Original Paper

Effect of different mowing intensities on phytomass production of permanent grassland in a warm and an arid region

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The aim of the work was to analyse the impact of different intensities of grassland exploitation on the productive capacity in the context of declining livestock numbers and the need for temporary or permanent extensification. The research was carried out in 2017–2020 in the locality of Žirany in the Nitra district, located in the temperate zone at the boundary between the continental and Atlantic-continental regions. Average annual temperatures are around 9 °C. The original semi-natural vegetation has been used for sheep grazing for many years. There were 8 experimental variants of use/cutting with different intensity of exploitation: var. 1 – abandoned unused, var. 2 – 3× per year, var. 3 – 2× per year, var. 4 – 1× per year, var. 5 – 4× – 3× – 2× – 2× – 1× per year, var. 6 – 1× – 2× – 3× – 4× per year, var. 7 – 3× – 1× – 1× – 3× and var. 8 – 2× – 1× – 1× – 1× – 2×. By comparing the sum of yields for the entire 4-year annual cycle, we concluded that, with the exception of the 1× annually mowed variant, all the others differentiated themselves from the abandoned stand by their increased production capacity. We also observed differentiation between fertilized and exploited variants into groups. The stand mowed 3 times annually (variant 2, 29.07 t/ha) was shown to be the most productive. The second group consisted of variants with production lower in the sum of 4 years by about 5 t/ha (3, 5, and 6). The same level of lower yield was then found on stands with temporarily reduced intensity of use (variants 7 and 8). In the effectiveness of applied nutrients on production growth, it was found that as the number of applications increased, nutrient use also increased. The average of the years in the overall assessment of the 4-year cycle showed the dynamics from the individual years and also confirmed the tendency of the highest nutrient use at a stable 3-cut use.

Keywords: grassland, dry matter production, different intensity of mowing, production efficiency of fertiliser

1 Introduction

Grassland covers 31–43 percent of the Earth´s terrestrial habitats offering a variety of critical ecosystem services including carbon storage, food, forage and biofuels, and opportunities for tourism and recreation (Hopkins et al., 2000; Gibson & Newman, 2019). Grasslands represent in several ways a special position in agricultural production areas and agricultural holdings. Their intensification process depends on the moisture, soil, and terrain conditions, which determine the productive capacity of the stands (Gliessman, 2015). Grasslands offer many environmental and economic advantages that put them at the heart of future sustainable ruminant production systems (Graux et al., 2020). Primary plant production, the conversion of sunlight energy and carbon into plant biomass, is a key ecosystem service provided by grassland (Borer et al., 2017). Grasslands are the main source of sustainable livelihoods for around one million people worldwide. In industrialized Europe, they form the basis for a strong ruminant livestock sector. They have a wide range of functions useful to humans (Schnyder et al., 2010). Ecosystem services of grasslands are increasingly promoted in particular their ability to reduce water pollution by nitrates (Cameron et al., 2013; Di & Cameron, 2002) and mitigate climate change by storing carbon in their soils (Paustian et al., 2016; Soussana et al., 2010). In addition, grasslands are a unique repository of biodiversity (Hopkins & Pinto, 1998; Gibson & Newman, 2019). Grasslands biodiversity also supports regulation functions that underpin production,

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including maintenance of soil stability and fertility, soil water retention supporting production through the dry season, or pollination of crops (Orford et al., 2016). Natural grassland biomes around the world have a rather variable species composition which is dominated by graminoids but also contains broadleaved herbs (forbs), generally, less than 10 percent are covered by trees in temperate zones, and 40 percent are covered by trees in tropical zones (Dixon et al., 2014). Biomes are defined as clusters of plant species that are characterized by the ecophysiological characteristics of the dominant species (Jones, 2019). Human interventions during the growing season act collectively as a system of pratotechnical systems, which are significantly reflected both in the floristic composition and in the production of vegetation (Čunderlík, 2020). At present, there is a growing demand for an increase in the intensity and overall recovery of agricultural production, which also presupposes an increased demand for bulk feed (Hanzes et al., 2015). The production capacity of permanent grassland in Slovakia lags far behind their potential possibilities and we can consider them the largest reserve of agricultural production in our country. This reserve consists mainly in reconciling the plant's requirements for agroclimatic environmental factors with the agro-climatic potential of the landscape (Repa et al., 2011). From a practical point of view, we are interested in the height and quality of cultivated and economically usable phytomass. This can be influenced by the appropriate intensity of use (Grzegorczyk & Grabowski, 2007; Dugátová et al., 2015). The aim of the work was to analyse the impact of different intensities of grassland exploitation on the productive capacity in the context of declining livestock numbers and the need for temporary or permanent extensification.

