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Short communication

Impact of various moisture regime on selected growth-production characteristics of *Medicago sativa* L. and *Trifolium pratense* L.

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The aim of the experiment was to find out the impact of different moisture regime on selected indicators of the growth and production process of *Medicago sativa* L. cv. Zuzana and *Trifolium pratense* L. cv. Poľana. The pot experiment was carried out at the Department of Grassland Ecosystems and Forage Crops, FAFR SUA in Nitra in 2015. There were evaluated two treatments of irrigation: 1st – irrigation once a week and 2nd – irrigation twice a week with a single dose of 300 ml of water per pot. The results of the experiment showed a positive effect on the height of *Medicago sativa* L. and *Trifolium pratense* L. plants ($p = 0.006$ and $p = 0.316$), the number of stems ($p = 0.001$ and $p = 0.002$), dry phytomass production ($p = 0.016$ and $p = 0.154$) and the quantity of harvest residues of evaluated legume forages ($p = 0.100$ and $p = 0.146$) with a general more visible effect under irrigation twice a week. By comparison of both species, irrigation twice a week was more effective for *Medicago sativa* L. on plant height, number of stems and weight of above-ground phytomass, whereas for *Trifolium pratense* L. only on the weight of harvest residues compared to irrigation once a week.

Keywords: legume forages, growth, production, water deficit

1 Introduction

The amount of available water and the temperature are determined not only for the maximum length of the growing season, but also for the growing spectrum of crops and their final harvest. In growing areas with permanent or periodically occurring drought has water stress becomes an important external factor limiting the effective implementation of plant production. The water deficit itself greatly limits the physiological activity of the plants and with it the associated phytomass formation (Krivosudská and Filová, 2016). Although it is predominantly dependent on meteorological conditions, it is also related to the tolerance and resistance properties of plants to drought (Brestič and Olšovská, 2001). According to several authors (Lichner et al., 1983; Gejguš et al., 1998; Skládanka et al., 2014) are diverse the requirements of legumes for habitat conditions and specified on either with the strong emphasis on the soil or moisture conditions.

Medicago sativa L., the most important leguminous with a beneficial protein composition (Bíro et al. 2006), feels a lack of moisture especially in the early stages of development (Porvaz, 2001). *Medicago sativa* L. drought resistance is quite strong, though not typical signs of dry-loving plants and consumes twice as much water than cereals and about a one third more than *Trifolium pratense* L. (Procházka, 2003). Its transpiration coefficient is in the range 500–900, in dry and warm areas up to 1,600–1,900 (Holúbek et al., 2007). As a result, the yield of *Medicago sativa* L. is very variable and, in general, hay production varies from 3–4 to 10–15 t/ha (Říha, 2009). *Trifolium pratense* L., which approximates by a nutrient content to the nutritional value of a *Medicago sativa* L. (Gálik et al., 2011), requires more humid conditions and needs approximately 500–700 litres of water to produce 1 kg of dry matter. The increased need for water mainly occurs in the period after 1st cut (Abberton and Marshall, 2005).

The aim of the experiment was to find out the impact of the various moisture regimes on the selected growth

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and production characteristics of *Medicago sativa* L. and *Trifolium pratense* L.

2 Material and methods

Pot experiment, realized at the Department of Grassland Ecosystems and Forage Crops of FAFR SUA in Nitra, was established on 21 April 2015 by sowing seeds of *Medicago sativa* L. cv. Zuzana and *Trifolium pratense* L. cv. Poľana into rooting pot. After 5 weeks from sowing (26 May 2015), the emerged plants were torn by to the final number of 5 plants per container. Planting of plants from rooting pots into containers with volume 5 dm^3 (in 3 replicates) took place on 3 June 2015. The chemical composition of the used soil (universal gardening substrate made from a mixture of quality peat, mineral combined fertilizer with trace elements and finely ground dolomitic limestone, the content of combustible substances min. 35%, electrical conductivity max. 1.0 mS/cm, and particles above 10 mm max. 5%) is documented in Table 1. Additional fertilization was not realised. After planting, the plants were irrigated with 300 ml of water per container once a week (on Monday – "Irrigation 1-time") and twice a week (on Monday and Thursday – "Irrigation 2-times") without the possibility of water getting from atmospheric precipitation (rain). Average daily temperatures (°C) during growing season in year 2015 are presented in Table 2.

