Journal of Ecological Engineering
Volume 14, No. 3, July 2013, pp. 59–62
DOI: 10.5604/2081139X.1056044

Research Article

THE INFLUENCE OF NITROGEN FERTILIZATION APPLIED IN DIFFERENT DOSES ON FODDER QUALITY OF MEADOW SWARD

Kazimierz Jankowski[1], Joanna Jodełka[1], Jacek Sosnowski[1]

[1] Institute of Agronomy, University of Natural Sciences and Humantities, B. Prusa 14, 08–110 Siedlce, Poland, e-mail: laki@uph.edu.pl

Received: 2013.04.28
Accepted: 2013.06.10
Published: 2013.07.10

ABSTRACT

The experiment was organized in four replicants in arrangement split-plot with plots having a surface equal 9 m^2. The basic fertilization was applied under the first regrowth. It was a mixture of unary fertilizers (ammonium nitrate, superphosphate, potassic salt) or polifoska. One form of supplementary fertilization was applied under the second and third regrowth. It was the stable form of fertilizer applied to soil. This form of supplemented nitrogen gave respectively: 50 kg $N \cdot ha^{-1}$; 80 kg $N \cdot ha^{-1}$; 110 kg $N \cdot ha^{-1}$ per each moving. During the vegetation season three movings were harvested. From each movings the sampIes of green matter were taken for chemical analyses, i.e. total protein content, soluble carbohydrates and net energy (NEL). The obtained results showed large differences in fodder quality of the meadow sward fertilized with three doses of nitrogen.

Keywords: total protein, net energy (NEL), nitrogen dose, permanent meadow.

INTRODUCTION

According to many authors [8, 17, 16], mineral fertilization is one of the basic treatments influencing botanical composition of meadow sward. Mineral fertilization influences the height and quality of crops. In order to obtain high yields, it is necessary to apply a suitable mineral fertilization regime [6, 2, 18]. High fertilization of grasslands has often negative consequences, such as a worse chemical composition of the fodder, disappearance of some bird or insect species, unfavorable changes in the content of macroelements in soil [17, 9]. Currently, smaller amounts of fertilizers are used on meadows or pastures; this can help to maintain the ecological equilibrium of natural grasslands by improving biodiversity [16, 15, 3, 13]. However, it is necessary to look for other solutions which would, for example, reduce environmental contamination [4].

The present intensification of plant production rise a need to search for various solutions, such as a new fertilization allowing combined fertilizing components and improved utilization of nitrogen by plants. It has been empirically confirmed that different doses of fertilization in meadow sward is beneficial [6, 7, 1, 11], and it has encouraged us to study the reaction of fodder grasses to fertilization methods in terms of mineral compounds' contents. The present study is part of an attempt to formulate guidelines for fertilization of grasslands by testing supplementary nitrogen fertilizations.

MATERIALS AND METHOD

A three-year experiment was established in spring 2003 on permanent meadow in the region of Siedlce. The trial plots were set out on gley proper soil created from light loamy sand on medium silt clay. The soil was slightly alkaline in reaction, both in KCl solution and in H_2O (pH in l n KCl 7.15); it had a high content of total nitrogen (0.45%), manganese (450 $mg \cdot kg^{-1}$) and iron (1700 $mg \cdot kg^{-1}$), a common magnesium content (0.31 $mg \cdot kg^{-1}$) and a very low phosphorus (0.15 $mg \cdot kg^{-1}$) and potassium (0.25 $mg \cdot kg^{-1}$).

The meteorological measurements (temperature and precipitation) were obtained from the meteorological station in Siedlce, and were quite different across the 3 years' experiment. Average air temperature in the growing period (April-September) in the successive years was higher than the long-term average (4.1, 3.9 and 3.8 °C respectively). Also the total precipitation in the growing seasons exceeded the long-term average (about 87.3 mm in 2003, about 74.5 mm in 2004 and about 46 mm in 2005). Two forms of fertilizer were used for basic fertilization: multiple (polifoska 15) and a mixture of single-element fertilizers (ammonium nitrate, superphosphate, potassium salt); both added to the soil 60 kg $N \cdot ha^{-1}$, 60 kg $P \cdot ha^{-1}$ and 60 kg $K \cdot ha^{-1}$. Additionally, the second and third regrowth were fertilized with nitrogen applied in a solid form (ammonium nitrate) to soil. The fertilization treatments introduced respective amounts of nitrogen: N – 50 $kg \cdot ha^{-1}$, N2 – 80 $kg \cdot ha^{-1}$, N3 – 110 $kg \cdot ha^{-1}$. Three cuts were harvested in the vegetation period; the chemical analysis of the plant material was performed on lnfra Alyzer 450 equipment for determination of total protein and soluble carbohydrates.

Mathematical models proposed for this type of experiments were applied. The significance of differences between means of the experimental factors was determined with Tukey's test at the level of significance $P \leq 0.05$.

