Yield and Sward Composition Responses of Natural Grasslands to Treatments Meeting Sustainability

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***Abstract*—**An outstanding part of the animal products are based on the grasslands, due to the fact that the grassland ecosystems can be found all over the globe. In places where economical and successful crop production cannot be managed, the grassland based animal husbandry can be an efficient way of food production. In addition, these ecosystems have an important role in carbon sequestration, and with their rich flora – and fauna connected to it – in conservation of biodiversity. The protection of nature, and the sustainable agriculture is getting more and more attention in the European Union, but, looking at the consumers' needs, the production of healthy food cannot be neglected either. Because of these facts, the effects of two specific composts - which are officially authorized in organic farming, in Agri-environment Schemes and Natura 2000 programs – on grass yields and sward compositions were investigated in a field trial. The investigation took place in Hungary, on a natural grassland based on solonetz soil. Three rates of compost (10 t/ha, 20 t/ha, 30 t/ha) were tested on 3 m X 10 m experimental plots. Every treatment had four replications and both type of compost had four-four control plots too, this way 32 experimental plots were included in the investigations. The yield of the pasture was harvested two-times (in May and in September) and before cutting the plots, measurements on botanical compositions were made. Samples for laboratory analysis were also taken. Dry matter yield of pasture showed positive responses to the rates of composts. The increase in dry matter yield was partly due to some positive changes in sward composition. It means that the proportions of grass species with higher yield potential increased in ground cover of the sward without depressing out valuable native species of diverse natural grasslands. The research results indicate that the use of organic compost can be an efficient way to increase grass yields in a sustainable way.

***Keywords*—**Compost application, crude protein content, dry matter yield, native grassland, sward composition.

I. Introduction

THE esteem of grassland ecosystems are growing over the years thanks to their various ecological functions [1], [2]. Their contribution in maintaining the flora and fauna biodiversity [3] or their role in the carbon sequestration [4] and erosion regulation [5] are undisputable. Because the survival of many species present in these habitats are highly dependent on the condition of it, to sustain the richness in plant [6], [7] and animal species [8], [9] the European Union conduces the maintenance of these grasslands with subsidies and regulations. But to receive these financial aids, the farmers must apply extensive technologies in order to prevail the ecosystem services.

The type and the amount of externalities supplied by a certain farm are determined by the ratio of the use of on-farm and off-farm resources, the land use and the level of intensification [10]. It means that to fulfill their multifunctionality, the grassland farmers have to apply extensive, environmental-friendly methods while they have to keep profitability also. Since five-sixths of the world's grasslands are on low and zero quality land [11] the profitability and extensity seem antagonistic to each other, but with the reasonable utilization of the on-farm resources, these principles can co-exist. It is well known that mowing and long-term grazing also causes soil nutrient loss, therefore it would be desirable to use fertilizers on grasslands also, to maintain the nutrient balance. Dungait et al. [12] and Fanguiero et al. [13] stated that the application of organic fertilizers result in favorable conditions for production and increases the soil respiration. These improving conditions generate faster growing and bigger yield, which is welcome, but as Borer et al. [14] reported plant species loss can occur thanks to the competition for light. However with intensified utilization the negative changes can be managed, and the loss of precious species may be avoided.

II. Material and Method

The experiment took place in the sheep farm of University of Debrecen AKIT Karcag Research Institute on natural grassland based on solonetz soil. The dominant herbs are *Alopecurus pratensis* and *Festuca pseudovina*, but more than 40 species can be found per hectare. The main goal was to receive information about the effectiveness of the two types of compost produced by this certain sheep farm and made of sheep manure. Two type of compost were investigated in this experiment. The first compost is natural compost (N), without any additional compounds, the second is enriched with phosphorus (E). Both compost are allowed by the authority of organic farming.

The compost was spread in October 2015. Three rates were tested (10 t/ha, 20 t/ha, 30 t/ha) in 3m X 10m experimental plots. Every treatment had four replications and both types of compost had four control plots (marked with "Z"). On the 17th of May and the 8th of September sward composition was analyzed, followed by harvesting of the plots.

For the sward composition analysis, the Balázs-method was used. Ground cover (GC) percentage of each species found in the plot were estimated. During the evaluation process, plant

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groups we created are like: Tall grasses (above 30 cm), short grasses (under 30 cm), leguminous plants and other ones (herbs, weeds, etc.). Dry matter yield, crude protein content and yield were measured.

