# Study of *Trifolium angulatum* (Waldst. et. Kit.) phytomass in Karcag

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**Abstract:** Our studies were conducted at the Hungarian University of Agricultural and Life Sciences in Karcag, where in 2023, due to favourable precipitation and temperature conditions, we had the opportunity to study the phytomass yields of a massively reproducing annual *Trifolium* species in a saline soil condition. Yield measurements (green yield, hay yield, crude protein yield, dry matter yield) showed that in all cases higher yields were measured in the *Trifolium angulatum*-covered grassland than in the control grassland, and statistical analysis showed a close correlation in all cases. Through our studies, we aimed to provide new data on the specific floristic events in environmentally managed grassland in the Pannonian Basin from a farmer's perspective.

## Introduction

The short-lived clover fluctuation event is a floristic wonder of the Carpathian Basin's solonec salt meadows. This is essentially the mass emergence of annual, salt-tolerant, lime-avoiding *Trifolium* species (Matus, 2012), with up to 60-80% cover. Local farmers' saying this is a "meadow turmoil" (Vinczeffy, 1993). It also projects the emergence of a highly valuable ruminant fodder base, which has always been regarded as 'good fattening pasture' (Dorner 1923; Molnar & Csizi 2015).

According to Baskay-Toth (1962), *T. angulatum* is the most widespread and the most prolific annual Trifolium species that cause short-lived clover fluctuation. Since several species of short-lived clovers sometimes occur in the same area, we should mention the reversed clover (*T. retusum* L.), the upright clover (*T. strictum* L.), the slender hop clover (*T. micranthum* Viv.), the knotted clover (*T. striatum* L.) and the bird's-foot clover (*T. ornithopodioides* (L.) Sm.). In general, short-lived clovers are described by their ability to exploit the scarce water resources of extreme hard, saline soils, their very short growing season, flowering in mid-May and setting seed by June. They are also very sensitive to frost, and after a mild, rainy winter, a short-lived clover fluctuation can be expected; in the Pannonian flora, this phenomenon can occur every 3-4 years, according to Thaisz (1893), based on many years of observations. According to Molnar (2014), the mass emergence of *Trifolium* sp. is highly dependent on the weather, and under favorable climatic conditions abundant phytomass yields can be expected.

The periodicity of short-lived clover fluctuation can be overridden by climate change, phenomena that seem natural and constant can change and disappear. Elias

et al. (2020) published that the floristic treasures of Pannonian Basin might disappear due to reduced habitats and living conditions. This includes short-lived clovers. The cenological recording of *Trifolium angulatum* is a scientific event beyond the Carpathian Basin. Kessler reported (2014) about a *T. angulatum* habitat in the Loire region, and Tallon mentions (2014) *T. angulatum* recorded in Nimoise as a rare element of the French flora. Also noteworthy is Raabe's manuscript (2015) reporting the discovery of *T. angulatum* in north-eastern Burgenland, indicating that this plant species is not recorded in modern Austrian floristics. The westward spread of the species could be a separate research direction.

In the floristic monitoring of Hungary, *T. angulatum* is listed as an important character species in the associations dominated by *Festuca pseudovina* (Hack.) (Penksza et al 1999; Herczeg et al. 2006). For this reason, it is also essential that *T. angulatum* is present in the seed bank of natural grassland soils (Tóth et al. 2022) and in high biodiversity grass seed mixtures (Valkó et al. 2016). Diaz and Csizi (2019) achieved a significant increase in *T. angulatum* cover with 20 t/ha of composted sheep manure applied to extensive grassland.

The objective of our manuscript is to refine the quantitative and qualitative data on the phytomass yield resulting from the mass emergence (short-lived clover fluctuation) of *Trifolium angulatum* in the habitat and in this particular season we studied.

## Materials and Methods

The trial was carried out at the research site in MATE Nagykunsági Tájtermesztési Ltd. (Cataster No-01712), where a typical "short-lived clover fluctuation" (Figure 1.) occurred in spring 2023. The control area is situated at the same field.

Both the area affected by the short-lived clover fluctuation and the control area is *Achilleo-Festucetum pseudovinae* (Soó (1933) 1947 corr. Borhidi 1996)) association, with an elevation of 91-92 m. The soil type is medium meadow solonyec (Table 1). Basic soil analysis was carried out by the accredited laboratory of the MATE Research Institute in Karcag in 2022.

