МИНИСТЕРСТВО СЕЛЬСКОГО ХОЗЯЙСТВА
РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ
ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
«РЯЗАНСКИЙ ГОСУДАРСТВЕННЫЙ АГРОТЕХНОЛОГИЧЕСКИЙ
УНИВЕРСИТЕТ ИМЕНИ П.А.КОСТЫЧЕВА»

# «ЭКОЛОГИЧЕСКОЕ СОСТОЯНИЕ ПРИРОДНОЙ СРЕДЫ И НАУЧНО-ПРАКТИЧЕСКИЕ АСПЕКТЫ СОВРЕМЕННЫХ АГРОТЕХНОЛОГИЙ»

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ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
«РЯЗАНСКИЙ ГОСУДАРСТВЕННЫЙ АГРОТЕХНОЛОГИЧЕСКИЙ УНИВЕРСИТЕТ ИМЕНИ П.А. КОСТЫЧЕВА»

# Экологическое состояние природной среды и научно-практические аспекты современных агротехнологий

The ecological state of the natural environment and the scientific and practical aspects of modern agricultural technologies

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# INFLUENCE OF NITROGEN RATES AND GENOTYPE ON NITROGEN AND SULPHUR CONTENT OF WINTER WHEAT AND TRITICALE

## ВЛИЯНИЕ ДОЗ АЗОТА И ГЕНОТИПА НА СОДЕРЖАНИЕ АЗОТА И СЕРЫ В ОЗИМОЙ ПШЕНИЦЕ И ТРИТИКАЛЕ

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Keywords: grain, quality, N/S, fertilizer.
Summary: Nitrogen is the most important element for high yield and protein content in grain. In addition, it affects the adoption and accumulation of certain ions in plants, including sulphur. The aim of this paper was to examine the influence of increasing quantities of N rates and genotype on grain and aboveground vegetative biomass N and S contents of winter wheat and triticale and their relationship, and to find optimum doses of nitrogen that can give good grain quality. A two year stationery

trial with increasing quantities of N (0, 50, 100 and 150 kg $ha^{-1}$) and three cultivars of wheat and one of triticale was performed at the experiment field of the Institute of Field and Vegetable Crops in Novi Sad. The grain and aboveground vegetative biomass N and S content of winter wheat and triticale grew with increasing doses of nitrogen fertilizers. It was determined that the genotypes responded differently to different rates of nitrogen fertilizers when it came to their N and S contents. Due to a strong relationship, the N/S ratio can be an important parameter for indicating the nutritional status of wheat and triticale.
The present study showed that by using the right quantities of nitrogen fertilizer we can optimize the fertilization in wheat production with proper environmental care.

Резюме: В статье предложены исследования по изучению влияния доз азота на зерновую и надземную вегетативную биомассу озимой пшеницы и тритикале и их взаимосвязь, а также поиск оптимальных доз азота, которые могут дать зерно хорошего качества. На опытном поле Института полевых и овощных культур в Нови-саде проведено двухлетнее испытание с различными дозами азота (0, 50, 100 и 150 кг/га) и трех сортов пшеницы и одного тритикале. Установлено, что генотипы по-разному реагируют на различные нормы азотных удобрений. Исследование показало, что с помощью правильных количеств азотных удобрений можно оптимизировать внесение удобрений в производство пшеницы с учетом экологизации агротехнологии.

## Introduction

Crop production increases will come primarily from higher yields and thus higher nutrient application rates. Nitrogen is often the most deficient of all the plant nutrients. **Wheat** grain N content depends on the cultivar, the environmental conditions, and the fertilization management. Amount and timing of application of **fertilizer** are factors that affect **wheat** quality. So there is a need to estimate the optimum N **fertilizer** dose needed to obtain the greatest yield and the desired **protein** content. Nitrogen deficiencies generally affect crop growth, decrease grain protein content, and ultimately decrease grain yield and grain protein yield [1]. N deficiency resulted in much slower accumulation of grain N and S and lower final concentrations [2].

In addition, N affects the adoption and accumulation of certain ions in plants, including sulphur. Controlling the quality of **wheat** for breadmaking is a major concern for the milling and baking industry.

The aim of this paper was to examine the influence of increasing quantities of N rates and genotype on grain and aboveground vegetative biomass N and S contents of winter wheat and triticale and their relationship. The goal was to find the optimum doses of nitrogen that can give good grain quality with proper environmental care.