The measurements and samplings were determined by the "beginning of plant flowering" phenophase. Then, the first measurement and sampling of the phytomass were carried out on 29 July 2015, the second measurement and sampling were approximately 2 months later (on 1 October 2015). In the above-mentioned terms, the height of the plants was measured at each replication, and then the crop was sheared by a scissors at a height of 50 mm.

The harvested phytomass was used to determine the yield in g/m^2. After shearing of above ground phytomass, the number of stems was determined in each container, with subsequent conversion to pieces (pcs) per/m^2.

At the end of the experiment (after the 2nd measurement and shearing), the containers were placed in a drier to kill the plants. Subsequently, the stubble was separated and the roots cleaned from the soil. After drying, their weight – expressed as post-harvest residues in g/m^2 – was determined.

Data were statistically evaluated in STATISTICA 7.1 Complete CZ (StatSoft Inc. 2005) using one-way analysis of variance (ANOVA). To assess differences between variants was used the Fischer´s LSD test at $P \leq 0.05$.

3 Results and discussion

The average height of *Medicago sativa* L. and *Trifolium pratense* L. plants in the individual harvests at the determined level of irrigation is presented in Figure 1. We can state the significant influence of irrigation ($p = 0.006$) on the plants height of *Medicago sativa* L. and insignificant influence of irrigation ($p = 0.316$) on *Trifolium pratense* L. height on the basis of the found values. At irrigation once a week, the plants were on average about 141 mm (*Medicago sativa* L.) and 46 mm (*Trifolium pratense* L.) lower compared with irrigation twice a week. Similarly, there were also differences between cuts, whereas under the conditions of 1 irrigation dose per week (irrigation 1-time) were minimal the differences in the height of the *Medicago sativa* L. plants (16 mm) in favour of the 1st cut. The higher plants were characteristic in the 2nd cut

Table 1 Agrochemical composition of soil used in experiment

N_t	P*	K*	Mg*	Ca*	Na*	C_{ox}	pH
mg/kg						g/kg	
4,067.07	71.53	538.78	716.29	6,720.00	556.52	44.10	6.70

* Content of pure nutrients; used analytical methods: N_t – Kjeldahl method, P, Mg – spectrophotometry, K, Ca, Na – atomic emission spectrometry, C_{ox} – determined by the wet combustion Tyurin method in modification by Nikitin, pH – exchangeable in 1 M KCl

Table 2 Average daily temperatures (°C) during growing season in year 2015

Day	Month							
	III	IV	V	VI	VII	VIII	IX	X
1–10	4.0	6.1	15.8	21.7	24.1	25.3	17.8	13.3
11–20	5.9	10.6	14.4	17.9	22.2	21.4	18.6	8.5
21–31	8.3	11.8	13.9	16.2	22.6	21.3	13.1	8.9
1–31	6.3	10.4	15.1	19.9	23.6	23.5	17.5	10.5

Source: Bulletin Meteorology and Climatology (2015); modified

for the *Trifolium pratense* L. (by 113 mm). Irrigation twice a week was likely to created more suitable conditions, especially for the growth of *Medicago sativa* L. stems. It was particularly visible in the second cut, when *Medicago sativa* L. was significantly higher (by 102 mm) compared to the 1st cut in this irrigation variant. Although *Trifolium pratense* L. is more demanding to moisture than *Medicago sativa* L. (Holúbek et al., 2007; Skládanka et al., 2014), to 2 irrigations per week reacted by increasing of height only in the 1st cut (by 92 mm compared to irrigation once a week). Possible reasons for this condition could be a more favourable temperature conditions for the *Trifolium pratense* L. in the period to the 1st cut. An optimum day temperature for *Trifolium pratense* L. is of

