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ORIGINAL SCIENTIFIC PAPER

# Liming effect on wheat yield and some grain quality properties

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## Abstract

Wheat production worldwide is affected mainly with weather conditions and soil fertility where soil acidity represent very common problem. The aim of this study was to evaluate the effect of liming with hydrated lime on winter wheat yield, some yield components (ear number per $m^2$, 1000 grain weight), hectolitre mass and quality (protein, starch and wet gluten content and sedimentation value) three years after lime application. Field trial was set up by RCBD in four treatments: control (0 t $ha^{-1}$), 3.5 t $ha^{-1}$, 7.0 t $ha^{-1}$ and 14.0 t $ha^{-1}$ of hydrated lime. Vegetation season 2013/2014 was specific for winter wheat growing due to exceptionally mild winter and high amount of rainfall in the spring time, when flooding occurred. Average grain yield was relatively low (5.65 t $ha^{-1}$) regarding to genetic potential. However, effect of liming was significant for yield, yield parameters and grain quality. Generally, yield, ear number per $m^2$, protein content, wet gluten content and sedimentation value were significantly higher on the treatments with higher lime doses.

Key words: liming, winter wheat, grain yield, grain quality, weather conditions

## Introduction

Food production is a very complex process affected by numerous factors whereby soil fertility and weather conditions are the most important. Soil is considered to be a "living organism" in which constantly occurs a number of physical, chemical and biochemical processes, and some of them can be more or less favourable for plant growth and development.

Globally, wheat is one of the most important filed crops for human consumption, industrial process and animal feed. According to FAO database in period 2007 – 2016 wheat occupied about 200 million ha worldwide with average grain yield of 3.14 t $ha^{-1}$ and average production of 691 million tons (FAOSTAT, 2018).

One of the common problems in wheat growing is soil acidity. Different degrees of soil acidity are the global problem in many agricultural areas that leads to the yield and quality reduction. Although it is impossible to determine, some authors consider that 30% to 40% area worldwide have more or less acidic reaction (Noble and Sumner, 2003; Hede et al., 2001). Similar value was indicated by Mesić et al. (2009) for Croatia. Generally, deficiency (N, P, Ca, Mg, Mo, Zn) and toxicity (Al, Mn, Fe) of elements under soil acidity are crucial factors limiting the plant growth.

Liming is the most important and most effective practice to ameliorate soil acidity for short term and long term soil fertility. Various materials can be applied for acidity alteration but the most commonly are ground limestone, dolomitic ground limestone, chalk, ground chalk and hydrated lime (Goulding, 2016). Studies show that effect of a singular lime application has different benefit to soil-plant complex and could last from two to several years depending of many factors (Blomquist et al., 2018; Inagaki et al., 2016; Anikwe et al., 2016; Kovačević et al., 2015; Farhoodiab and Coventry, 2008).

Aim of this study was to evaluate the residual effect of the hydrated lime material on winter wheat yield, yield

components (ear number per $m^2$, 1000 grain weight), hectolitre mass and grain quality parameters (protein, starch and wet gluten content and sedimentation value) three years after application.

## Material and methods

The field trial was set up in 2011 on the agricultural land of Family farm Jović, Bosnia and Herzegovina (45°03'51.8"N 18°22'44.9"E) near Croatian border. The trial was conducted by randomized complete block design (RCBD) with four treatments: 0 t $ha^{-1}$ (control), 3.5 t $ha^{-1}$, 7.0 t $ha^{-1}$ and 14.0 t $ha^{-1}$ of hydrated lime containing 72% CaO, 2% MgO and 21% bound water. In autumn of 2010 soil samples were taken for chemical analysis. Preliminary research has shown pseudogley soil type, very acid reaction (pH in KCl 4.13) and low to moderate contents of plant available phosphorus (14,0 mg $P_2O_5$/100 g soil) and potassium (19,3 mg $K_2O$/ 100 g soil) what was described by Iljkic et al. (2018.).