## Materials and methods

The influence of increasing quantities of nitrogen rates and genotype on grain and aboveground vegetative biomass nitrogen and sulphur content were examined during 2002 and 2003 at the experiment field of the Institute of Field and Vegetable Crops in Novi Sad. The experiment was arranged in a randomized complete block design with two factors and four replications. The plot size was 10m². The soil was a chernozem. The experimental material consisted of three winter wheat cultivars (Sonata, Durumko, and Pobeda) and one triticale cultivar (Novosadski triticale), each of which has different agronomic, physiological and technological characteristics. Nitrogen fertilizer was applied in different doses of N: 0, 50, 100 and 150 kg $ha^{-1}$. The usual cultural practices were applied. The total N content in wheat grain was determined by the CHNSO elemental analyzer according to the AOAC Official Method 972.43:2000, Microchemical Determination of Carbon, Hydrogen, and Nitrogen, Automated Method, in Official Methods of Analysis of AOAC International. The total S content in wheat grain was determined by elemental analyzer [3].

The results were processed by statistical methods of variance analysis (Statistica 10). The significance of differences between individual means was tested by Duncan's test.

**Results and discussion**

The weather conditions during the growing season influence the expression of genotypic traits. The analyzed parameters had lower values in 2002 because of larger winter moisture reserves. The year 2003 was marked by water and temperature stress, which resulted in higher amounts of N in plants [4].

**Table 1 – Effect of N rates on winter wheat and triticale grain nitrogen content (%) in 2002 and 2003**

| N (kg $ha^{-1}$) | Sonata | Durumko | Pobeda | N. triticale | $\bar{x}$ | Sonata | Durumko | Pobeda | N. triticale | $\bar{x}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | | | | | 2003 | | | | |
| 0 | $1.38^{g}$ | $1.80^{f}$ | $1.33^{g}$ | $1.52^{f}$ | $1.50^{c}$ | $1.70^{f}$ | $2.11^{cde}$ | $2.17^{cde}$ | $2.35^{c}$ | $2.08^{c}$ |
| 50 | $1.52^{f}$ | $1.93^{ef}$ | $1.86^{f}$ | $1.87^{f}$ | $1.80^{b}$ | $2.04^{e}$ | $2.22^{cde}$ | $2.03^{e}$ | $2.68^{b}$ | $2.24^{b}$ |
| 100 | $1.85^{f}$ | $2.50^{ab}$ | $1.97^{ef}$ | $2.30^{bcd}$ | $2.15^{a}$ | $2.09^{de}$ | $2.88^{ab}$ | $2.24^{cde}$ | $2.58^{b}$ | $2.45^{a}$ |
| 150 | $1.83^{f}$ | $2.43^{abc}$ | $2.17^{cde}$ | $2.64^{a}$ | $2.27^{a}$ | $2.09^{de}$ | $2.72^{ab}$ | $2.33^{cd}$ | $2.71^{ab}$ | $2.46^{a}$ |
| $\bar{x}$ | $1.64^{c}$ | $2.16^{a}$ | $1.83^{b}$ | $2.08^{a}$ | | $1.98^{c}$ | $2.48^{a}$ | $2.19^{b}$ | $2.58^{a}$ | |

Distinct letters in the row indicate significant differences according to Duncan's test ($P \leq 0.05$).

**Table 2 – Effect of N rates on winter wheat and triticale aboveground vegetative biomass nitrogen content (%) in 2002 and 2003**

| N (kg $ha^{-1}$) | Sonata | Durumko | Pobeda | N. triticale | $\bar{x}$ | Sonata | Durumko | Pobeda | N. triticale | $\bar{x}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | | | | | 2003 | | | | |
| 0 | $0.26^{de}$ | $0.29^{de}$ | $0.31^{cde}$ | $0.19^{e}$ | $0.26^{c}$ | $0.37^{bc}$ | $0.32^{c}$ | $0.29^{c}$ | $0.33^{c}$ | $0.33^{c}$ |
| 50 | $0.42^{bcd}$ | $0.54^{ab}$ | $0.31^{cde}$ | $0.28^{de}$ | $0.39^{b}$ | $0.40^{abc}$ | $0.36^{bc}$ | $0.51^{ab}$ | $0.34^{c}$ | $0.40^{b}$ |
| 100 | $0.47^{abc}$ | $0.47^{abc}$ | $0.43^{bcd}$ | $0.47^{abc}$ | $0.46^{b}$ | $0.51^{ab}$ | $0.50^{ab}$ | $0.50^{ab}$ | $0.43^{abc}$ | $0.48^{a}$ |
| 150 | $0.48^{abc}$ | $0.57^{ab}$ | $0.64^{a}$ | $0.56^{ab}$ | $0.56^{a}$ | $0.43^{abc}$ | $0.53^{a}$ | $0.54^{a}$ | $0.40^{abc}$ | $0.47^{a}$ |
| $\bar{x}$ | $0.41^{ab}$ | $0.47^{a}$ | $0.42^{ab}$ | $0.37^{b}$ | | $0.43^{ab}$ | $0.43^{ab}$ | $0.46^{a}$ | $0.37^{b}$ | |

Distinct letters in the row indicate significant differences according to Duncan's test ($P \leq 0.05$).

