus and potassium forms found to be 11.4 mg/100 g soil and 23 mg/100 g soil respectively. Based on the results which is relevant to the particular location, the experiment was set up to find out how the lime rates applied to the soil would be able to influence its pH reaction and subsequently the qualitative traits in wheat. As such, the experiment was set up following a randomised block design with four variants and three replications along with the field area measuring 70 m^2. The quantity of lime rates applied amounted to 1, 3 and 4 t/ha $CaCO_3$, though no lime rate was used along with the check variant. The lime rates were calculated in dependence of the field area. Liming mode was the same in all the fields where $CaCO_3$ was evenly sprayed over the soil surface and ploughed at 20 cm depth. The lime was finely powdered (granulation of 0.2 mm) and dissolved easily, which generally gave better liming effects.

During both research years, the wheat (*Triticum aestivum* L. cv. 'Novosadska rana 5') was sown in mid-October. Seeding density, use of manure, cropping practices and other necessary agrotechnical measures taken in order to promote wheat growth were the same in all the plots studied. Seeding density was 550 seeds per square metre, and the manure used in the pre-sowing stage with 300 kg/ha NPK fertilizer with microelements ratio of 10-20-30 over tillering and tasseling, amounted to 150 kg NPK.

Grain filling was done in the stage of tasseling, just when the crop was the most sensitive to moisture deficit, with a norm of 45 mm of water used in 2010, and a norm of 60 mm water used in 2011 based on the calculation made on the following parameters: depth of the soil being irrigated (0.40 m), voluminous mass of the soil (1.36 g/cm^3), field water capacity (30.50 weight percent) and pseudogley moisture at the very moment of grain filling (22.25 weight percent, that is, 19.51 weight percent).

Wheat was sown in the second half of June and the values, recorded on its average samples of the following parameters were: spike length, number of spikes per m^2, number of grains per spike and 1000-grain weight. The obtained data were processed statistically using the standard statistical methods of analysis of variance (ANOVA) and multiple test (Dunett multiple range test) was conducted using Microsoft Excel 2003 and Statistica 5.0. Based on the analysed data, the obtained results were clarified and the relevant conclusions were drawn.

RESULTS AND DISCUSSION

The effect of lime rates on the pH value of the soil under investigation is outlined in Figure 1. All the liming measures applied had a positive effect on the pH of pseudogley soil at which its highest increase was reported to be in variant 3, which was realistically expected because it has the highest $CaCO_3$ rate when compared with the check (variant no. 4), which is the untreated variant. The effect of lime rates on the values

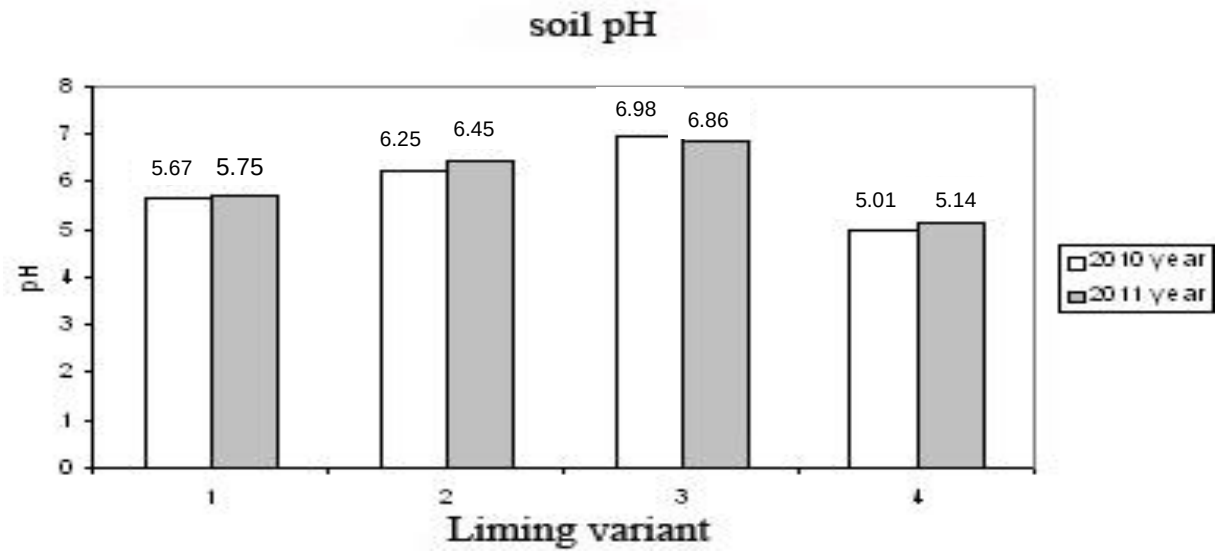

Figure 1. Soil pH values in dependence of liming variant per study years.