Winter wheat Apache was sown at the end of October 2013 and standard fertilization and cultivation practices for wheat were carried out. At the beginning of July 2014 wheat ears of 1.0 $m^2$ were harvested manually by shears, enumerated, dried on open air and thrashed by special combine for small-field experiments for determining yield, yield components and grain quality. Quality parameters (protein, starch, wet gluten and sedimentation value) of wheat grains were determined by Near-infrared transmittance spectroscopic method. Data were statistically analysed by ANOVA and treatment means were compared using t-test and LSD at 0.05 probability levels.

For weather conditions, the data of Meteorological station Gradište, about 20 km air-distance from field trial, were used (Table 1). Vegetation season 2013/2014 was quite specific for winter wheat growing due to very mild winter and high amount of rainfall in the spring time, especially in the May. Precipitation amount during sowing time was similar to the long term mean (LTM) from 1971 to 1990, while during winter season precipitation was lower, what is suitable for winter wheat. Furthermore, the highest precipitation was noted in spring time, when wheat was in phase of intensive growth and needed higher amount of water. Unfortunately, during May 2014 flooding occurred Average air temperature during vegetation season was higher by 2.1 °C, mostly because of quite high temperatures in winter and early spring while the air temperatures during spring-summer period were similar to LTM what is a positive aspect considering the sensitivity of winter wheat to high air temperature.

Table 1. Weather conditions in growing season 2013/2014 and long term mean (1971-1990) from weather station Gradiste (DHMZ, 2018.)

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | April | May | June | Total/Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2013/2014 | | | | | | | | | |
| mm | 62 | 57 | 4 | 29 | 35 | 39 | 88 | 165 | 46 | 525 |
| °C | 13.9 | 7.8 | 1.7 | 4.5 | 6.2 | 10.2 | 13.3 | 16.2 | 20.7 | 10.5 |
| LTM (1971-1990) | | | | | | | | | | |
| mm | 59 | 59 | 50 | 41 | 36 | 42 | 53 | 66 | 81 | 487 |
| °C | 11.3 | 5.6 | 1.7 | 0.3 | 2.4 | 6.9 | 11.5 | 16.7 | 19.6 | 8.4 |

## Results and discussion

Three years after application residual effect of hydrated lime was significant for yield, tested yield parameters and grain quality. Average wheat grain yield was 5.65 t $ha^{-1}$ what is relatively good in comparison with the official data of Croatian Bureau of Statistics for 2014 (4.16 t $ha^{-1}$). Control treatment achieved statistically lowest grain yield while the highest yield was obtained on the treatments with 7.0 and 14.0 t $ha^{-1}$ of lime with a slight difference between them, indicating that smaller amount of lime could be sufficient for yield improving (Table 2). Similar results were shown by Kamaruzzaman et al. (2013). The authors concluded that application of smaller lime doses have statistically identical effect on the wheat grain yield and some other tested parameters (plant height, tillers $plant^{-1}$, spike length and grains $spike^{-1}$) in comparison with higher doses. Second year after lime application at the same trial Iljkić et al. (2018) reported significant effect of hydrated lime on wheat yield, ear number per $m^2$, proteins and wet gluten contents as well as sedimentation value.

Average ear number per $m^2$ in this study was 580 with variations between treatments. In comparison with control treatment, statistically higher value was only on the highest lime amount of 14.0 t $ha^{-1}$ (Table 2). Lower ear number per $m^2$ is most likely a consequence of the flooding. In this experiment, effect of liming did not have any statistical influence on thousand grain weight and hectolitre mass. However, Jurković et al. (2008) found that liming with other material (Carbocalk) increased not only grain wheat yield and ears number per $m^2$ but also a thousand grain weight.

