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# CHANGES OF CRUDE PROTEIN CONTENT IN ITALIAN RYEGRASS INFLUENCED BY SPRING NITROGEN APPLICATION

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**Abstract:** During a three-year field experiment with Italian ryegrass forage in the first production year, a dynamics of crude protein content under the influence of different levels of spring nitrogen application was examined. Crude protein content decreased from stem elongation to flowering, but the changes had different intensity among years and treatments. The highest crude protein content during stem elongation was obtained using the highest nitrogen rate - 150 kg $ha^{-1}$, even 100% higher than control treatment in 2006 and 2007. Differences among treatments decreased prior flowering, and all treatments hay yield was equable per year. The highest hay yield was reached in 2007. and it was influenced by spring nitrogen rates.

**Key words:** crude protein, growth, hay yield, Italian ryegrass, nitrogen

## Introduction

The nitrogen (N) quantity absorbed by the crop is largely variable during crop development and changed by year and locality. However, in a nitrogen-rich soil the absorption by the crops is highly correlated with a crop growth rate and biomass accumulation. In order to obtain good yield and to prevent N losses it is essential to apply the fertilizer in the time when the crop is physiologically prepared to create generative tillers and when there are climate and soil conditions for movement of nutrition towards the root, and the quantity of warmth necessary for growth is provided as well. In the greatest number of cases, N absorption preceeds the stem elongation phenophase and rapid growth. In grass crops, N absorption is very rapid during April and terminates by the middle of May in most cases. The plants are not stimulated by supplemental N quantities, even in the high temperature conditions suitable for growth *(Griffith, 1990)*.

The Italian ryegrass, short-termed but qualititative grass forage was taken and examined as a model plant for spring nitrogen absorption. The N content is the greatest individual nutrition factor effecting the growth and development of Italian

ryegrass *(Griffith and Chastain, 1997)*. A principal limiting factor in ryegrass crops can be water deficit, and among mineral elements nitrogen impedes the growth and yield the most. By nitrogen application in spring in the range of 0 to 150 kg $ha^{-1}$ the yield of crude proteins (CP) in forage from 133 to 169 g $kg^{-1}$ was increased *(Simić et al., 2007)*, whereas an intraspecies competition, due to increased seeding rate, decreased the yield of CP from 160 to 144 g $kg^{-1}$. A critical CP increase level of 164 g $kg^{-1}$ was reached with 100 kg $ha^{-1}$ N and did not increase significantly by fertilizing with 150 kg $ha^{-1}$ N.

*Mijatović (1975)* reported that by the fertilizer application the CP content in the hay from sown meadow was two times higher in relation to natural unfertilized meadows. Due to a late cutting, ie. untimely utilization in the phase of flowering or seed germination, a productive value and economic value of sowing grasslands decreased (162 g $kg^{-1}$ CP in the stem elongation, 140 g $kg^{-1}$ heading with, and 115 g $kg^{-1}$ seed germination). The research by *Simić et al. (2006)* on meadow grass mixture showed that spring N application, although it influenced the modifications in the content of some energy components, it did not influence the energy value per mass unit, furthermore, an increased nitrogen doses could even be a negative energy factor. On the contrary, N effected the increase of hay energy value through quantitative parameters, by increasing the meadow productivity, ie. increasing DM per sward unit.

A quantity of CP in Italian ryegrass, according to numerous authors, varies depending on cultivars or growing conditions. Thus, *Choi et al. (2006)* in the Koreanean conditions reported following CP quantities for the four domestic cultivars: 145, 161, 152 and 132 g $kg^{-1}$. Italian ryegrass a week after the heading in the conditions of Finland could contain 216 g $kg^{-1}$ CP *(Nissinen and Hakkola, 1998)*. Slovenian ryegrass cultivars had from 141 to 161 g $kg^{-1}$ CP *(Fišakov and Meglič, 1988)*.

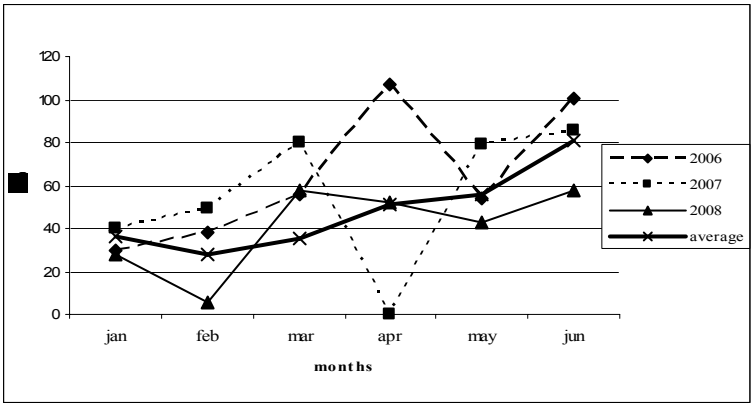
Since the Italian ryegrass is the grass of intensive growth and rapid spring development, especially after nitrogen application, the question of the vegetable nitrogen absorption dynamics and its transformation in the plant in the form of CP is being posed. The aim of a three-year trial on Italian ryegrass forage in the year after sowing, using different rates of nitrogen for spring application, was to determine the changes in the CP content starting from an intensive growth in spring to flowering.