*Figure 1. Trifolium angulatum* with clipping frame (Photo by Krisztina Varga)

*Table 1.* Soil characteristics results for the study area (Karcag, 2022)

| Parameter | Unit | Value |
|---|---|---|
| pH (KCl) | | 4,475 |
| Soil plasticity of Arany ($K_A$) | | 44 |
| Total water soluble salts | (m/m)% | 0,03 |
| Carbonic acid. Lime | (m/m)% | 0,05 |
| Humus | (m/m)% | 3,975 |
| (Nitrate+nitrite)-N | mg/kg | 2,325 |
| Phosphorus pentoxide | mg/kg | 84,5 |
| Potassium oxide | mg/kg | 309,25 |
| Sodium | mg/kg | 569,5 |
| Magnesium | mg/kg | 533 |
| Sulphate sulphur | mg/kg | 14,175 |
| Zinc | mg/kg | 3,75 |
| Copper | mg/kg | 10,5 |
| Manganese | mg/kg | 324,25 |

The 50-year average precipitation of the area is 503 mm. Monthly precipitation and temperature data were provided by the meteorological station of the National Meteorological Service at the Karcag Research Institute (Table 2). Vinczeffy (1993) categorized the nature of the seasons, specifying that the optimum climate index is 0.200-0.250 mm/°C. The climate index by month was established on the basis of his calculations and then the nature of the months was classified into the categories he provided (Table 2). The following formula was used to determine the climate index of the months:

$$Climate\ index\ \left(\frac{mm}{°C}\right) = \frac{Monthly\ precipitation\ sum\ (mm)}{Monthly\ mean\ temperature\ (°C)\ \times number\ of\ days\ of\ the\ month}$$

Table 2. shows that the temperature and precipitation conditions in November-December 2022 and January 2023 created the conditions for a perfect short-lived clover fluctuation season.

*Table 2.* Climatic data of the experiment (Karcag October 2022 - May 2023)

| Month | Monthly mean temperature (°C) | Monthly precipitation sum (mm) | Climate index (mm/°C) | Type of Month |
|---|---|---|---|---|
| 2022. October | 12,54 | 2,8 | 0,007 | desert |
| 2022. November | 6,48 | 36,9 | 0,190 | mesic |
| 2022. December | 2,46 | 81,1 | 1,063 | heavy rain |
| 2023. January | 4,30 | 60,1 | 0,451 | heavy rain |
| 2023. February | 2,60 | 6,8 | 0,093 | drought |
| 2023. March | 7,40 | 34,5 | 0,150 | slightly dry |
| 2023. April | 9,50 | 39,7 | 0,139 | slightly dry |
| 2023. May | 16,54 | 49,9 | 0,097 | drought |

In our study, we compared the vegetation structure of the short-lived clover fluctuation area with that of a saltmarsh grassland with the same growing conditions. In the study area, the plant population was measured using the Balázs quadrat method (1949). In the experiment, the phytomass was clipped at 8-8 random, representative sampling points, covering an area of 1-1 square metre, with a 5 cm residual height, and the green mass and hay yields (kg/ha) of the plots were determined. Plant samples from the plots were analysed at the MATE accredited ÖVKI Environmental Analytical Laboratory (plant analysis report number: n0889-n0928-2023), from which dry matter yield and crude protein yield (kg/ha) were calculated.

The data were recorded in Microsoft® Excel. Descriptive statistics and one-point analysis of variance were used to evaluate the data. P values at 95% significance level were used to evaluate the results.

# Results

## Phytocoenological monitoring

The cover of the different plant species was assessed in the grassland area under study and the average values are shown in Table 3. First of all, we would like to emphasise that *Trifolium angulatum* had a significant cover value in the control area, but we considered as a guideline the finding of Baskay-Tóth (1962) that a cover of around 80% is typical for short-lived clovers during mass emergence. No uncovered patches were observed in any of the areas. We recorded 8 plant species in the control grassland and only 5 plant species in the short-lived clover grassland. In the control area we recorded *Festuca rupicola* (Heuff.), *Plantago lanceolata* (L.), *Vicia tetrasperma* ((L.) Schreb.) with low cover, while in the short-lived clover grassland we did not find any of them.

