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Influence of the seeding rate, row spacing, and cultivar on alfalfa forage yield in the first production year

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Abstract

The cultivated lucerne (*Medicago sativa* L.) is the most widely grown forage legume, mainly due to its high nutritive quality and yield. The objective of this study was to provide information about the optimal seeding rate and row spacing for alfalfa cultivation under rainfed conditions in the Republic of North Macedonia. Alfalfa was sown in the fall of 2020 using randomized complete block design in a split-split plot arrangement with three replications. The effects of two seeding rates (8 and 16 kg ha^{-1}) and two row spaces (20 and 40 cm) were examined on the fresh forage yield (FFY) and dry matter yield (DMY) of four alfalfa cultivars. Based on the evaluation, the sowing method (row spacing) and cultivar choice have shown a significant impact on the obtained forage yield. Higher average yield of fresh (73.7 t ha^{-1}) and dry (20.3 t ha^{-1}) forage was achieved at a sowing distance of 20 cm. Since the seeding rate did not significantly impact the FFY and DMY, in regions with a temperate climate, it is recommended that lower seeding rates than 16 kg ha^{-1} should be used in order to have sufficient and cost-effective alfalfa production. The inevitable issues for increasing alfalfa production are the selection of an appropriate cultivar with good adaptability to recent climate change within compatible establishment methods.

***Key words**:* seeding rate, row spacing, cultivar, FFY, DMY.

Introduction

Alfalfa (*Medicago sativa* L.) is a forage crop grown worldwide due to its vast adaptability to different agroecological conditions, high biomass production, and high nutritional quality as a livestock feed. Cultivated lucerne (alfalfa) is estimated to be grown on 32 million hectares worldwide, mainly in temperate regions (Russelle, 2001; Bouton, 2012). In the Republic of North Macedonia, alfalfa is a dominant forage crop grown on 19,653 ha, with an average hay yield of 5,016 kg ha^{-1} in 2021 (SSO, 2022). Most often, it is cultivated on small arable plots in the frame of a family agriculture household. The farmers still use the same old traditional production habits when growing alfalfa. Aiming to achieve high forage yield, they use high seeding rates of 20-30 kg ha-1, and sowing is carried out by randomly tossing the seeds. In the past, some research was conducted evaluating the qualitative and quantitative traits of different alfalfa cultivars as a base for perspective selection in our agroecological conditions (Prentovic et al., 1996; 1997). Alfalfa forage and seed yield were investigated under different agrotechnical measures in several Macedonian locations (Dimov et al., 1996; 1998; Lukic et al., 2001; 2002; Prentovic, 2002; Prentovic & Ivanovski, 2002; 2003). Unfortunately, there has been no scientific contribution in the last decade about introducing appropriate agrotechnical methods in an alfalfa establishment in the temperate climatic conditions of R. North Macedonia.

There is a lot of published research which aims to investigate the effects of different seeding rates on alfalfa productivity (Lloveras et al., 2008; Zhang et al., 2008; Hall et al., 2010; 2012; Abdel-Rahman & Abu Suwar, 2012; Stanisavljević et al., 2012; Yan-Hua et al., 2017; Berti & Samarappuli, 2018; He et al., 2018; Katanski et al., 2018; 2020; Abasov et al., 2019; Atis et al., 2019; Hui-gang et al., 2019; Geun et al., 2021; Xu et al., 2021). The recommended seeding rates vary significantly in different regions of the world, depending on the applied agricultural practices and environmental conditions. The recommended seeding rate for alfalfa establishment during late summer in the USA is between 11.2 and 13.4 kg ha^{-1} (Rankin, 2001). On the contrary, according to Stjepanović and Popović (2009), in the conditions of Southeast Europe, the alfalfa seed amount for forage production is in the range of 16 to 25 kg ha^{-1}. Đukić (2002) reported a slightly lower seeding rate (18-20 kg ha^{-1}) for the same region. Quite the opposite data were reported in Sudan, where ordinary farmers' practice is to spread 53 to 106 kg ha^{-1} seeds on flat plots (Abdel-Rahman & Abu Suwar, 2012). According to Bolger & Meyer (1983), Lloveras et al. (2008), and Atis et al. (2019), seeding rates vary from 4 to 40 kg ha^{-1}, depending on a series of agro-technical measures (soil cultivation, seedbed preparation, sowing method, and sowing season), as well as on environmental factors (air temperature, amount and frequency of precipitation, duration of daylight, and soil productivity).