## Materials and Methods

A three-year field experiment on Italian ryegrass was conducted in the region of Mačva, west Serbia. During the period from 2005-2007 the crop seeding rate of 20 kg $ha^{-1}$ was established and in the next year it was fertilized by nitrogen (KAN 27%N) in early spring, in the rates of 0, 50, 100 and 150 kg $ha^{-1}$. In the year

after sowing, in two-week interval the samples were taken in 4 repeats for CP analysis, starting on the fourteenth day post-application. The CP content per phenophases was measured: intensive stem growth, heading onset, full heading and flowering. After the samples have been taken in the last examined phenophase Italian ryegrass was cut, dried and hay yield measured. CP content was obtained by Kjeldahl method *(AOAC, 1984)*.

Weather conditions in the experimental years are shown by the amount of monthly precipitation from January to June, what matches the period prior N application for Italian ryegrass up to the full flowering and seed germination stages (Graph 1).




**Graph 1. Monthly precipitation during vegetative stages in Italian ryegrass (2006-08)**

The years 2006 and 2007 had completely different conditions in April, in the first year the precipitation maximum of 107 mm was realized, whereas in the next year there was a total absence of precipitations – 0 mm. The third trial year was the closest to perennial average precipitation, the months of May and June being below the average.

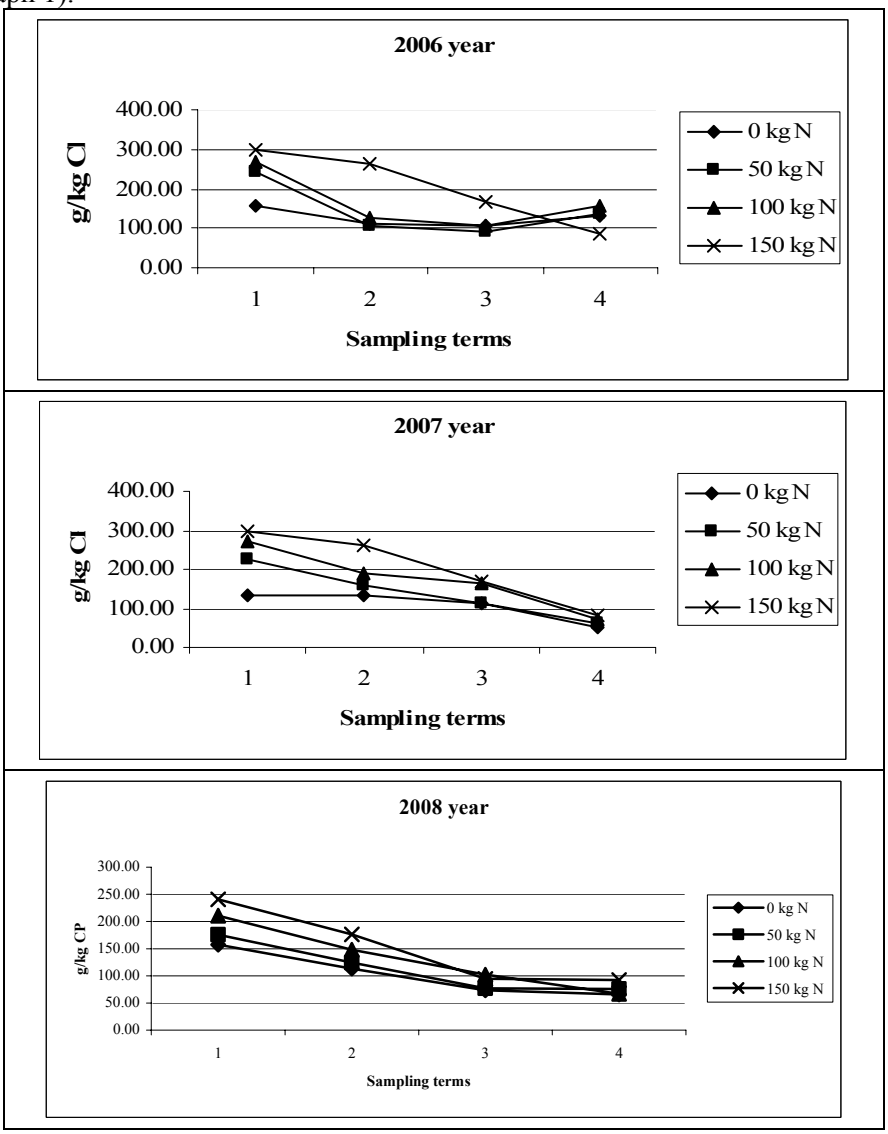
The soil in which the trial was conducted belongs to the type of meadow dark soil, of acid soil reaction. Total nitrogen content was good, while the content of easily–soluble mineral nitrogen ($NH_4$+$NO_3$-N) was low. The content of easily accessible phosphorus was in all profile depths very low, while the soil was moderately supplied by potassium.