III. Results

The results of the botanical composition analysis showed that the application of compost favors the tall grasses at the expense of short grasses (Fig. 1). In treatment NZ, the GC of tall grasses and short grasses were 20% and 45%, respectively. In the treatment N30, the GC of the tall grasses were 43% compared to only 18% for the short grasses. The changes in E compost treatments were more eye-catching. The GC of tall grasses in EZ was 19% and the short grasses was 47%, whereas in E30, the GC of tall grasses reached 67%, whereas the GC of short grasses decreased to 12%. In this case, the highest rate of compost application GC of the leguminous plants was remarkably reduced. For both types of composts, it was experienced that the 30 t/ha rate was unfavorable for the leguminous plants. On the plots where 10 and 20 t/ha compost were applied, more leguminous could be found, but the 30 t/ha treatment reduced the cover area of these plants. It was most noticeable in the case of the E type compost.

Regarding species composition, it can be observed that the *Alopecurus pratensis* and the *Trifolium angulatum* species showed the best response to the compost application e.g. in treatment E30, 90% of the GC of tall grass species was *Alopecurus pratensis* and in E20 treatment, 92% of the leguminous species was *Trifolium angulatum*. These species were the most dominant in these treatments.

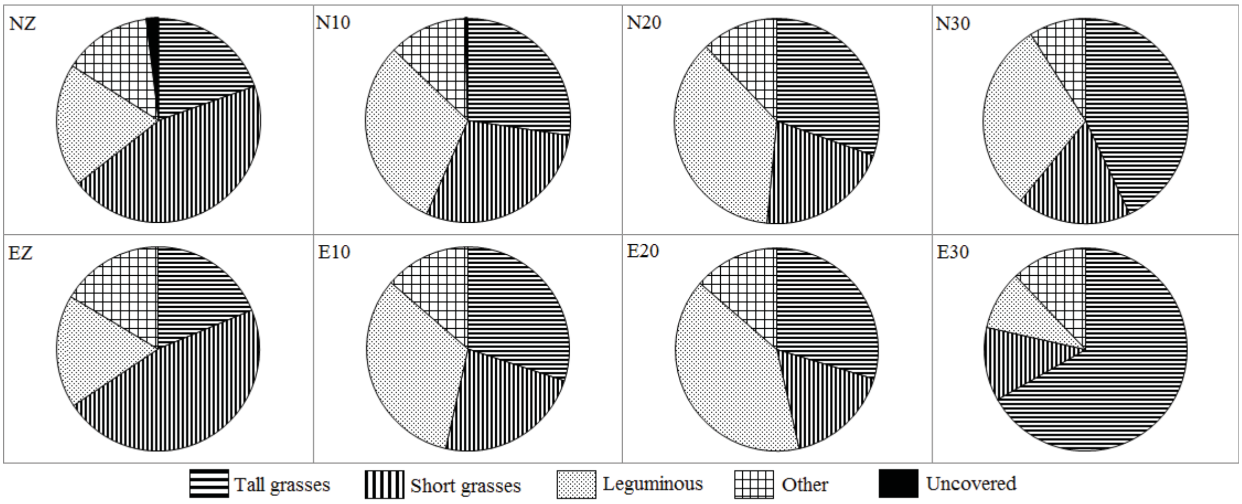

Fig. 1 The representation of different plant groups in sward composition (17th May 2016)

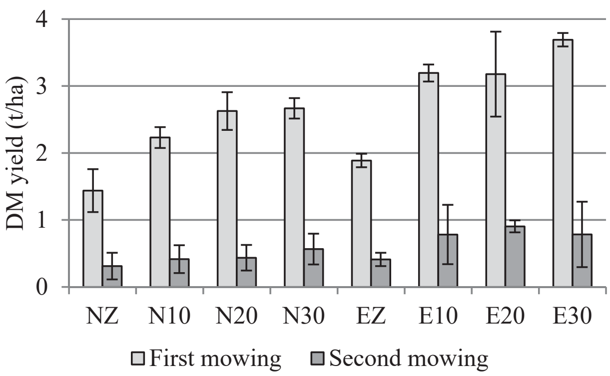

Fig. 2 The average DM yield of the treatments

The year 2016 was rich in rainfall thus we expected high yield in every plot. The average rainfall between the 1st of January and the 30th of September – based on the data of the last fifty years – is around 380 mm, but this year it was 486 mm. On the low quality soil in the experiment, with this high amount of precipitation, even in the control plots' yields could reach relatively high levels, considering the average yield (1.5 t/ha DM) of Hungarian grasslands. With this much rainfall, the applied composts had better conditions to being decomposed and uptaken. Under these conditions the effect of the composts on the yield of grasslands seems explicit. After measuring the yield and analyzing the data on the computer we experienced that the application of any type of compost in any rate results in significantly bigger DM yield than the control (Fig. 2). N10 produced 2.23 t/ha DM, whereas N30 produced 2.67 t/ha DM. E10 and E30 treatments produced 3.19 and 3.69 t/ha DM respectively. However, in the case of same type of composts significantly different yields were found between treatments N10-N30 and E10-E30, which means that potentially the yield response of 20 t/ha compost application may reach the yield response of the 30 t/ha compost applications, but the standard deviation between the 20 t/ha plots is high. E.g. the minimum and maximum of DM yield of E20 plots were 2.74 and 4.09 t/ha.