2 Material and methods

The research was carried out between 2017 and 2020 in the cadastral territory of the municipality of Žirany in the Nitra district on land managed by the University Agricultural Enterprise SPU, s. r. o. It represented a closed 4-year annual cycle.

Geographically, the site is characterized by the coordinates 48° 22′ 34.2 "N 18° 10′ 55.8 "E. The average altitude is 250 m above sea level (Municipality of Žirany, Economic and Social Development Programme 2014–2020).

The experimental area is located in the temperate zone at the interface between the continental and Atlantic-continental regions. Average annual temperatures are around 9 degrees Celsius and annual rainfall averages 600 mm. Table 1 shows the weather conditions over the period under consideration.

The soil substrate was formed on weathered limestones and quartzites, which gave rise to a predominant soil type of fluvisoil with a weakly acidic to acid soil reaction. The agrochemical parameters of the soil prior to the establishment of the experiment are given in Table 2.

Table 1 Weather patterns over the evaluated period (2017–2020)

Month	Average temperature (°C)				Precipitation amount (mm)			
	year				year			
	2017	2018	2019	2020	2017	2018	2019	2020
January	-7.3	2.4	-3.5	-0.4	3.7	27.8	54.8	10.4
February	2.2	-0.7	0.9	4.7	29.4	27.4	27.4	41.4
March	8.3	3.4	5.0	6.2	21.3	22.9	22.4	64.4
April	9.4	15.2	9.4	10.9	56.8	15.6	21.4	6.6
May	16.2	18.5	9.3	13.2	19.0	28.6	134.8	54.4
June	20.8	20.4	18.7	18.9	31.8	44.4	29.0	66.8
July	21.0	21.5	21.1	20.6	12.9	12.9	52.2	38.4
August	22.1	22.5	21.6	21.9	10.3	3.0	64.0	74.0
September	14.7	15.2	15.7	16.6	83.4	56.4	52.8	96.0
October	10.5	9.7	11.5	10.8	44.2	24.7	17.8	151.8
November	5.1	2.1	8.2	4.5	27.5	23.9	95.4	17.8
December	1.4	-1.6	2.7	3.4	80.2	57.6	53.4	47.4
Per year	10.4	10.7	10.1	10.9	420.5	345.2	625.4	669.4
Per vegetation	16.4	17.6	15.3	16.1	279.7	208.5	394.4	552.4

Source: internal records of the SPU University Agricultural Enterprise

Table 2 Agrochemical properties of the soil of the original site before the establishment of the experiment (2017)

N_{tot}	P	K	Ca	Na	Mg	C_{ox}	pH
mg/kg						%	
2457.84	27.73	192.49	1186.32	55.56	88.53	2.69	5.78

The permanent grassland where the experiment is being carried out has been used for sheep grazing for many years. It belongs to semi-natural grassland. There are various species of clover, herbs, and grasses. Clover plants are dominated by strawberry clover (*Trifolium fragiferum* L.) and white clover (*Trifolium repens* L.). Herbs are dominated by chicory (*Cichorium intybus* L.) and yarrow (*Achillea millefolium* L.). Grasses were dominated by perennial ryegrass (*Lolium perenne* L.) and meadow blue grass (*Poa pratensis* L.).

The field trial was set up in a block of four repetitions. The area of one experimental variant was 2 × 3 m (6 m^2). Seven variants with different mowing and fertilization intensities were monitored and compared with the production potential of the original but abandoned and unfertilized stand. Specifically:

Variant 1 – native, unfertilized, and unused stand, sampling for production was carried out at the time of seed ripening.

Group of variants used in the same way every year

Variant 2 – mowed 3 times (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 60 days after the first mowing, 3rd mowing 60 days after the second mowing). Fertilization: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).

Variant 3 – mowed twice (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 90 days after the first). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).