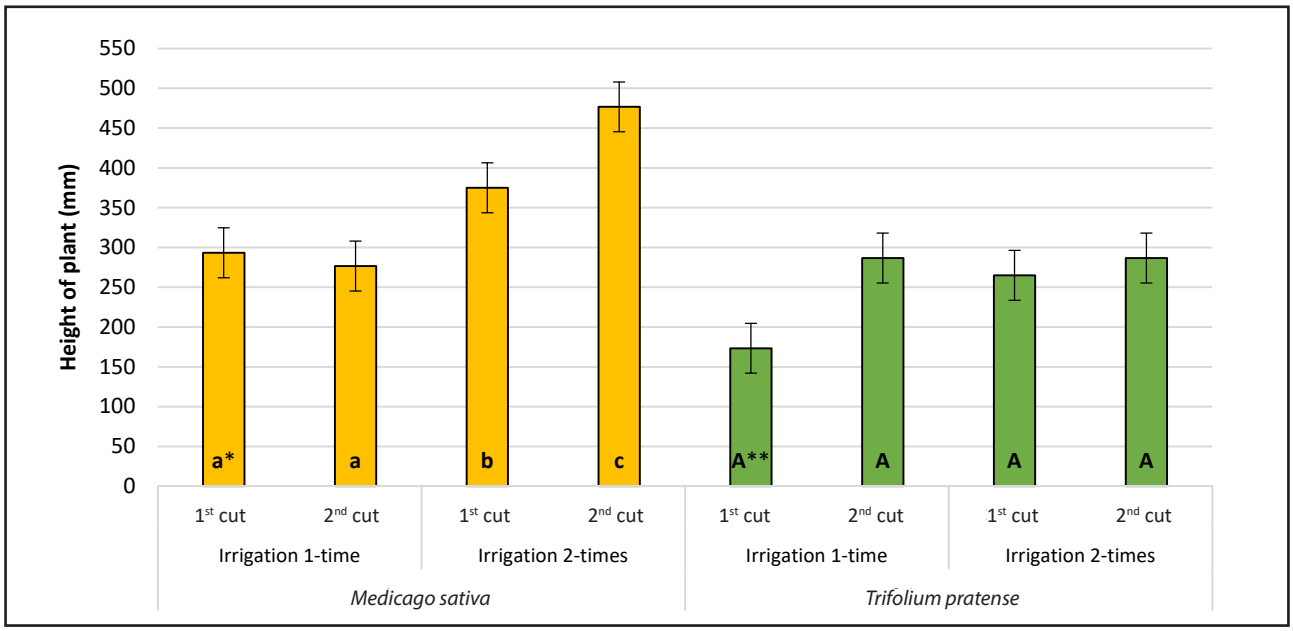

Figure 1 Average plant height (mm) of *Medicago sativa* L. and *Trifolium pratense* L. in cut at individual levels of irrigation
The different letters at an average values mean statistically significant difference (Fischer´s LSD test, $P \leq 0.05$) for *Medicago sativa* L. (*) and *Trifolium pratense* L. (**).The error bars in upper part of columns indicate standard deviation