The grain N content of all the cultivars responded positively to the increasing N quantities in both years for all cultivars for 0.30-1.12% (Table 1), which was also confirmed in a study by Milošev [5]. The aboveground vegetative biomass N content grew for 0.1-0.37% (Table 2). Not only increasing the N fertilization rate but also splitting the N rate had a beneficial effect on grain quality.

The lowest N content was found in treatments without N fertilizers. Much higher N contents were obtained in treatments with 50 kg $ha^{-1}$ in relation to the control, 0.16-0.30% on average in grain, and 0.07-0.13% on average in aboveground vegetative biomass. There was no significant difference in grain N content between cultivars at this level of fertilizer application, except for the significantly higher nitrogen content found in N. triticale in 2003, but there was significant difference in aboveground vegetative biomass.

In the treatment in which 100 kg $ha^{-1}$ of N fertilizer were applied, grain N content was significantly higher relative to control (for 0.37-0.65%) and relative to the treatment with 50 kg $ha^{-1}$ N (for 0.16-0.30%). There were significant differences in grain N content between the cultivars. The highest increase was achieved with N. triticale in first and with Durumko in second year. There were no significant differences in aboveground vegetative biomass N content between the cultivars, but some cultivars achieved higher values in relation to the control treatment.

In our study N content grew with increasing N quantities up to the rate of 150 kg $ha^{-1}$ N, but this difference was not statistically important relative to the application of 100 kg N $ha^{-1}$. There was a significant difference in grain N content between the cultivars at this level of fertilizer application. The highest value was found in Novosadski triticale in the first year and in Durumko in the second. The lowest value was found in the grain of Sonata in both years. There was no significant difference in aboveground vegetative biomass N content between the cultivars and also relative to the lower treatment, except the significantly higher N content was found in Pobeda in the first year. Habtegebrial and Singh [6] examined the effects of increasing N doses (N at 0, 100 and 180 kg/ha N) on the protein contents of two bread wheat cultivars grown in Andisols and Cambisols. Both cultivars responded significantly ($P < 0.05$) to N applications. Bogdanović [7] however, obtained results similar to ours, with both studies indicating that the highest protein content is achieved by using 150 kg/ha N, but there was no significant difference relative to the rate of 100 kg/ha N. In northern Spain 13 experiments were conducted in the years 2001-2004 where 0, 100, 140, 180, and 220 kg N ha-1 were applied.

Both the influence of the variety and that of fertilization on S content in grain are statistically significant (Table 3). The mean value of grain S-content (calculated from all cultivars) for the lowest fertilization rate was significantly higher than that of the control. Also there was a significant difference between the cultivars. The effect of the fertilization on S content in aboveground vegetative biomass was not statistically significant at this level (Table 4).

In our study, the medium dose of N significantly increased grain S content by an average of 0.022% for both years relative to the control. In 2002 the increase of grain S content for the medium fertilization rate relative to the lowest one was significant, but this was not the case in 2003. The highest S-content was measured in 2003 in the treatment in which 150 kg ha$^{-1}$ of N fertilizer were applied, with the difference being significant relative to the lower treatment and the control. In 2002 this level of N application was not different from the lower treatment.

**Table 3 – Effect of N rates on winter wheat and triticale grain sulphur content (%) in 2002 and 2003**

| N (kg ha$^{-1}$) | Sonata | Durumko | Pobeda | N. triticale | Mean |
|---|---|---|---|---|---|
| | | | 2002 | | |
| 0 | $0.173^{abc}$ | $0.153^{de}$ | $0.116^{g}$ | $0.117^{g}$ | $0.140^{c}$ |
| 50 | $0.171^{abcd}$ | $0.144^{ef}$ | $0.160^{bcde}$ | $0.130^{fg}$ | $0.151^{b}$ |
| 100 | $0.188^{a}$ | $0.171^{abcd}$ | $0.168^{bcd}$ | $0.152^{de}$ | $0.170^{a}$ |
| 150 | $0.176^{abc}$ | $0.177^{ab}$ | $0.157^{cde}$ | $0.165^{bcd}$ | $0.168^{a}$ |
| Mean | $0.177^{a}$ | $0.161^{b}$ | $0.150^{c}$ | $0.141^{d}$ | |
| | | | 2003 | | |
| 0 | $0.142^{h}$ | $0.174^{cdef}$ | $0.152^{gh}$ | $0.150^{gh}$ | $0.155^{c}$ |
| 50 | $0.152^{gh}$ | $0.163^{efg}$ | $0.159^{fgh}$ | $0.186^{bc}$ | $0.165^{b}$ |
| 100 | $0.160^{fgh}$ | $0.195^{b}$ | $0.154^{gh}$ | $0.170^{defg}$ | $0.170^{b}$ |
| 150 | $0.230^{a}$ | $0.184^{bcd}$ | $0.155^{fgh}$ | $0.180^{cde}$ | $0.188^{a}$ |
| Mean | $0.171^{a}$ | $0.179^{a}$ | $0.155^{b}$ | $0.172^{a}$ | |