Variant 4 – mown 1× (1st mowing at the time of seed ripening). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).

Group of variants used within the cycle in a differentiated way

Variant 5

1. Year 1 – mowed 4 times (1st mowing at the time of stalking, 2nd mowing 45 days after the first mowing, 3rd mowing 45 days after the second mowing, 4th mowing 45 days after the third mowing). Fertilisation: N (120 kg/ha) – 80 kg/ha N in spring at the time of greening of vegetation, 40 kg/ha N after the first mowing, P (40 kg/ha), K (80 kg/ha).
2. Year 2 – mowed 3 times (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 60 days after the first mowing, 3rd mowing 60 days after the second mowing). Fertilization: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
3. Year 3 – mowed twice (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 90 days after the first). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
4. Year 4 – mown 1× (1st mowing at the time of seed ripening). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).

Variant 6

1. Year 1 – mown 1× (1st mowing at the time of seed ripening). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
2. Year 2 – mowed twice (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 90 days after the first). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
3. Year 3 – mowed 3 times (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 60 days after the first mowing, 3rd mowing 60 days after the second mowing). Fertilization: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
4. Year 4 – mowed 4 times (1st mowing at the time of stalking, 2nd mowing 45 days after the first mowing, 3rd mowing 45 days after the second mowing, 4th mowing 45 days after the third mowing). Fertilisation: N (120 kg/ha) – 80 kg/ha N in spring at the time of greening of vegetation, 40 kg/haN after the first mowing, P (40 kg/ha), K (80 kg/ha).

Variant 7

1. Year 1 – mowed 3 times (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 60 days after the first mowing, 3rd mowing 60 days after the second mowing). Fertilization: N (60 kg/ha) – full

dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).

2. Year 2 – mown 1× (1st mowing at the time of seed ripening). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
3. Year 3 – mown 1× (1st mowing at the time of seed ripening). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
4. Year 4 – mowed 3 times (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 60 days after the first mowing, 3rd mowing 60 days after the second mowing). Fertilization: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).

Variant 8

1. Year 1 – mowed twice (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 90 days after the first). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
2. Year 2 – mown 1× (1st mowing at the time of seed ripening). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
3. Year 3 – mown 1× (1st mowing at the time of seed ripening). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).
4. Year 4 – mowed twice (1st mowing at hay maturity – from booting to beginning of flowering, 2nd mowing 90 days after the first). Fertilisation: N (60 kg/ha) – full dose in spring at the time of greening of vegetation, P (40 kg/ha), K (80 kg/ha).

Nitrogen was fertilised in the form of ammonium liniment with dolomite (27% N) on the dates indicated for each variant. Phosphorus was applied in the form of granular superphosphate (8% P) in the spring at the time of greening of the vegetation, potassium in the same way in the form of potassium sulphate (50% K_2O) in the spring at the time of greening of the vegetation in the whole dose.

Determination of primary production from the mowed variants was based on determining the weight of green matter from the harvested area (6 m^2). To calculate the annual dry matter yield on the abandoned unused variant (Variant 1), the mass from 1 m^2 was taken in each repetition. Green matter samples (0.50 kg) taken from each variant were mixed after drying and grinding. Average samples were taken from the plant material and thus prepared to determine the dry matter content (drying at 105 °C to constant weight).

The production efficiency (PE) we calculated from the formula:

PE = (yield of fertilized crop – yield of unfertilized crop)/ NPK rate (kg/kg)

Soil sampling was carried out at the beginning of the observations, before the experiment was established, always in autumn after the end of the growing season from a depth of 0–0.15 m. The following chemical determinations were made from the samples collected:

- N_{tot} – modified Kjeldahl method.
- P – spectrophotometrically by phosphomolybdenum method from leachate according to Melich 3.
- Mg – spectrophotometrically with titanium yellow from leachate according to Mehlich 3.
- K, Ca, Na – by flametric method from Mehlich 3 leachate.
- pH – exchangeable in KCl.
- C_{ox} – according to Tjurin as modified by Nikitin (1972).

The obtained data were statistically evaluated in STATISTICA Cz, version 10 (www.statsoft.com) using one-factor analysis of variance (ANOVA) with verification of the significance of differences by Fisher's LSD test at the 95% probability level (P = 0.05).