Discovering the optimal seeding rate is a basic agro-technical tool in order to achieve profitable alfalfa production. Yan-Hua et al. (2017) and Hui-gang et al. (2019) stated that the applied rates in practice should be in a range of 22.5 to 30 kg ha^{-1}, as in their studies the dry matter yield increased with higher examined seeding rates. In line with these studies are the findings of Glaspie et al. (2011), who, comparing several seeding rates, attained the highest dry matter yield when using the highest seeding rate of 18 kg ha^{-1}. Another research conducted in South Dakota in which four seeding rates were compared also confirmed a higher dry matter yield in the seeding year with each increase in seeding rate when irrigation was used (Hansen & Krueger, 1973). These reports are also in compliance with the findings of Geun et al. (2021), who observed maximum yield response when alfalfa was seeded at the highest seeding rate (40 kg ha^{-1}).

On the contrary, Lloveras et al. (2008) studied the effects of four seeding rates (10, 20, 30, and 40 kg ha^{-1}) on alfalfa dry matter yield under irrigated conditions in the Mediterranean climate and discovered little justification for increasing the seeding rate to higher than 10 kg ha^{-1}. Another research confirmed that a 10.1 kg ha^{-1} seeding rate was the threshold below which total herbage yield in the seeding year declined (Hall et al., 2004). Furthermore, Berti & Samarappuli (2018), from their assessment, concluded that increasing the sowing rate above the recommended rate (10 kg PLS ha^{-1}) did not increase forage yield or quality. According to the results obtained by Katanski et al. (2020), in a temperate climate, alfalfa growers should apply lower seeding rates (below 16 kg ha^{-1}) in order to provide sufficient dry matter, but the priority should be given to good establishment practices. Thus, detecting the optimal seeding rate should be accompanied by the right choice of some agro-technical measures (selection of pure seed material, soil type and cultivation, seedbed preparation, and irrigation method).

Besides determining the optimal seeding rate, choosing an appropriate row spacing is an important management decision for both alfalfa seed and forage producers. Hakl et al. (2021) outlined that not only seeding rate manipulation but also this, in combination with the appropriate spatial arrangement of plants, could provide good root development and consequently enhance forage yield. In an experiment conducted in Argentina, which included different row spacings (10-30 cm), the total dry matter yield was increased by narrow spacing up to an optimal distance of 13 cm when comparing all row spacings at the same plant density (Mattera et al., 2013). Chocarro and Lloveras (2014) also highlighted the importance of plant arrangement and confirmed that higher DM yields were obtained from the narrowest rows (20 cm) under irrigated Mediterranean conditions.

As a consequence of alfalfa's great prevalence, in different geographical and climatic regions it is a real courage to define the accurate seeding rate. Due to dramatic climate change, there will always be a need for constant monitoring and scientific research to detect the optimal seeding rate, row spacing, and appropriate cultivar, depending on the aim of production. Despite the general guidance, there is a lack of research-based knowledge about the effects of the seeding rate, row spacing, and autumn establishment on the alfalfa productivity under rainfed conditions in R. North Macedonia. Therefore, the objectives of this study were to evaluate the effects of seeding rate and row spacing on the total fresh and dry matter yield of four alfalfa cultivars in the first production year.

Material and Methods

Design and preparation of the experiment

The field experiment was conducted in the Skopje region, North Macedonia (Photo 1). The experiment was established using a randomized complete block design in a split-split-plot treatment arrangement with three replicates. The seeding rates as the main factor were distributed in main plots whereas the row spaces and the cultivars were distributed in both subplots and sub-subplots. Alfalfa was manually seeded on 12 September 2020. Various seeding rates (8 and 16 kg ha-1), methods of sowing (with row spaces of 20 and 40 cm) and four alfalfa cultivars were studied. The plot area at a row spacing of 20 cm was 3 m^2 and 4.8 m^2 of 40 cm row spacing.