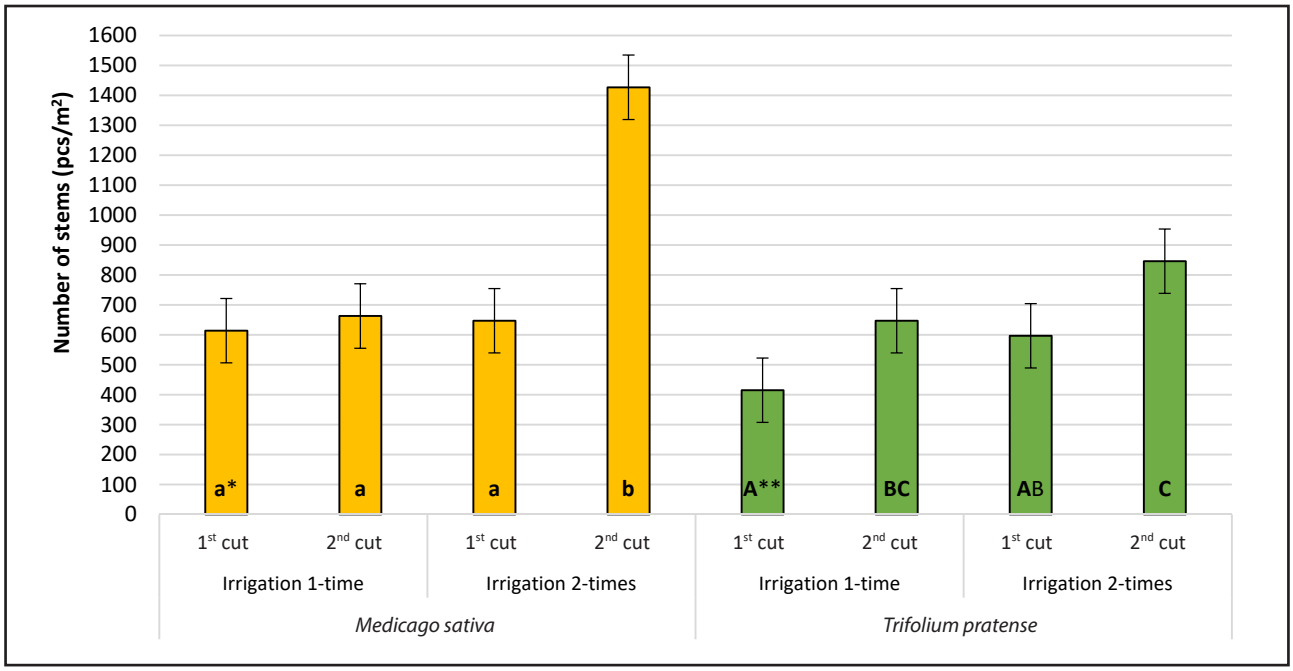

Figure 2 Average number of stems of *Medicago sativa* L. and *Trifolium pratense* L. (pcs/m²) in cut at individual levels of irrigation
The different letters at an average values mean statistically significant difference (Fischer´s LSD test, $P \leq 0.05$) for *Medicago sativa* L. (*) and *Trifolium pratense* L. (**).The error bars in upper part of columns indicate standard deviation

about 18 °C (20–30 °C for *Medicago sativa* L.) according to several authors (Holúbek et al., 2007; Radovic et al., 2009).

One of the criteria for evaluate the condition of perennial forage crops is the coppice density, which depends on the number of plants, respectively stems per unit area (m^2). The values of this indicator are shown in Figure 2.

Similarly to the previous case, there was demonstrated a significant effect of the irrigation ($p = 0.001$ – *Medicago sativa* L. and $p = 0{,}002$ – *Trifolium pratense* L.). *Medicago sativa* L. and *Trifolium pratense* L. had in average 639 stems/m^2 and 531 stems/m^2 under irrigation once a week, respectively. While irrigation twice a week encouraged plant growth and we found out in average 1,037 stems/m^2 (*Medicago sativa* L.) and 722 stems/m^2 (*Trifolium pratense* L.). According to Lichner et al. (1990) *Medicago sativa* L. created a "sparse" coppice and *Trifolium pratense* L. "very sparse" (irrigation 1-time). In the case of irrigation twice a week was found out, on average, the "dense" coppice of *Medicago sativa* L. and the "sparse" coppice of *Trifolium pratense* L. The lack of water was also negatively reflected among the cuts within the different irrigation treatments of the evaluated species of legume forages. In both treatments we found denser crops in the term of the 2nd cut. The number of stems of *Medicago sativa* L. was insignificantly increased by an average of 50 pcs/m^2 (from 614 pcs/m^2 to 664 pcs/m^2) under irrigation once a week, whereas in the case of more frequent irrigation (twice a week), the coppice density has increased on average by 780 pcs/m^2, i.e. approximately 2.2-times (from 647 pcs/m^2 to 1,427 pcs/m^2). Likewise, *Trifolium pratense* L. was denser in the 2nd cut with the minimum difference between the irrigation treatments, but in favour of irrigation twice a week (by 232 pcs/m^2 – Irrigation 1 and 249 pcs/m^2 – Irrigation 2-times).

The part of biological control of perennial forage crops is also finding out the production of above-ground phytomass. According to several authors (Brestič and Olšovská, 2001; Safarnejad, 2008; Farissi et al., 2014) phytomass formation is associated with plant physiological activity, which can be significantly limited by the water deficit itself. From the values presented in Figure 3 can see differences in the amount of above-ground phytomass not only between individual cuts, but also between irrigation treatments ($p = 0.016$ – *Medicago sativa* L.; $p = 0.154$ – *Trifolium pratense* L.). Total production of dry above-ground phytomass of *Medicago sativa* L. was 131.39 g/m^2 under irrigation once a week, while for irrigation twice a week the total yield of phytomass was 233.96 g/m^2. Comparison of the total dry above-ground phytomass weight of evaluated legume forages showed that *Trifolium pratense* L. was more productive (about 99.92 g/m^2 – Irrigation 1-time and 74.40 g/m^2 – Irrigation 2-times) than *Medicago sativa* L. Similarly to the height of plants (Figure 1), in this case, the water deficit was more pronounced in the 2nd cut by reducing the production of *Medicago sativa* L. by 18.55 g/m^2 in comparison with the 1st cut under irrigation once a week (for *Trifolium pratense* L. only about 0.50 g/m^2). This is consistent with the claim of Míka et al. (1997), who state that, despite the deep root system of *Medicago sativa* L. is characterized by