3 Results and discussion

The magnitude of primary aboveground phytomass production is the result of photosynthetic activity of the leaf area of a stand over a period of time, interacting not only with site conditions (soil, moisture, temperature) but also with interrelationships among plants in the stand (Hopkins et al., 1990; Gibson, 2009). Closely related to these determinants of production is another of the critical factors on which aboveground biomass yield depends, namely frequency of use (Pearson & Ison, 1987; Marriott et al., 2004) and nutrition and fertilization (Hanzes et al., 2004). Smith & Jones (1991) state that the effect of timing or frequency of mowing on grassland can sometimes be overlaid by fertilizer application.

The evolution of dry matter production of aboveground phytomass on the different variants affected by the different intensities of use, and the level of nutrition adapted to it, can be seen in Table 3.

In the first year of the experiment (2017), we observed a partial differentiation in yields of the different variants. In the 1st cutting, the production values were relatively even, with the lowest (1.99 t/ha) found on variant 5, which was cut 4 times and the date of use was earlier. The other mowing's were on variants that were mowed more than once (variant 2 – 3×, variant 3 – 2×, variant 5 – 4×, variant 7 – 3×, and variant 8 – 2×) were characterized by very low production, which did not exceed the level of 1.06 t/ha (variant 5, 2nd mowing). In the summation of the whole year, after the application of mowing of different intensities, we observed differences at the borderline of demonstrability, with the lowest production on variant 6, mowed 1× (2.4 t/ha). The yield was only slightly higher on the abandoned stand. The highest production was on variants 7 (3.95 t/ha) and 8 (4.25 t/ha). The results were higher, but inconclusive, compared to variants 2 (mown 3×) and 3 (mown 2×).

A characteristic feature of the 2nd year of the experiment (2018) was a very even low of production in the 1st cutting, ranging from 3.55 t/ha (variant 2, mowed 3 times annually) to 4.06 t/ha (variants 3 and 4, mowed 2 and 1 times annually, respectively). A slightly lower yield was also presented by variant 8 (2.97 t/ha, mowed 1× in 2018). The number of mowing's was a major factor in the total production from all uses, and all variants with 3 (variants 2 and 5) and 2 (variants 3 and 6) mowing's had demonstrably higher production withstands mowed only 1× (variants 1, 4, 7 and 8). We also found differences in the year-on-year comparison, where we observed more than 2-fold higher production in the multi-cropped stands, demonstrably higher (Table 4) with 2017. A limiting factor may have been the higher proportion of low grasses in the original stand, which limited further increases in production in Year 1 of the

Table 3 Dry matter yield (t/ha)

Cut	Variants							
	VAR 1	VAR 2	VAR 3	VAR 4	VAR 5	VAR 6	VAR 7	VAR 8
Year 2017 (p = 0.081413)								
1.	2.77	3.06	2.77	3.74	1.99	2.40	3.11	3.31
2.	–	0.31	0.75	–	1.06	–	0.44	0.94
3.	–	0.22	–	–	0.30	–	0.40	–
4.	–	–	–	–	0.17	–	–	–
Σ	2.77^{ac}	3.58^{abc}	3.52^{abc}	3.74^{ab}	3.52^{abc}	2.40^{c}	3.95^{ab}	4.25^{b}
Year 2018 (p = 0.000000)								
1.	3.70	3.56	4.06	4.06	4.04	4.02	4.09	2.97
2.	–	2.44	3.07	–	2.34	3.43	–	–
3.	–	2.38	–	–	2.33	–	–	–
4.	–	–	–	–	–	–	–	–
Σ	3.70^{a}	8.38^{bc}	7.71^{b}	4.06^{a}	8.71^{c}	7.45^{bc}	4.09^{a}	2.97^{a}
Year 2019 (p = 0.000010)								
1.	3.45	4.38	3.99	4.67	4.73	3.87	3.91	4.71
2.	–	2.22	2.53	–	3.20	2.10	–	–
3.	–	3.01	–	–	–	2.15	–	–
4.	–	–	–	–	–	–	–	–
Σ	3.45^{a}	9.61^{d}	6.52^{bc}	4.67^{ab}	7.92^{cd}	8.12^{cd}	3.91^{a}	4.68^{ab}
Year 2020 (p = 0.000058)								
1.	3.60	3.36	2.42	4.22	4.71	1.23	3.00	2.87
2.	–	2.90	3.79	–	–	2.92	3.87	4.25
3.	–	1.23	–	–	–	1.39	0.96	–
4.	–	–	–	–	–	0.49	–	–
Σ	3.60^{c}	7.49^{ab}	6.21^{abd}	4.22^{c}	4.71^{cd}	6.03^{ad}	7.83^{b}	7.12^{ab}
Σ crop yields 2017–2020 (p = 0.000002)	13.52^{e}	29.07^{f}	23.38^{bcd}	16.69^{ae}	24.87^{df}	24.00^{cd}	19.78^{abc}	19.05^{ab}