Table 2. Residual effect of liming on yield, grain yield components and hectolitre mass in 2013/2014

| Treatment (t $ha^{-1}$) | Yield (t $ha^{-1}$) | Ear number ($m^2$) | Thousand grain weight (g) | Hectolitre mass (kg) |
|---|---|---|---|---|
| 0 | 5.05 | 558 | 35.8 | 75.0 |
| 3.5 | 5.17 | 547 | 35.5 | 74.4 |
| 7.0 | 6.15 | 587 | 35.1 | 74.6 |
| 14.0 | 6.24 | 628 | 35.3 | 74.6 |
| Average | 5.65 | 580 | 35.4 | 74.6 |
| $LSD_{0.05}$ | 0.83 | 77 | ns | ns |

*ns – not significant*

From the point of view of human nutrition, proteins are very important source of essential amino acids as well as the main determinants of wheat bread making quality. The average protein content found in the study was exceptionally low and was only 9.3% what can be related with moist conditions and flooding during spring, but also with cultivar (Table 3). However, significant increase for protein content was obtained in treatments with 7.0 t $ha^{-1}$ and 14.0 t $ha^{-1}$ of hydrated lime.

Table 3. Effect of liming on grain quality in 2013/2014

| Treatment (t $ha^{-1}$) | Protein (%) | Starch (%) | Wet gluten (%) | Sedimentation value ($cm^3$) |
|---|---|---|---|---|
| 0 | 8.8 | 75.3 | 19.5 | 19.5 |
| 3.5 | 8.9 | 75.3 | 20.4 | 21.2 |
| 7.0 | 9.8 | 74.5 | 22.0 | 23.8 |
| 14.0 | 9.9 | 74.3 | 24.5 | 25.6 |
| Average | 9.3 | 74.8 | 21.6 | 22.5 |
| $LSD_{0.05}$ | 0.7 | ns | 1.9 | 1.4 |

*ns – not significant*

Starch content is the most common grain component and its average value in this experiment was 74.8% without any significant differences between treatments. Liming has a significant effect on the content of wet gluten and sedimentation value. By increasing the amount of hydrated lime, there was almost a linear increase in the content of wet gluten and sedimentation value in the grain with protein content what is expected due to the their positive correlation (Horvat et al., 2013).

## Conclusions

The experiment demonstrated that hydrated lime application had a positive residual effect on winter wheat parameters. Wheat yield was higher by 22% and 24% on liming treatment in comparison with control, while ears number was higher by 13% on the highest lime treatment. Moreover, liming had a significant influence on wheat quality. Protein content was higher by 13%, wet gluten by 26% and sedimentation value by 31%. Third year after application the best results were obtained on the highest lime treatment, especially regarding wet gluten content and sedimentation value. However, difference in grain yield between treatments with 7 and 14 t $ha^{-1}$ were negligible indicate that smaller amount of lime also could increase yield and improve grain quality. With that aspect, liming the acid soil can be a very positive long-term investment.

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# Učinak kalcizacije na prinos i neke parametre kvalitete zrna pšenice

**Sažetak**

Proizvodnja pšenice u svijetu je u velikoj mjeri ovisna o vremenskim uvjetima i plodnosti tla pri čemu je kiselost tla učestali problem. Cilj istraživanja je bio utvrditi naknadni učinak primjene hidratiziranog vapna na prinos zrna pšenice, pojedine komponente prinosa (broj klasova po $m^2$, masa 1000 zrna), hektolitarsku masu i kvalitetu zrna (sadržaj proteina, škroba, vlažnog glutena i sedimentacijska vrijednost) tri godine nakon kalcizacije. Poljski pokus je postavljen po slučajnom bloknom rasporedu s četiri tretmana: kontrola (0 t/ha), 3,5 t/ha, 7,0 t/ha i 14,0 t/ha hidratiziranog vapna. Vegetacijska sezona 2013/2014 bila je specifična za uzgoj ozime pšenice zbog izuzetno blage zime i velike količine oborina u proljeće, kada su se dogodile i poplave. Prosječan prinos zrna je bio relativno nizak (5,65 t/ha) s aspekta genetskog potencijala. Međutim, tri godine nakon primjene hidratiziranog vapna utvrđen je statistički opravdan učinak kalcizacije na prinos, komponente prinosa i kvalitetu zrna. Prinos zrna, broj klasova po $m^2$ te sadržaj proteina, vlažnog glutena i sedimentacijska vrijednost bili su signifikantno veći na tretmanima s višim dozama hidratiziranog vapna.

Ključne riječi: kalcizacija, ozima pšenica, prinos zrna, kvaliteta zrna, vremenske prilike