RESULTS AND DISSCUSION

The results presented in Table 1 show a significant impact of fertilization applied in spring on total protein content in dry matter. Higher values have been obtained by adding a mixture of fertilizers.

Total protein content in the sward of permanent grassland is one of the most important quality parameters of harvested crop, and its value should be close to 200 $g \cdot kg^{-1}$ D.M. Fertilization, especially with nitrogen, has a strong influence on the protein content in plants and higher doses of nitrogen used in fertilization, eliminate legumes plants, which have a biological capacity to collect larger amounts of this component.

Analysis of the results indicates the differential impact of the applied nitrogen fertilization on the content of total protein in different years. On the objects where multiple fertilizer was applied in spring and 110 kg $N \cdot ha^{-1}$ in the summer, plant material from the first year of the study contained significantly lower amount of total protein (142 $g \cdot kg^{-1}$ D.M.), but significant1y higher amount of this component (168 $g \cdot kg^{-1}$ D.M.), in comparison to the same objects in the third year of the study. It should be noted that during the same period with the same dose of nitrogen fertilization in the summer, only with a mixture of fertilizers used in spring, total protein content in the harvested plant material did not differ significant1y (170 and 169 $g \cdot kg^{-1}$ D.M.). These results show that in our system, the evaluation of agricultural production and different ways of nutrients supply depend on the distribution of temperature and precipitation, in agreement with previous work [5, 6, 10, 14, 12]. An important element of quality of harvested crop is also the content of soluble carbohydrates, which affect the testability of feed and possibility of conservation [6].

The data showed no significant differences in soluble carbohydrate content (Table 2). It should be noted that there were significant differences in the content of this component in the fodder harvested in successive years of research. Significantly higher content of soluble carbohydrates

Table 1. Content of total protein ($g \cdot kg^{-1}$ D.M.) in meadow sward in successive research year depending on the kind of spring fertilization and nitrogen doses applied in summer

Kind of fertilization	Nitrogen dose $kg \cdot ha^{-1}$	Years of study			Mean
		2003	2004	2005	
Multipe fertilizers	50	149	157	150	152
	80	160	155	157	157
	110	142	158	168	156
Mixture of fertilizers	50	169	162	165	165
	80	165	157	170	164
	110	170	161	169	167
Mean	–	159	158	163	160

Table 2. Content of soluble carbohydrates (g·kg^{-1} D.M.) in meadow sward in successive research years depending on the kind of spring fertilization and nitrogen doses applied in summer

Kind of fertilization	Nitrogen dose kg·ha^{-1}	Years of study			Mean
		2003	2004	2005	
Multipe fertilizers	50	54.7	60.9	75.2	63.6
	80	59.1	61.9	67.8	62.9
	110	55.1	63.0	69.8	62.8
Mixture of fertilizers	50	51.0	63.0	80.9	65.0
	80	49.2	58.5	70.9	59.5
	110	53.2	58.4	74.9	62.2
Mean	–	53.8	60.9	73.2	62.6

was characterized the yield harvested in 2005 (73.2 g·kg^{-1} D.M.) On the contrary, the lowest concentration of this nutrient has been found in the plant material from the first year of the study (53.8 g·kg^{-1} D.M.). Increasing doses of nitrogen fertilization in summer 2005 was a factor reducing the quantity of soluble carbohydrates in the harvested yield, while in the remaining years of research, such impact was not stated.

The Nutrients contained in the feed fulfilling many important functions in the body of animals not only cover their living needs, but also placed the higher production requirements. Ruminants for the right conduct of life processes require energy, which must be taken from a given feed. Synthetic evaluation of nutritive value of feed from different research objects (Table 3) shows higher values of net energy of lactation in the yield from plants fertilized with a mixture of fertilizers, which in terms of composition contain large quantities of mine ballast.

An important indicator of this feed quality, is the digestibi1ity which, according to Mrkvicka and Wesela (2009), in the feed given to catt1e shou1d be about 65–67%. The ana1yzed plant material did not meet that standards, which the most simi1ar va1ue (64.26) was obtained on the objects fertilized with a mixture of mineral ferti1izer in spring and with the lowest dose of nitrogen in summer. To compare, the highest obtained va1ues (61.76) were recorded at the same dose of nitrogen used in summer but with the multiple ferti1izers applied in spring. The estimation of nutritive va1ue of feed from different research objects indicates, that the highest quality parameters had the plant material from the object ferti1izered with the mixture of fertilizer used in spring and the lowest dose of nitrogen applied in summer. Whi1e the lowest quality of tested parameters were stated for using the same dose of nitrogen applied in the summer and multip1e ferti1izers used in spring.

CONCLUSION

1. The introduction of multip1e ferti1izers into a model of permanent grassland ferti1ization significantly worsens protein parameters of harvested feed.