Different indices indicate significant differences in the row (Fisher's LSD test, α = 0. 05); VAR 1 – unfertilized and unused vegetation, VAR 2 – mowed annually 3×, VAR 3 – mowed annually 2×, VAR 4 – mowed annually 1×, VAR 5 – mowed with years 4× – 3× – 2× – 1×, VAR 6 – mowed with years 1× – 2× – 3× – 4×, VAR 7 – mowed with years 3× – 1× – 1× – 3×, VAR 8 – mowed with years 2× – 1× – 1× – 3×; p – significance

Table 4 Effect of year on yield (t/ha)

Year	Production (t/ha)
2017	3.47[b]
2018	5.68[a]
2019	6.11[a]
2020	5.90[a]

Fisher's LSD test, α = 0.05, p = 0.000000

experiment (*Lolium perenne* L. and *Poa pratensis* L.). Later on, the botanical composition gradually adapted by increasing the representation of more productive species (*Arrhenatherum elatius* L. and *Alopecurus pratensis* L.), which allowed a further increase in yields. Similar conclusions were reached by Jančovič et al. (2004), who found the maximum production of a stand dominated by *Festuca rubra* L. to be 5 t/ha despite a dose of 240 kg/ha N.

In the results of the third year of the experiment (2019), we found similar trends as in 2018. Only variant 3 stood out from this framework, where we observed lower yields compared to the most productive variants, by about 1.5–3 t/ha, but higher yields compared to the mono-crop or abandoned variants to the same extent. Again, this was mainly due to the production from the 2nd and 3rd cut, respectively.

In the last year of monitoring (2020), we observed significant differences in yields already in the first mowing, when, especially on variant 6 (mowed 4 times in that year), the dry matter production of aboveground phytomass was only 1.23 t/ha. It was also interesting to note that, except for variant 2, we observed the highest yield in the year in the second cut. This is explained by the extreme drought in the period prior to the 1st cutting, when only 6 mm of rainfall in the month preceding the cutting, April (Table 1), and higher rainfall came only in the period after the 1st use. Frame (1992) reports that dry matter production in each cutting shows a familiar pattern: the first cutting has been shown to give the highest yield and the third cutting is usually the lowest, depending on weather conditions. Also, Vozár et al. (2003) found the opposite tendency and linked it to the uneven distribution of rainfall during the mowing season. Similarly, Gaborčík and Čunderlík (1996) explain this as a consequence of the redistribution of rainfall in the growing season.

In the total production for the whole year, variant 3, steadily mown 3 times a year (7.49 t/ha), was again one of the most productive stands. In this respect, we positively evaluate the rapid response to the supplied nutrients and the increased intensity of use on variants 7 (3 times mown) and 8 (2 times mown) after the previous two years without nitrogen fertilization and single-axle use. The mono-crop variants, despite the introduced nutrients, resembled the abandoned stand in terms of production.

By comparing the sum of yields over the entire 4th annual cycle, we concluded that, with the exception of the annually 1× mowed variant, all others differed from the abandoned stand by increased production capacity. We also observed differentiation between fertilized and exploited variants into groups. The stand mowed 3 times annually (variant 2, 29.07 t/ha) was shown to be the most productive. The second group consisted of variants with production lower in the sum of 4 years by about 5 t/ha (3, 5, and 6). The same level of lower yield was then found on stands with temporarily reduced intensity of use (variants 7 and 8). In contrast to our results, Kováčiková et al. (2012) found the highest production in stands mowed twice a year in an experiment with differentiated intensity of use.