**Table 1. Agrochemical properties of soil**

| Depth in cm | pH in KCl | Humus % | total N% | $NH_4$-N (ppm) | $NO_3$-N (ppm) | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|
| 0-30 | 5.25 | 2.54 | 0.197 | 14.1 | 10.0 | 15.1 | 3.0 |
| 30-50 | 5.83 | 1.41 | 0.153 | 4.7 | 12.7 | 13.5 | 2.3 |

## Results and Discussion

The CP content in Italian ryegrass was measured in the course of 3 years varying in weather conditions, especially in the quantities of spring precipitation (Graph 1).




**Graph 2. Changes of crude protein content in Italian ryegrass during vegetative stages in the first production year, three years trial (2006-2008)**

In grass forage production occasional precipitations and precipitations in shorter time periods have a lot greater influence on biomass yield than temperatures or insolation *(Chastain, 2000)*. The same author suggests that specificity of the time of rainfall or moistening in shorter period is critical for determination of influence on the yield of grass dry matter. Nitrogen absorption by Italian ryegrass in early spring is also under the influence of weather conditions.

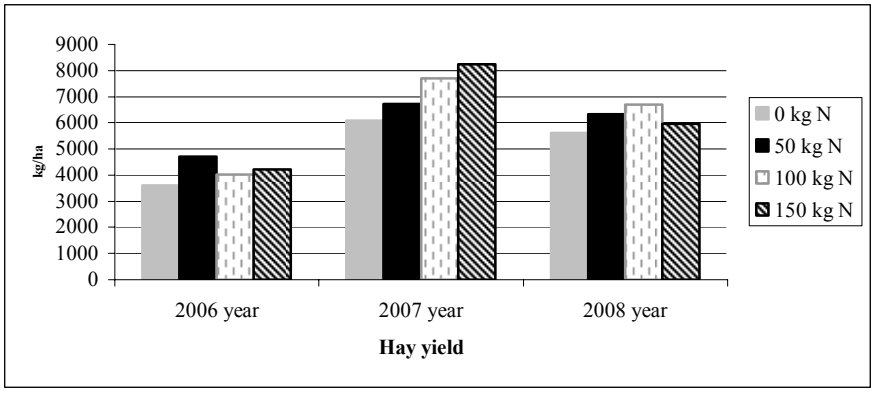
The precipitation perennial average indicates a stable increase in precipitations from March to June, when Italian ryegrass growth and development is the most intensive (Graph 2).

In all three experimental years a spring application preceded the onset of stem elongation, but further movement of nitrogen in the soil and its absorption by the plants was under the influence of specific weather conditions for each year. The CP content in 14-day sampling had a similar decreasing trend (Graph 2), but the differences among treatments in the first sampling were of different intensity. Thus on control treatment the CP content in 2006 and 2008 was equable with average of 157, ie. 158 g $kg^{-1}$, while with the greatest quantity of applied nitrogen of 150 kg N response of CP was 300 ie. 241 g $kg^{-1}$. However, in 2007 in control treatment with no fertilizing, Italian ryegrass had 131 g $kg^{-1}$ CP on average, while with the greatest application, the CP content was the same as in 2006 – 300 g $kg^{-1}$.

As expected, at the onset of heading, the CP content decreased in all three years. In 2006 due to decreased precipitations in this stage, the CP content underwent the least changes with the greatest quantity of applied N, whereas in the other two doses it almost equalized with the control variant. Greater nitrogen quantities in Italian ryegrass have led to more intensive clustering and crop density *(Simić, 2008)*, and thus to more intensive intraspecies competition for sources. For that reason all the way to the end of measuring the curve of the CP content decreased in the treatment with 150 kg applied N, while smaller quantities of available nitrogen in other treatments yielded less dense crop. In less dense crop, and due to favourable humidity, there occurred regeneration and renewing of grass sward in the flowering stage, slightly increasing the CP content in relation to a previous stage. In the next two experimental years the Italian ryegrass CP content had a similar tendency of decreasing by phenophases, and in 2007 the initial great differences in the CP content in stem elongation had a tendency of equalizing up to the flowering stage (from 52 to 84 g $kg^{-1}$ CP, with increasing quantities of applied N). Thus, in 2008 with weather conditions similar to perennial average and a moderate precipitation quantity, the CP content per treatments of Italian ryegrass fertilization showed an equable decreasing tendency, with the smallest differences among treatments, and similarly to a previous year a final CP content ranged from 66 to 92 g $kg^{-1}$ according to the increasing N doses. *Thomet et al. (1990)* by investigating the quality of Italian ryegrass in different phenophases in the conditions of Switzerland also conluded that CP content was lowest in the