Figure 1. Location of the experiment (Source: Google Earth)

The experimental plot before the trial was fallow represented with low and high grass vegetation. Basic cultivation practices (primary and pre-sowing tillage) were carried out prior to crop establishment. Due to the low precipitation in September 2020, there was a need for several sprinkler irrigations soon after sowing. To improve the alfalfa establishment, weeds that emerged after sowing were manually removed.

Plant material

In this research four alfalfa cultivars were used: Debarska, Banat VS, NS Jelena, and Nijagara. Except Debarska which is a domestic cultivar created at the Agricultural Institute in Skopje, the other cultivars were imported. Debarska is distinguished by its longevity achieving high yield with good quality and resistance to low temperatures (Ивановски, 2000). Banat VS, NS Jelena, and Nijagara are Serbian cultivars, originating from the Institute of Field and Vegetable Crops in Novi Sad. Banat VS is suitable for cultivation on fertile soils with neutral pH reaction. It is a high-yielding cultivar with good tolerance to low temperatures, drought, and lodging. On the other hand, Nijagara is tolerant to acid soils, representing synthetic populations designed for mountainous regions and heavy hydromorphic soils. It wasdeveloped using interspecies hybridization between M. sativa ssp. sativa and M. sativa ssp. falcata gene pools (Milić et al., 2014; Rhouma et al., 2017; Milić et al., 2019a). NS Jelena has been basically created for breeding in Mediterranean regions as it originates from crosses between Greek and Serbian populations. It is a drought-tolerant cultivar belonging to dormancy group 6 and is suitable for intensive cutting regimes.

Climate and soil conditions

The soil type of the experimental site is alluvial. The results from the agrochemical soil analysis are shown in Table 1. Basic fertilization with 400 kg ha-1 of 8:16:24 NPK fertilizer was applied before sowing. In the early spring of 2021, supplementary fertilization with 200 kg ha-1 of UNIKO 25.5 % N nitrogen fertilizer was performed.

The location where the experiment was set up has temperate continental climate, characterized by moderately dry and hot summers and moderately wet and cold winters. On the contrary, according to UHMR data, in the first winter of plant life (2020-2021) higher average temperatures were registered compared with the long-term average (LTA), which justify a rarely applied fall alfalfa establishment. Figure 1 shows weather conditions for the evaluation period in the

Skopje region. The higher average temperature in September 2020 (21˚C) compared with the LTA (19.3˚C) and the lower amount of precipitation in September and October (24.5 mm, 43.4 mm) compared with the LTA (44 mm, 51.4 mm) respectively, led to decreased soil moisture, and delayed plant germination. The winter period that followed was characterized by higher average temperatures compared with the long-term average, thus contributing to successful wintering of the crop without any serious stand thinning. Compared with the LTA amount of precipitation (502.4 mm), the annual amount of precipitation in 2021 (521.5 mm) was higher, which contributed to better crop productivity.

Tab. 1 Chemical properties of soil on the experimental site

Depth (cm)	pH (KCl)	$CaCO_3$ (%)	N (%)	Humus (%)	P_2O_5 (mg/100g)	K_2O (mg/100g)
0-30	7.71	9.16	0.13	2.47	24.70	22.59
30-60	7.80	9.60	0.10	1.58	11.37	9.61

