EFFECT OF FERTILIZATION ON SPECIES COMPOSITION OF GRASSLAND

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Abstract: The aim of this study is to evaluate the effect of different intensities of fertilization on the species composition of the grassland on the experimental area of Kameničky. The evaluated factors were in the range of the intensity of fertilizer. It means the unfertilized level, PK, N90+PK and N180+PK. The unfertilized crops do not always show high species diversity. The highest and balanced species diversity was assessed in the crops with PK fertilization while the lowest one was found out in the grassland fertilized with N90+PK during these years. The proportion of grass, compared to the unfertilized variant, was the most increased ($P<0.05$) in the variant of N90+PK (60.3%) at the expense of other herbs (33.7%). The PK fertilizer (14.8%) significantly ($P<0.05$) increased the development of legumes in the grassland.

Key Words: permanent grassland, species composition, diversity, grass quality of grassland

INTRODUCTION

The grassland is defined as a multispecies community consisting of three basic components. It is a component of grass (Poaceae family - *Poaceae*), Viciaceae (*Viciaceae*) and herbal. Dicotyledonous species of short-term to permanent create the component, which are the second widespread grassland on the planet proving a number of production and non-production functions. Without long-term insertion of the additional energy in the form of mowing and grazing, the original forest vegetations would not be stable. Permanent grassland exists in the so-called absolute habitat at which the adverse environmental conditions prevent the cultivation of crops (Hrabě, Buchgraber 2004, Urban, Šarapatka 2003).

The species composition of the grassland is highly dependent on the management method. It has been proved that diversity decreases with the increasing productivity. The application of organic fertilizers, the proportion of herbs, and an incorrect application cause other adverse effects on biodiversity. The decrease of species diversity of grassland has a direct impact on reducing species diversity of fauna (Urban, Šarapatka 2003).

With a decrease of cattle in 2006, a degradation of the management and the use of permanent grassland happened. From an economic point of view, it is important to perform a proper management. Green forage of permanent grassland is a relatively cheap feed. In the ecological terms, grassland provides the best protection against the erosion and leaching. Grassland management also has an impact on the number of species (Kohoutek et al. 2007, Gaisler et al. 2004).

Industrial fertilizers provide nutrition and reduce the deficit of nutrients in the soil losing them by high harvests of crops. World consumption of pure nutrients (N, P_2O_5, K_2O) in mineral fertilizers increases from 1.7 mil. of tonnes to 111.7 mil. of tonnes from 1900 to 1980. Grasslands are effectively able to use high doses of nutrients. For this reason, they are highly valued in the protection of water sources. In the conditions of the Czech Republic, a low content of the acceptable phosphorus and higher potassium content are in the soils (Urban, Šarapatka 2003, Havelka 1984).

The most important nutrients are N, P, K, Ca and Mg for the formation and quality of the fodder. Nitrogen is a critical nutrient for yield. Permanent grassland, which is unfertilized with the mineral or organic fertilizers approximately reach the hay yield from 3 to 4.5 $t \cdot ha^{-1}$. NPK fertilizer can increase

from 2 to 3 times the forage yield of dry matter. Permanent grasslands reacts better to the fertilizer treatment than fields left fallow (Hrabě, Buchgraber 2004, Laieş, Moisuc 2009).

The nitrogen is present from 98 to 99% in the organic form in the soil. It is the inaccessible form for plants. The remaining of 1–2% are in the soil in the form of ammonium and nitrate ions, which are available for plants. Organic nitrogen is partially released by the microorganisms mineralization, immobilization, denitrification and fixation of atmospheric nitrogen for plants. Symbiotic bacteria are capable to store up to 3 kg.ha^{-1} of N in the 1% of legume representation in the grassland by fixing of the atmospheric nitrogen. The air precipitations supply approximately 10 kg · ha^{-1} of N per year. The decomposition of organic matter is supplied up to 30 kg · ha^{-1} of N per year. Nitrogen fertilization change the qualitative composition of the forage. With a balanced fertilizer of P and K, the content of nitrogen substances and digestibility of dry matter are increased. In the excessive doses of N, solids content and water-soluble sugars are reduced. Fiber content is increased and the palatability of forage was reduced followed by the increase of the content of the nitrogen fraction of NO_3-N or PDIN and it can be worsen the course of the fermentation process in silage. An indirect effect of nitrogen is to reduce the proportion of legumes in the grassland and thereby supports the growth of grasses and herbs (Hrabě, Buchgraber 2004, Urban, Šarapatka 2003).