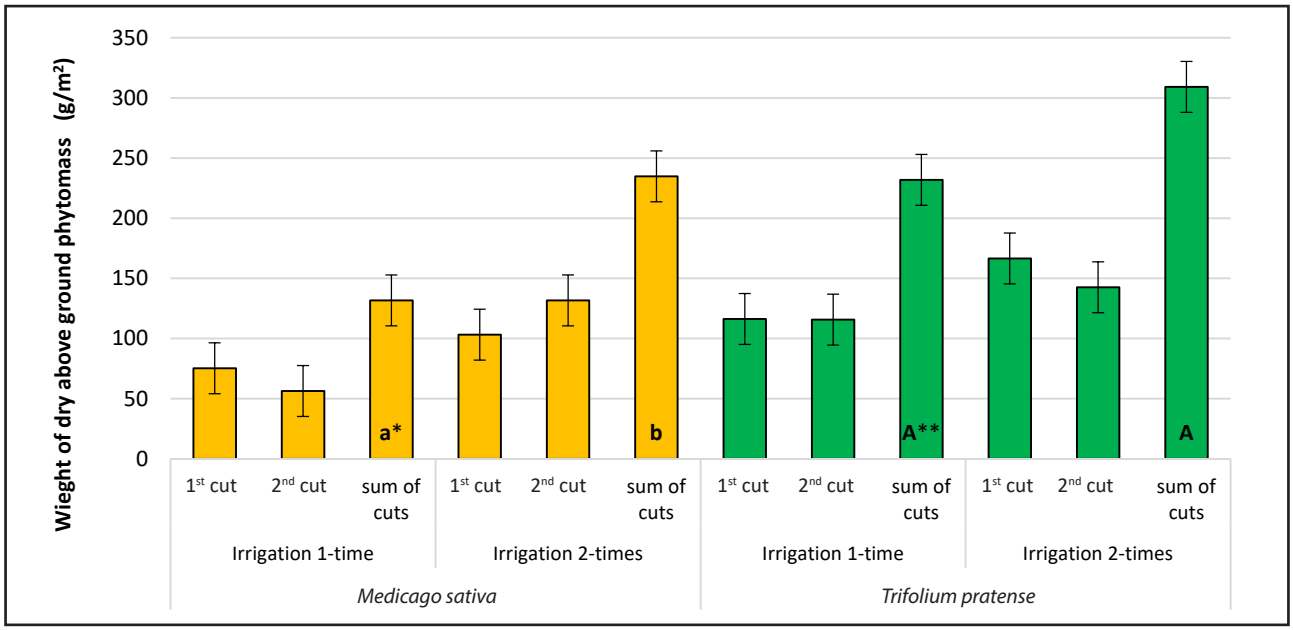

Figure 3 Average weight of dry above ground phytomass of *Medicago sativa* L. and *Trifolium pratense* L. (g/m^2) in cut at individual levels of irrigation

The different letters at an average values mean statistically significant difference (Fischer´s LSD test, $P \leq 0.05$) for *Medicago sativa* L. (*) and *Trifolium pratense* L. (**).The error bars in upper part of columns indicate standard deviation