In both surveyed areas, we observed a high piling of *Trifolium angulatum*. On average, the cover ranged from 31.28 to 62.50% in the control grassland, while in the short-lived clover grassland it ranged from 81.28 to 87.50%. This high percentage of cover was 66.28% higher in the short-lived clover grassland area compared to the control site. By variance analysis, it was found that cover was higher in the short-lived clover grassland area (p-value: 9.36E-07).

*Festuca pseudovina*, as the dominant plant species in the area, showed moderate cover values in both areas. The cover ranged from 1.56-18.75% in the control grassland area and only 1.56-3.13% in the short-lived clover grassland area (p-value: 0.0003).

The cover of *Alopecurus pratensis* (L.) was 15.63-50% in the control grassland area and 74.99% in the short-lived clover grassland area (p-value: 0.001).

The cover of *Poa pratensis* (L.) was similar in both areas, with cover values ranging from 1.56-9.38% (p-value: 0.61).

*Podospermum canum* (C.A. Mey.) cover was also low in both areas. Cover values ranged from 0-9.38% in the control grassland and from 1.56-6.25% in the short-lived clover grassland (p-value: 0.10).

*Table 3.* Average vegetation cover of the study areas (Karcag, 2023)

| **Average cover (%)** | **Control field** | **Short-lived clover (*Trifolium angulatum*)** |
|---|---|---|
| *Alopecurus pratensis* | 23,44 | 5,86 |
| *Festuca pseudovina* | 12,11 | 2,15 |
| *Festuca rupicola* | 2,15 | 0,00 |
| *Plantago lanceolata* | 0,78 | 0,00 |
| *Poa pratensis* | 5,27 | 4,49 |
| *Podospermum canum* | 4,88 | 2,74 |
| *Trifolium angulatum* | 50,98 | 84,76 |
| *Vicia tetrasperma* | 0,39 | 0,00 |

**Results of Yield measurement**

Four types of yield indicators were tested in our experiment: green yield, hay yield, crude protein yield, dry matter yield, the average values of which are illustrated in Figures 2-5. The measurements showed that in all cases, higher yields were measured in the short-lived clover fluctuation grassland than in the control grassland.

The green yields for the samples taken from the short-lived clover fluctuation area were between 21 600 and 26 000 kg/ha, while for the control grassland the yields were between 7 113 and 21 107 kg/ha. On average, the green yields of the short-lived clover fluctuation grassland samples were 58.64% higher than those of the control grassland samples. Statistical analysis of variance showed a strong correlation (p-value 7.10E-07).

For the short-lived clover fluctuation grassland, the hay yield was 5 600-9 200 kg/ha, while for the control grassland it was 2 312-6 489 kg/ha. Thus, the average hay yield of the short-lived clover fluctuation grassland was 55.58% higher than that of the control grassland. Statistical analysis of variance showed a strong correlation (p-value: 2.25E-06).

The crude protein yield was 12.56-21.00 kg/ha for the short-lived clover fluctuation grassland and 3.31-11.81 kg/ha for the control grassland. The average crude protein yield of the short-lived clover fluctuation grassland was 42.87% higher than that of the control grassland. Statistical analysis of variance showed a strong correlation (p-value: 4.72E-05).

Dry matter yields of 6,363.64-10,747.66 kg/ha were measured for the short-lived clover fluctuation grassland, while for the control grassland the yields were 2615.2-7290.57 kg/ha. On average, the dry matter yield of the short-lived clover fluctuation grassland was 56.03% higher than that of the control grassland. Statistical analysis of variance showed a strong correlation (p-value: 2.10E-06).