Phosphorus fertilization affects not only the P content in the forage but also its mutual relationship with calcium. It supports the development of legumes and improves the taste and quality of forage. The changes in species composition are negligible at first, then increased having long-term duration in the use of phosphorus fertilizing. The importance of potassium is to transfer energy - ADP, ATP. It is a nutrient proving a high retention in the soil and limited danger of leaching losses. Phosphorus is mostly bound in the form of organic compound in the grassland. Its usefulness is dependent on soil pH. In acidic soils, plants usefulness is lower because of forming insoluble ferric and aluminum phosphates. The phosphorus content varies according to the proportion of grass or herbal ingredients in the fodder. Other factors, affecting phosphorus content in the forage, are the stage of plant growth and seasons. More important factor than the phosphorus content is the ratio between the Ca: P in forages. In lactating dairy cows, it should be from 1.5 to 2:1(Urban, Šarapatka 2003, Havelka 1984, Hrabě, Buchgraber 2004).

MATERIALS AND METHODS

Plot

The experimental plot of the Department of Animal Nutrition and Forage Production at Mendel University is called Kameničky located in Českomoravská vrchovina (CHKO- protected landscape area, Žďárské vrchy) in the land register of Kameničky village. The experimental plot lies at an altitude of 650 m, on the south-facing slope with an inclination of 3°. Soil type is classified as pseudogley, sandy soils to loamy. The average annual precipitation was of 785 mm and the average annual temperature was of 6.7°C in the same period (Nawrath et al. 2013).

Experimental organization

Small-plot trial with four replications was established in 1992. The size of each parcel was 1.5 x 10m. The test factor was the level of fertilization, which means the unfertilized level, PK (30 kg · ha^{-1} of P and 60 kg · ha^{-1} of K), N90+PK (90 kg · ha^{-1} of N, 30 kg · ha^{-1} of P, 60 kg · ha^{-1} of K) a N180+PK (180 kg · ha^{-1} of N, 30 kg · ha^{-1} of P, 60 kg · ha^{-1} of K). Fertilizers used for to nutrients supply were ammonium nitrate (27% N), potassium salt (60% K_2O) and hyperkorn (26% P_2O_5). Nitrogen was applied in two doses - 2/3 in the spring and 1/3 after the first mowing. Potassium and phosphoric fertilizers were applied in the spring. The harvest takes place three times - in early June, early August and early October (Nawrath et al. 2013).

Proportion of agrobotanical groups

The proportion of agrobotanical groups was determined in all three mowings. The samples were taken from the above-ground phytomass area of 0.5 m^2. The samples were divided into clover, grasses and other herbs, than dried at 60°C, weighed and calculated to a percentage of each agrobotanical group of the harvested forage (Rychnovská 1987).

Hill's diversity index N_2

Species diversity (variety) of community is dependent on the species richness but the number of species is not sufficient. For a better expression, it is preferable to calculate the ratio of the number of species to the number of individuals (Šrámek et al. 2001). The Hill's diversity index is used for its simplicity in practice and is calculated according to the formula

$N_2 = (\sum x_i)^2 / \sum(x_i^2)$, where $\sum$ = Sum; x_i = projective dominance i- th species in grassland [%]

It is in the range of values from 1 to 100, where 100 is only theoretical value and 1 indicates a pure monoculture. In Central Europe, the richest communities reach a value of N_2 from 40 to 50 (Jurko 1990, Spellerberg 1995).

Hill's index was assessed only on the first mowing without repetition in our experiment.

Statistical evaluation

For the processing and evaluation of the results, Microsoft Office Excel version 2007 was used. The data were put into the tables from which were subsequently created the graphs of average values. Statistical evaluation was performed in Statistica CZ 12 using multi-factor analysis of variance (ANOVA) followed by Tukey test.

RESULTS AND DISCUSSION

Proportion of agrobotanical groups

In the grassland, the proportion of agrobotanical groups, depending on the intensity of fertilization, ranged from 37.5 to 60.3% of the grass, from 1.0 to 14.8% of the clover and from 33.7 to 55.6% of other herbs (Table 1).

Raus et al. (2013) observed in their experiment that grasses accounted for an average of 46% in crops. Novák (2004) gives the average proportion of grass of 38.3% in the meadow community, which corresponds with our results. Štýbnarová, Hakl (2011) found out that the proportion of grass was the largest in the variant N180+PK (80%) in the crops, the least proportion was observed in the unfertilized variants, and in PK variants, it was identically reached of 55%. Velich (1996) in his publication states that the proportion of grasses formed 55% in unfertilized crops and at an intensity of N200+PK fertilizer, it was up to 90%. These high values can be attributed to the different intensity of fertilization (200 kg · ha^{-1} of N).