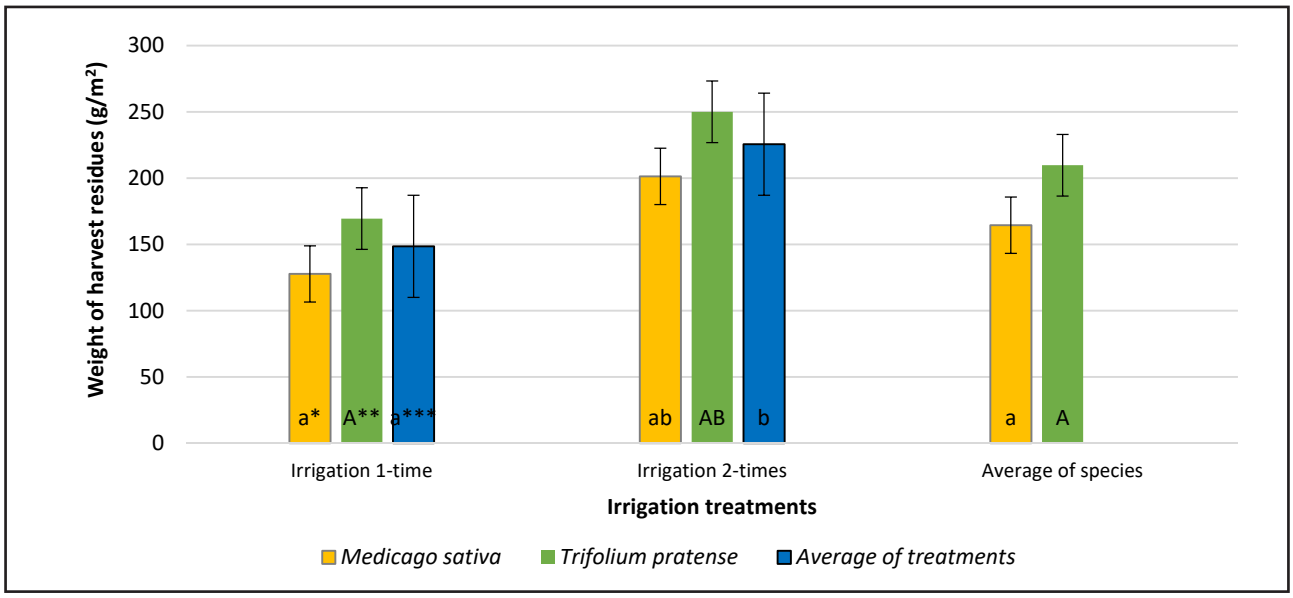

Figure 4 Average weight of harvest residues of *Medicago sativa* L. and *Trifolium pratense* L. (g/m²) at individual levels of irrigation
The different letters at an average values mean statistically significant difference (Fischer´s LSD test, $P \leq 0.05$) for *Medicago sativa* L. (*), *Trifolium pratense* L. (**) and average of treatments (***).The error bars in upper part of columns indicate standard deviation

a decrease in phytomass production in the case of water deficit.

The water stress affects the physiological processes of plants and it is visible not only on the above-ground part of plants but also significantly affects the root system. According to Bláha et al. (2003) and McKenna et al. (2018), in the case of a long-term water deficiency, is inhibited the formation of a root system with initial extension to depth but with limited formation of lateral roots. The root system is greatly reduced, root hairs and growth stop with continued water stress. We can conclude a positive and in average insignificant effect of irrigation on the amount of post-harvest residues (roots + stubble) of *Medicago sativa* L. ($p = 0.100$) and *Trifolium pratense* L. ($p = 0.146$) based on the values presented in Figure 4. There were created 127.75 g/m² and 169.51 g/m² of post-harvest residues for *Medicago sativa* L. and *Trifolium pratense* L. under irrigation once a week, respectively. An increase in the frequency of irrigation (irrigation 2-times) resulted to an increase in post-harvest residues by 73.57 g/m² (*Medicago sativa* L.) and by 80.52 g/m² (*Trifolium pratense* L.). However, this increase for individual species was statistically insignificant ($p = 0.148$). From a general point of view it can be stated that on average a larger amount of post-harvest residues produced a *Trifolium pratense* L. (209.77 g/m²) compared to a *Medicago sativa* L. (164.54 g/m²).

4 Conclusions

Based on the results of the pot experiment, it can be stated that when irrigated twice per week, *Medicago sativa* L. plants were significantly higher, produced a larger number of stems (denser stand) and also was found greater weight of the above-ground phytomass and post-harvest residues in comparison with irrigation once a week. For *Trifolium pratense* L. were these growth-production parameters equally positively influenced by more frequent irrigation (twice per week). From a practical point of view it can be stated that by eliminating water stress, the growth-production process is promoted not only for the water of more demanding species (*Trifolium pratense* L.), but also for relatively more resistant species of clovers (*Medicago sativa* L.). However, these results also need to be verified in natural (field) conditions, where they interact, respectively may interact several factors.

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