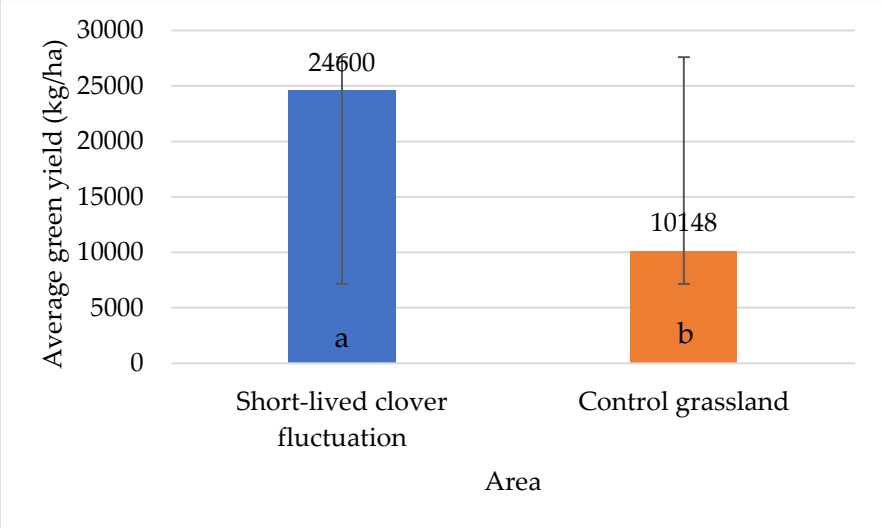


*Figure 2.* Average green yield in the surveyed grassland area (Karcag, 2023).
Note: a: significant, b: not significant

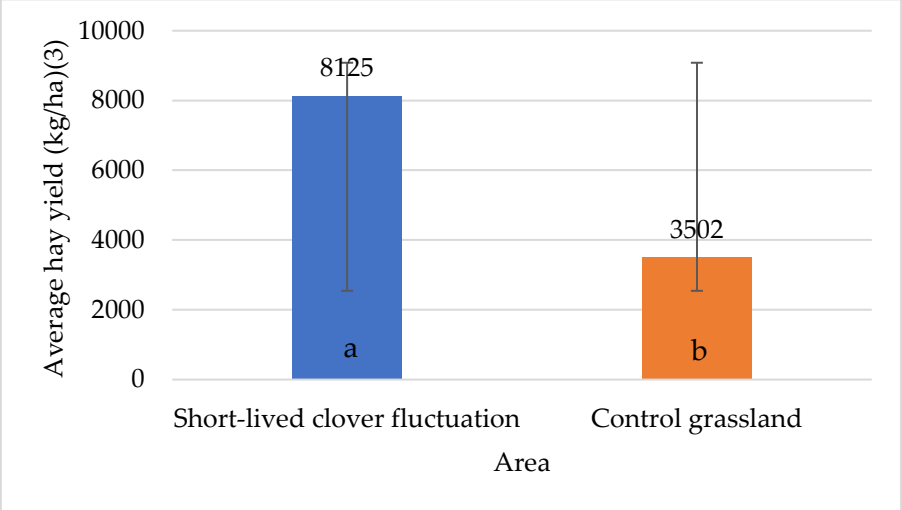


*Figure 3.* Average hay yield in the surveyed grassland area (Karcag, 2023)
Note: a: significant, b: not significant

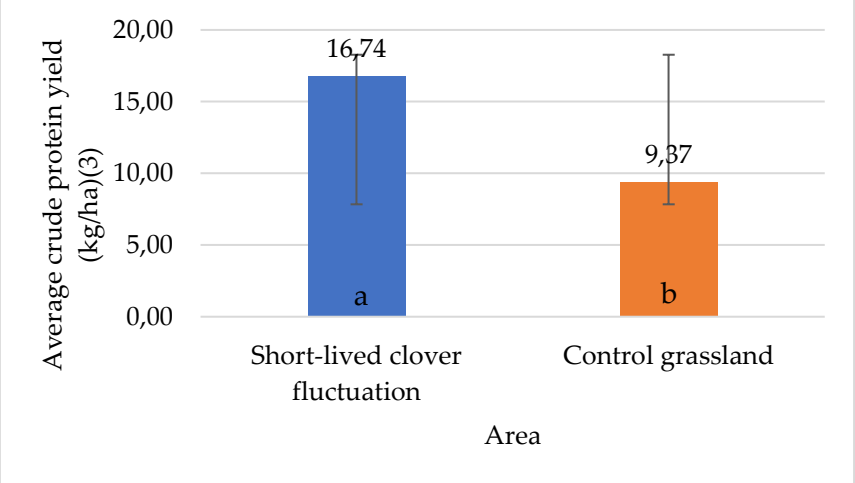


*Figure 4.* Average crude protein yield in the surveyed grassland area (Karcag, 2023)
Note: a: significant, b: not significant