Novák (2004) indicates the proportion of clover was up to 13.2% in a meadow vegetation. Štýbnarová, Hakl (2011) describe that the proportion of legumes in the grassland was low up to 2% in the variations of N90+PK and N180+PK. In the fertilized variant, it was up to 3% and up to 6% was in the PK variant. Velich (1996) shows in his work that the proportion of legumes was up to 12% in the fertilized crop and in a PK variant, it was even up to 21%. The fertilization of phosphosilicate-potassium fertilizers significantly promotes the development of legumes in the grassland. Nitrogen fertilizers resulted in the retreat of legumes.

Štýbnarová, Hakl (2011) reported that the proportion of other dicotyledonous plants decreases with higher intensity of fertilization. In the unfertilized variant, the representation of 42% of the other herbs was evaluated in the grassland, in the variant of N180+PK was only up to 18%. According to Velich (1996), other herbs consist of 30% of the meadow grassland with the fertilization of 60 kg · ha^{-1} of N + PK, with higher fertilization rate of (N200+PK), this proportion decreases up to 9%.

The retreat of other dicotyledonous species is not a damage. A large part of them is not an important feed and can reduce the quality of the entire crop. Phosphorus fertilization increases the proportion of legumes in the grassland at the expense of other dicotyledonous herbs (Mrkvička, Veselá 2001).

Hill's diversity index N_2

The values of Hill's diversity index N_2 were in the wide range from 4.24 to 11.55 (low to high species diversity) in all vegetation. The variants of N90+PK and N180+PK prove medium to low species diversity (in 2. and 3. year). The PK variant achieves medium to high species diversity, and in 2. year

(up to 10.19), in 3. year (up to 10.18) and in 5. year (up to 11.55). The unfertilized variant predominates medium species diversity, and between 2. and 5. year, even high species diversity was observed. Nawrath et al. (2013) reported in his experiment that the highest species diversity reached (up to 8.4) in the grassland fertilized with phosphorus and potassium. Crops, fertilized with nitrogen (N90+PK, N180+PK), showed significantly reduced species diversity up to 2.5. The deterioration of species diversity can also be caused by the improper use of nitrogenous fertilizers (Mrkvička, Veselá 2001).

Table 2 shows the change in species diversity N_2 among the fertilization variants from 1. to 5. year. In the unfertilized variant, a reduction in species diversity can be seen from 2. to 4. year. This decrease can be explained by higher proportion of sedge vegetation, which was developed in the grassland in the dependence on higher temperatures and lower rainfall in the springs from 2. to 4. year.

The comparison of the values of generic diversities of the individual variants of fertilization between each other can be seen in the PK variant, which shows N_2 almost always higher than in other variants. The highest value of N_2 (up to 11.55) was determined in PK variations in year 5.

From the mentioned results, it can be indicated that the unfertilised grassland does not always prove the highest species diversity as stated in the available literature. Species diversity is also greatly affected by climatic conditions - rainfall and temperature.

Table 1 Effect of fertilization on proportion of agrobotanical groups (the average) (Kameničky)

Treatment	Grasses (%)	Clovers (%)	Other herbs (%)
Unfertilized	40.3^{a}	4.1^{ab}	55.6^{a}
PK	37.5^{a}	14.8^{c}	47.8^{ab}
N90+PK	60.3^{b}	6.0^{b}	33.7^{c}
N180+PK	59.6^{b}	1.0^{a}	39.4^{bc}

Different letters in the columns indicate statistically significant differences at a level of $p<0.05$

Table 2 Hill diversity index of N_2 of individual variants of fertilization (Kameničky)

Year	Unfertilized	PK	N90+PK	N180+PK
1	8.82	7.77	6.69	6.32
2	11.11	10.19	4.24	8.31
3	7.44	10.18	6.51	4.30
4	6.54	9.24	7.80	7.51
5	11.04	11.55	6.19	8.04

CONCLUSION

The agrobotanical proportion of component in grassland varies on the intensity of fertilization. The fertilized crops with nitrogen show significantly higher proportion of grasses (up to 59.6%) than the unfertilized crops (up to 40.3%). Conversely, the proportion of clovers decreases in the use of nitrogen fertilizers to a minimum (up to 1.0%) compared to the unfertilized grassland (up to 4.1%), as well as other herbs representation decreases from 55.6% to 39.4%. The fertilization of phosphosilicate-potassium fertilizer has a positive impact on the representation of legumes in the grassland up to 14.8%. With a regard to a fiber content, NL a NEL appear to be as the most valuable fodder crops fertilized with phosphorus and potassium in Kameničky experimental plot.

The fertilizing of grassland is needed to ensure the production of high-quality forage. Fertilized crops are indeed richer, but in terms of the feed, are not suitable for nutrition of high productive animals. They can be recommended in the areas with higher requirements for non-production functions, and for the extensive use such as grazing of less demanding cattle breeds.

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