Distinct letters in the row indicate significant differences according to Duncan's test ($P \leq 0.05$).

There was also a significant difference in grain S content between the cultivars at different levels of fertilization. The highest aboveground vegetative biomass S-content was measured in the first year in the treatment in which 150 kg ha$^{-1}$ of N fertilizer were applied, with the difference being significant relative to the lower treatment, medium treatment and the control. In the second year S- content grew with increasing doses of N fertilizer up to the rate of 100 kg ha$^{-1}$ N. In both years there was also a significant difference of S-content between the cultivars at the same level of N. Due to the strong N-S relationships, fluctuations in protein contents also caused decreases/increases in the S contents of the wheat grain.

The effects of N (0, 100 and 180 kg N ha-1) on content of S of two bread wheat cultivars showed a significant increase of S concentration in the grain with the increase of N [6].

N deficiency resulted in much slower accumulation of grain S and lower final concentrations [8]. Based on data from this experiment, a value of 100 kg ha$^{1}$ N is recommended for winter wheat and triticale.

This level is considered sufficient for this element for the agronomic conditions of the Vojvodina province. Due to the different grain N content responses of genotypes to different rates of N fertilizers [9] which have been confirmed in the present study as well, an individual approach is required in the case of each genotype.

**Table 4 – Effect of N rates on winter wheat and triticale aboveground vegetative biomass sulphur content (%) in 2002 and 2003**

| N (kg ha$^{-1}$) | Sonata | Durumko | Pobeda | N. triticale | Mean |
|---|---|---|---|---|---|
| | 2002 | | | | |
| 0 | 0.12$^{ef}$ | 0.15$^{cde}$ | 0.14$^{def}$ | 0.12$^{ef}$ | 0.13$^{c}$ |
| 50 | 0.12$^{ef}$ | 0.17$^{bcd}$ | 0.11$^{f}$ | 0.11$^{f}$ | 0.13$^{c}$ |
| 100 | 0.14$^{cdef}$ | 0.21$^{ab}$ | 0.14$^{cdef}$ | 0.13$^{ef}$ | 0.15$^{b}$ |
| 150 | 0.22$^{a}$ | 0.18$^{bc}$ | 0.22$^{a}$ | 0.12$^{ef}$ | 0.18$^{a}$ |
| Mean | 0.15$^{b}$ | 0.18$^{a}$ | 0.15$^{b}$ | 0.12$^{c}$ | |
| | | 2003 | | | |
| 0 | 0.14$^{cd}$ | 0.12$^{de}$ | 0.13$^{cde}$ | 0.09$^{g}$ | 0.12$^{b}$ |
| 50 | 0.13$^{cde}$ | 0.11$^{ef}$ | 0.11$^{ef}$ | 0.10$^{fg}$ | 0.11$^{b}$ |
| 100 | 0.17$^{b}$ | 0.13$^{cde}$ | 0.13$^{cde}$ | 0.10$^{fg}$ | 0.13$^{a}$ |
| 150 | 0.12$^{def}$ | 0.20$^{a}$ | 0.15$^{c}$ | 0.09$^{g}$ | 0.14$^{a}$ |
| Mean | 0.14$^{a}$ | 0.14$^{a}$ | 0.13$^{a}$ | 0.09$^{b}$ | |

Distinct letters in the row indicate significant differences according to Duncan's test ($P \leq 0.05$).

## Conclusions

The expression of genotypic traits in all the treatments in our study was affected by weather conditions. The grain and aboveground vegetative biomass nitrogen and sulphur content of winter wheat and triticale grew with increasing doses of nitrogen fertilizers. Based on data from this experiment with different cultivars, a value of 100 kg ha$^{1}$ N is recommended for winter wheat and triticale. Due to the fact that the genotypes responded differently to different rates of nitrogen fertilizers, an individual approach is required in the case of each genotype. The proper management of nitrogen is critical to the success of wheat and triticale production and environmental care.

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