Table 3. Energetic value of fodder (1 kg^{-1} D.M.) of meadow sward depending on the kind of fertilization and nitrogen dose (mean for three years)

Kind of fertilization	Nitrogen dose kg·ha^{-1}	Net energy lactation (NEL) [MJ·kg $^{-1}$ D.M.]	Digestibility
Multipe fertilizers	50	5.42	61.76
	80	5.57	63.04
	110	5.56	63.07
Mixture of fertilizers	50	5.71	64.26
	80	5.58	63.58
	110	5.55	63.15
Mean	–	5.57	63.14

2. Application of higher doses of nitrogen fertilization in the summer not a1ways positive1y influenced the accumu1ation of tota1 protein, but decreased 1eve1s of solub1e carbohydrates.
3. Increasing the doses of nitrogen fertilization during the summer did not improve the qua1ity of forage harvested from the objects by using of multiple ferti1izers applied in the spring and was the best by using the fertilizers mixture and the lowest dose of nitrogen.

REFERENCES

1. Butkute R., Daugeliene N. 2006. Study on long-term meadow productivity and botanical composition in response to different liming and fertilization. Grasslands Science in Europe, 13, 224-226.
2. Carassai I.J., Da Trindade J.K., Nabinger C., Lemaire G., Carvalho P.C.F., Silva C.E.G., Vieira P.C., Dutra V.S., Tischler M.R. 2012. Ecophysiological model of growth of annual ryegrass as function of nitrogen fertilization. Grasslands Science in Europe, 17, 91-93.
3. Dickson T.L., Bryan L. 2011. Fertilization decreases plant biodiversity even when light is not limiting. Ecology Letters, DOI: 10.1111/j.1461-0248.2011.01599.x, 1-9.
4. Hannessy D., Enriquez-Hidalgo D., O'Donovan M., Gilliland T. 2012. Effect of N fertilizer application rate on herbage production and sward clover contents in grazed grass clover plots. Grasslands Science in Europe, 17, 124-127.
5. Humphreys J., O'connell K., Casey I.A. 2008. Nitrogen flows and balance in four grassland based systems of dairy production on a clay-loam soil in a moist maritime climate. Grass and Forage Science, 63, 467-480.
6. Jodełka J, Jankowski K. 2001. Re1ation between soil and foliar fertilization of permanent meadow. Acta Agroph., 52, 87-91.
7. Kolczarek R., Ciepie1a G.A., Jankowska J., Jodełka J. 2008. Influence of different forms of nitrogen ferti1ization on the content of macroe1ements in meadow sward. J. Elementom., 13(3), 349-355.
8. Gough L., Osenberg C.W., Gross K.L., Collins S.L. 2000. Fertilization effects on species density and primary productivity in herbaceous plant communities. OIKOS, 89, 428–439.
9. Mrkvicka J., Wesela M. 2009. Species richness and diversity of foxtai1-type stand during 10 ng-term fertilization. Grasslands Science in Europe, 15, 196-199.
10. Muhammad A.U., Maqsood A., Amir S.R. 2010. Effect of nitrogen fertilization and harvesting intervals on the yield and forage quality of elephant grass (*Pennisetum purpureum)* under mesic climate of pothowar plateau. Pak. J. Agri. Sci., 47(3), 231-234.
11. Nefeler D., Huguenin-Elie O., Suter M., Frossard E., Lűscher A. 2006. Well-balanced grass-legume mixtures with low nitrogen fertilizations can be as productivities as highly grass monocultures. Grasslands Science in Europe, 13, 197-200.
12. Preś J. 1997. Produkcja pasz zielonych a potrzeby intensywnego żywienia zwierząt. Zesz. Prob. Post. Nauk. Ro1n., 24, 61-67.
13. Rajaniemi T.K. 2002. Why does fertilization reduce plant species diversity? Testing three competition-based hypotheses. J. Ecol., 90, 316–324.
14. Singh S., Nandita G., Singh K.P. 2007. Synchronizing nitrogen availability through application of organic inputs of varying resource quality in a tropical dryland agro ecosystem. Appl. Soil Ecol., 36, 164-175.
15. Spatz G., Buchgraber K. 2003. Balancing economic and ecological aspects. Optimal forage systems for animal production and the environment. Grasslands Science in Europe, 8, 11-13.
16. Wasilewski Z., Sutkowska E. 2001. Kształtowanie się składu botanicznego plonów pod wpływem nawożenia w wieloletnim doświadczeniu pastwiskowym. Pam. Puł., 125, 75-84.
17. Winnicka J., Bobrecka-Jamro D. 1996. Wpływ różnych dawek azotu na plon i skład florystyczny runi łąkowej przy wieloletnim użytkowaniu kośnym łąki górskiej. Zesz. Nauk. AR Kraków Roln., 312(3), 115-119.
18. Zhu Z.L. 2000. Loss of fertilizer N from plants soil system and the strategies and techniques for its reduction. Soil Environ. Sci., 9, 1-6.