flowering stage. If we compare the quantity of hay obtained by cutting in Italian ryegrass flowering stage (Graph 3) per trial years, the highest hay yield was obtained in 2007, then in 2008, and the lowest in 2006. The highest utilization coefficient of applied N was reached with 50 kg $ha^{-1}$ in 2006 confirming that lower doses of nitrogen fertilizers effect primarily the increase of forage yield while higher doses increase the CP content *(Erić and Mrfat-Vukelić, 2005)*. This is explained by the fact that with optimal nitrogen application a plant photosynthetic activity is considerably greater, and therefore also a creation of primary products of photosynthesis consumed for forage building-up. In these conditions although the plant absorbs a higher nitrogen quantity, its relative content, due to higher forage yield, can be lower. Therefore, if the dose of nitrogen fertilizer is so high that besides the increase in the forage yield there occurs also a greater nitrogen accumulation in plant tissue, the increase in CP content and nitrogen organic matters can occur as well *(Kastori, 1967)*. In 2007 the hay yield increased equally with the increase in the N rates up to maximal 8250 kg $ha^{-1}$. In the last year, the maximum yield was reached with 100 kg $ha^{-1}$ N, and further increase was not only uneconomical, but it also decreased an absolute hay quantity. Similar results with high doses of N fertilizers were reported by *Griffith and Chastain (1997),* where the decrease of forage yield was obtained by plant thinning and increased plant competition.

**Graph 3. Hay yield of Italian ryegrass at the end of flowering**




On the basis of the movement of CP content and final hay yield per treatments it can be concluded that different rates of N applied in Italian ryegrass fertilization during plant development resulted in a somewhat diluted reaction and finally in the equalization in quality expressed in proteins as well as in the biomass yield among treatments. The equalization of the yield during spring development of

Italian ryegrass takes place due to more intensive mineralization and drawing of nitrogen from relatively good soil reserves (Table 1). Depending on the planned stage of Italian ryegrass utilization the rate of application must also be incalculated, since high N rates are uneconomic in later utilization stages due to the effect of yield equalization. An initial abundant growth resulting from the action of nitrogen high doses can be best used by cutting the Italian ryegrass in earlier stages.

# Conclusion

On the basis of three-year experiment on the CP content in Italian ryegrass forage under the influence of spring N application it can be concluded that this grass species reacts rapidly to increased N application doubling the yield of proteins in relation to control. Fertilizer absorption and mobilization of soil nitrogen reserves are greatly influenced by weather conditions, primarily precipitations, thus, considerable variations among the years can take place. A quantity of vegetable proteins has decreased during vegetation season, regardless the fertilization treatment, but due to precipitations and thinner structure, the new tillers can appear in the flowering stage increasing the yield of proteins in total biomass.

Finally, the CP yield equalizes during vegetation as well as a final biomass yield, due to weakening influence of applied nitrogen. For that reason the increase in the CP content with N fertilizers must be undertaken carefully, and Italian ryegrass used for forage in optimal phenophases and the hay yield increased by using lower nitrogen quantites in fertile soil.

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# Promene sadržaja sirovih proteina italijanskog ljulja pod uticajem prolećne prihrane azotom

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## Rezime

U trogodišnjim ispitivanjima krme italijanskog ljulja prve proizvodne godine praćena je dinamika sadržaja sirovih proteina pod uticajem različitih nivoa primenjenog azota u proleće. Prema očekivanju, sadržaj proteina je opadao od fenofaze vlatanja do cvetanja, ali su promene bile različitog intenziteta po godinama, kao i među tretmanima. Najveći sadržaj proteina pri vlatanju je bio pri najvećoj primenjenoj dozi azota od 150 kg $ha^{-1}$, čak dvostruko veći u odnosu na kontrolu tokom 2006. i 2007. godine. Razlike među tretmanima prihrane su se smanjivale do cvetanja, a i prinos sena svih tretmana je bio ujednačen po pojedinim godinama. Najviši prinos sena je ostvaren u 2007. godini i povećavao se s rastućim dozama azota.

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