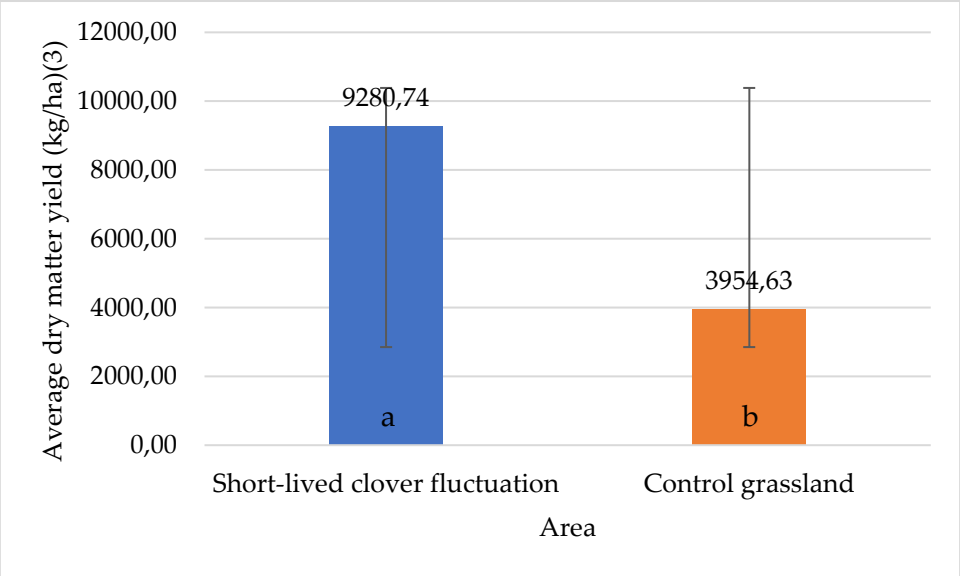


*Figure 5.* Average dry matter yield in the surveyed grassland area (Karcag, 2023)
Note: a: significant, b: not significant

## Discussion

Our studies clearly showed that the mass emergence of *Trifolium angulatum* in the plant structure of the *Achilleo-Festucetum pseudovinae* grass association resulted in a verified increase in all yield indicators tested.

In judging our results, however, it should be taken into account that in the case of grasslands with Solonyec soil conditions, the traditional four-yearly (Thaisz 1893, Baskay-Tóth 1962) brome borealis may be a memory of the past. We have observed over many years that although annual sturgeon species develop after a mild, wet winter, their development stalls in the early spring drought, and their stem height does not reach the minimum mowing height.

The browse is nature's gift to extensive grassland farmers, who have access to high quality fibre fodder and, thanks to the preserved phytomass, buffering potential for leaner years (Csizi & Monori 2012).

The seed supply of the so-called hard-seeded annual *Trifolium* species in the upper layer of the grassland has the potential to create a browse-induced browse through possible input inputs to extensive grassland (nutrient recycling, irrigation) (Diaz & Csizi 2019).

## Conclusion

For farmers on extensive grassland with poor conditions, meeting the fibre feed needs of their ruminant livestock is a constant challenge. The anomalies of climate change, combined with the strict limits of environmental subsidies, clearly make it even more

difficult to collect the necessary fodder base. The exploitation of the site-specific floristic phenomenon of the natural grasslands of the Solonyec soil, the bryophyte, is a key task from an economic point of view. On the other hand, a research perspective could be to study the echinoderm as thoroughly as possible, to explore its induction potential and to compare the yields of *Trifolium* species causing this fluctuation.

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# Bodorkajárás (*Trifolium angulatum* (Waldst. et. Kit.)) fitomassza vizsgálata Karcagon

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**Kulcsszavak:** rövid életű lóhere; extenzív gyepterületek; zöldtermés; szárazanyaghozam; fehérje

**Összefoglaló:** Vizsgálatainkat a Magyar Agrár- és Élettudományi Egyetem karcagi gyepterületein végeztük, ahol 2023-ban, a kedvező csapadék és hőmérsékleti viszonyok hatására, alkalmunk nyílt egy tömegesen felszaporodó egyéves Trifolium fajú, szikes talajadottságú gyepasszociáció fitomassza hozamainak tanulmányozására. A hozammérések (zöldhozam, szénahozam, nyersfehérjehozam, szárazanyaghozam) során megállapítottuk, hogy minden esetben nagyobb hozamokat mértünk a *Trifolium angulatum* borította gyepnél, mint a kontroll gyepnél, a statisztikai elemzés minden esetben szoros összefüggést mutatott. Vizsgálataink révén újabb adatokat szándékoztunk szolgáltatni a Pannon-medence környezetbarát módon hasznosított gyepein jelentkező, különleges florisztikai történésről, gazdálkodói szemszögből.