Comparing the two types of composts, E compost could produce higher DM yields than that of the N compost. On average N30 treatments could produce 2.67 t/ha DM, whereas the E30 treatments overyielded them with 3.69 t/ha DM.

The percentage of crude protein content did not significantly differ between the two types of compost in the same dose (Fig. 3). In the data of compost N, a slight tendency can be seen, that the higher dose resulted in lower crude protein content in the first cut, but in the second the opposite occurred. The crude protein content data of E compost treatments are balanced, exceptionally the E20, which produced the highest average crude protein percentage (12.27%). On the plots of this treatment the GC of leguminous plants were the highest, and their high protein content is well expressed through the received data.

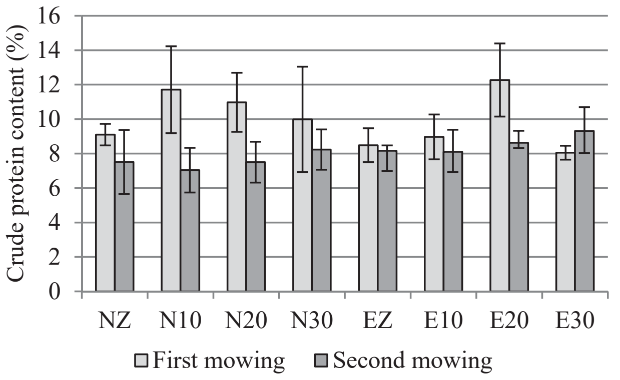

Fig. 3 The average crude protein content of the treatments

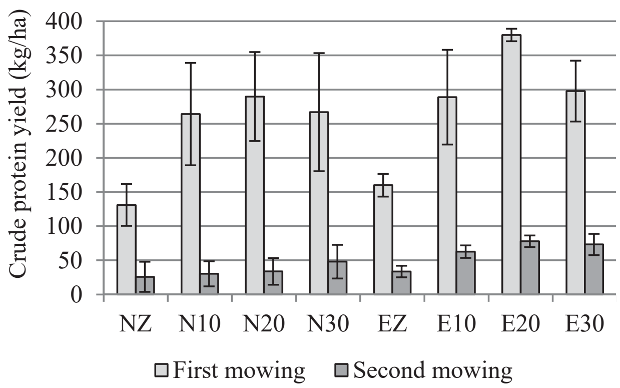

Fig. 4 The average crude protein yield of the treatments

Considering the fact that the higher DM yield does not mean higher quality, it was necessary to demonstrate the effectiveness of the composts on crude protein yield (kg/ha). The protein is one of the most important macronutrients, this way the amount of harvestable protein per unit area is of key importance for livestock farming.

Due to the relatively big standard deviations the differences between the 10-20-30 t/ha rates cannot be considered as significant differences (Fig. 4). The only exception was the E20 which is the best treatment based on the crude protein yield per hectare (379.83 kg/ha in first cut). Other treatments as the N20 (289.77 kg/ha) E10 (288.83 kg/ha) and E30 (297.8 kg/ha) essentially produced the same yield for the first cut.

All the treated plots produced more protein than the control plots. NZ produced 131 kg/ha crude protein, and EZ produced 159.95 kg/ha. It means that with compost application we could produce more than double of the control plots' crude protein yield.

IV. Discussion

The two composts, which are officially authorized and therefore are allowed to be applied in organic farming, in Agri-environment Schemes and Natura 2000 programs seem good fertilizers for increasing the yields of natural grasslands under unfavorable conditions. The application of these composts on farms can be considered as sustainable farming practice.

Bearing in mind the importance of crude protein yield per hectare, the E20 treatment was the most effective. In a farm where the offspring and growing animals are fed with the forage harvested from the treated grassland, the E20 treatment would be the most beneficial, because this treatment could meet the demands of animals. But in a farm where the forage is fed for adult and not producing animals (e.g. non-pregnant ewes, dry cows) the E30 would be the best choice, with its highest DM yield.

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