Table 1. Tabular view of the quantitative traits in winter wheat related to the lime rate and study year.

Variant of treatment	Quantitative traits in winter wheat									
	Spike length (cm)		Number of spikes per m^2		Grain weight per spike (g)		Number of grains per spike		1000-grain weight (g)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
V_1 (1 t ha^{-1})	9.255	9.140	608	606	0.782	0.788	17.004	16.833	45.98	46.80
V_2 (2 t ha^{-1})	9.565	9.546	607	606	0.837	0.829	18.166	17.666	46.08	46.93
V_3 (3t ha^{-1})	9.341	9.216	604	604	0.781	0.748	17.333	17.166	45.06	43.57
V_4 (control)	8.456	8.468	602	604	0.714	0.731	16.833	16.666	42.41	43.86
F test	*		n. s.		*		*		*	
$D_{0.05}$	0.728		-		0.0842					

Table 2. Analysis of variance of the average spike length.

Variation source	Degrees of freedom	Square mean	F-exp	Significance
Liming (A)	3	10.904	206.049	**
Year (B)	1	0.0455	1.111	n.s.
Interaction (AB)	3	0.0141	0.345	n.s
Error	40	0.0409		

of the quantitative traits in winter wheat (*Triticum aestivum* L. cv. 'Novosadska rana 5') independent of the study year is shown in Table 1, and the findings of the analysis of variance are shown in Tables 2, 3 and 4, respectively.

Based on the data given in Table 1, variant 2, with $CaCO_3$ used in the rate of 2 t/ha, exhibited the highest effect on the increase of all the wheat parameters, which was statistically justified for spike length, number of grains per spike, grain mass per spike and 1000-grain weight, but was not for the number of spikes per square metre. The data actually obtained for the number of spikes per square metre were realistically expected considering the fact that the planting density was identical in all the study plots.

As for lime rates, from one to three tonnes per hectare, contribution was made to the higher values of the wheat quantitative traits but to a much lesser extent as compared to the variant with 2 tonnes. The results obtained throughout this study are similar with those reached by numerous authors, suggesting a positive effect of the liming on the wheat quantitative traits (Lukin

Table 3. Analysis of variance of the average spike grain mass.

Variation source	Degrees of freedom	Square mean	F-exp	Significance
Liming (A)	3	2.525	6.221	**
Year (B)	1	2.288	0.056	n.s
Interaction (AB)	3	1.390	0.342	n.s
Error	40	0. 082		

Table 4. Analysis of variance of the average spike grain number.

Variation source	Degrees of freedom	Square means	F-exp	Significance
Liming (A)	3	9.861	25.724	**
Year (B)	1	0.749	1.956	n.s
Interaction (AB)	3	0.00833	0.217	n.s.
Error	40	0.383		

and Epplin, 2003; Zhang et al., 2004; Brown et al., 2008). However, different lime rates were used because of the different physicochemical properties of soils treated.

The analyses of variance of the average spike length (Table 2), average grain mass per spike (Table 3), and average number of grains per spike (Table 4) showed that the differences were randomly observed on a yearly basis, with no significant difference existing in the interaction between the study year and the parameter of the liming variant in question.

Overall, the results outlined clearly showed that liming measures could visibly raise the pH value of the pseudogley type of soil when adequately applied, and thus indirectly favour the creation of a more suitable medium for nutrient uptake by plants (Coventry et al., 1987). Under the conditions of conducting this trial, the rate of $CaCO_3$, which exerted the highest effect on the quantitative traits in wheat, was 2 t/ha.

Separately from the results currently obtained in this study, it should be noted that due to the specific characteristics of farming production, and the climatic and edaphic factors of a particular wheat crop, there is simply no unique norm determining the application of liming. However, the proximate norms determined throughout this research work still exist. These norms are specific in that they are specifically related to the locality under investigation and can be obtained through studying the physicochemical characteristics of the soil, especially its pH values.

Conclusion

Based on the results obtained in the current study, it may be inferred that the use of liming as an amendment measure for improving unfavourable soil chemical properties is fully justified by the increase observed in the quantitative traits in wheat (*Triticum aestivum* L. cv. 'Novosadska rana 5').

When liming is adequately applied on the pseudogley type of soil, which, under the current experimental conditions, amounted to 2 t/ha, and the other agrotec-hnical and soil amendment measures are effectively taken, the biological potential of *Triticum aestivum* L. cv. 'Novosadska rana 5' variety of wheat is realistically expected to be fully usable.

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