From an economic point of view, a very important factor in the adequacy of fertilization is its efficiency, which is the increase in production per 1 kg of nutrients supplied. The calculated production efficiency of the supplied NPK nutrients over the whole study period is demonstrated in Table 5. The results show a low production efficiency in the first year of the experiment (2017), with a maximum of 8.22 kg/kg (variant 8). Even on variant 6, where production was lower than the control unused stand (variant 1), production efficiency was negative (-3.08 kg/kg). In the 2nd year of monitoring (2018), we observed a significant increase in the production efficiency of the

Table 5 Production efficiency of supplied nutrients (kg/kg)

Year	VAR 2	VAR 3	VAR 4	VAR 5	VAR 6	VAR 7	VAR 8
2017	4.56	4.17	5.39	3.13	-3.08	4.92	8.22
2018	26.00	19.06	2.00	20.88	20.83	3.25	-6.08
2019	34.22	17.06	6.78	24.89	19.46	3.83	10.50
2020	21.61	14.50	3.44	9.25	10.13	17.63	14.67
Average of years	21.60	13.69	4.40	14.53	11.83	7.41	6.83

VAR 2 – mowed annually 3×, VAR 3 – mowed annually 2×, VAR 4 – mowed annually 1×, VAR 5 – mowed with years 4× – 3× – 2× – 2× – 1×, VAR 6 – mowed with years 1× – 2× – 3× – 4×, VAR 7 – mowed with years 3× – 1× – 1× – 3×, VAR 8 – mowed with years 2× – 1× – 1× – 3×

applied fertilization. Mostly on the stand fertilized 3 times annually (variant 2, from 4.56 kg/kg to 26 kg/kg). Similarly, the efficiency of nutrients supplied also increased on the other multi-crop variants. On the contrary, it also declined in the mono-axial ones compared to the previous year 2017. Similar trends as in 2018 were also observed in 2019. On the stably 3-cut variant, the increased production efficiency of nutrients delivered continued to increase (from 26.00 kg/kg to 34.22 kg/kg). The other variants were comparable in results to the previous period. Interesting was the development of variant 8, where, despite temporarily reduced intensity of use but continued fertilization intensity, first the production efficiency fell to negative values in 2018 (-6.08 kg/kg) and then increased to 10.50 kg/kg in 2019. The year 2020 confirmed the trend of the previous period. Nutrient utilization also increased with an increasing number of uses. The only exception was variant 6, where despite the highest number of cuts, production efficiency decreased in the last year (from 19.46 kg/kg in 2019, 3 cuts, to 10.13 kg/kg in 2020, 4 cuts). The average of the years in the overall assessment of the 4th year cycle showed the dynamics from the individual years while confirming the trend of the highest nutrient use with stable 3-cut use and the same fertilization each year. In a differential nutrition experiment, Jančovič and Holúbek (1993) found higher dry matter gain per kg nutrient supplied on variants with periodic alternation of PK fertilization and nitrogen application, possibly equalized with variants fertilized annually with nitrogen, contradicting our findings. However, the above authors observed higher production efficiency with alternate N application compared to the variant fertilized annually with PK only.

4 Conclusions

In permanent grassland in warm lowland areas, the impact of different intensities of grassland exploitation on productive capacity was studied in the context of declining livestock numbers and the need for temporary or permanent extensification. The 4-year grassland experiment showed that, with the exception of the annually 1-cut variant, all others differed from the abandoned stand in terms of increased production capacity. We also observed differentiation between fertilized and exploited variants into groups. The stand mowed 3 times annually was shown to be the most productive. The second group consisted of variants with production lower in the sum of 4 years by about 5 t/ha (annually mowed 2×, VAR 4 – annually mowed 1×, VAR 5 – mowed with years 4× – 3× – 2× – 1×, VAR 6 – mowed with years 1× – 2× – 3× – 4×). We then found the same level of lower yields on stands with a temporarily reduced intensity of use.

In the effectiveness of applied nutrients on production growth, it was found that nutrient use increased with an increasing number of applications. The average of the years in the overall assessment of the 4-year cycle showed the dynamics from the individual years and also confirmed the tendency of the highest nutrient utilization at a stable 3-cut utilization.

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