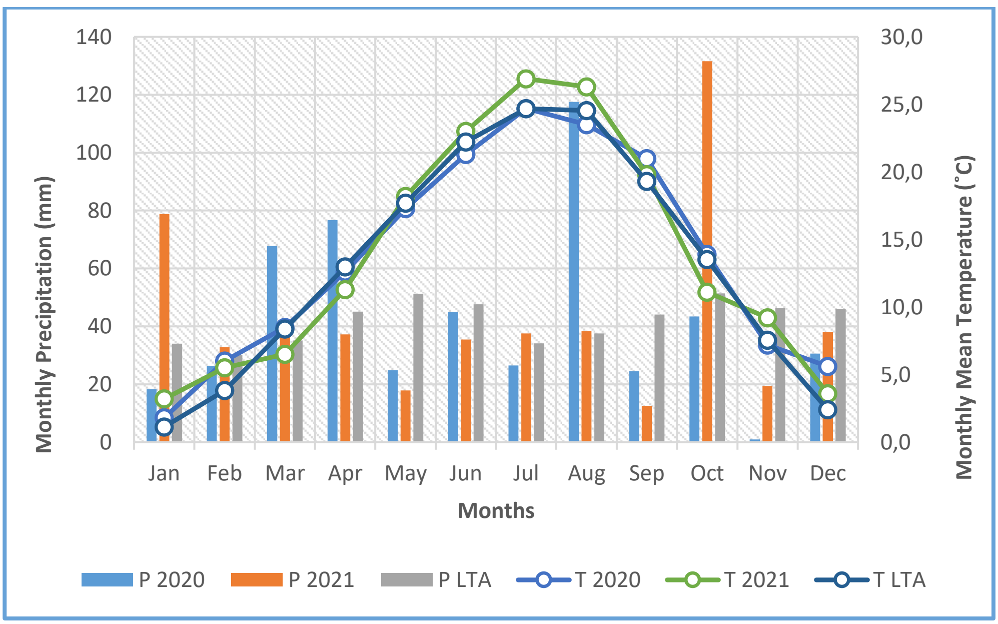

Figure 1. Precipitation distribution and air temperature for the examined period and LTA (1991-2020)

Measurements

In the first production year (2021), five cuttings in total were performed. Four cuts (I, III, IV, and V) were assigned for forage production, and one (II cut) was intended for seed production. Due to the heavy and frequent rains in June and July 2021, plant lodging and seedpod rot occurred. Simultaneously, plant re-growth started, causing the second cut not to be fully realized and recorded, so it had to be eliminated (Table 2).

The fresh forage yield (FFY) was determined right after the mowing of each plot. The mowing was realized manually (with a sickle) when the plants according to the Kalu & Fick (1981) were in an early stage of flowering (approximately 10% of plants with flowers). A sample of 300 g was taken from each harvested plot, dried at room temperature until its constant weight and the percentage of dry matter were determined. Afterwards, the dry matter yield (DMY) was calculated.

Tab. 2 Harvest plot dates during the first production year

Year / Cuts	Sowing year	Year 1
	2020	**2021**
I	×	27-May
II	×	×
III	×	9-Aug
IV	×	16-Sep
V	×	28-Oct

Aug – August; Sep – September; Oct – October; × - Plots not harvested

Statistical analysis

Alinear mixed model in RStudio software v. 1.4.1717 was used to analyze the data. ANOVA was conducted using the Kenward-Roger method aiming to resolve the impact of the fixed effects on the FFY and DMY. To compare the factor levels, emmeans (Estimated Marginal Means) package was used. The Tukey-test at a $P<0.05$ significance level was conducted to determine the significance of the differences between the mean values.

Results and Discussion

There was not any significant difference in the FFY and DMY, between assessed seeding rates. On the contrary, the row spacing and cultivar showed a significant impact on both traits. The interaction between the seeding rate and cultivar also demonstrated significance for the DMY (Table 3 and 4).

Tab. 3 Significance of the analyzed effects on the total FFY, according to the *F*-test

Source of variation	FFY		
	df	F-test	Pr(>F)
Replication	2	2.03	0.32991
Seeding rate (SR)	1	0.21	0.68834
Row spacing (RS)	1	193.93	0.00015***
Cultivar (C)	3	4.61	0.01095*
SR x RS	1	4.52	0.10049
SR x C	3	2.25	0.10790
RS x C	3	0.75	0.52792
SR x RS x C	3	0.20	0.89380

*** Significant at the P<0.001 level, ** Sig. at the P<0.01 level, * Sig. at the P<0.05 level

Tab. 4 Significance of the analyzed effects on the total DMY, according to the *F*-test

Source of variation	DMY		
	df	F-test	Pr(>F)
Replication	2	2.65	0.27356
Seeding rate (SR)	1	0.01	0.94274
Row spacing (RS)	1	120.55	0.00039***
Cultivar (C)	3	5.44	0.00533**
SR x RS	1	1.79	0.25112
SR x C	3	3.90	0.02110*
RS x C	3	1.12	0.35992
SR x RS x C	3	0.72	0.54809

*** Significant at the P<0.001 level, ** Sig. at the P<0.01 level, * Sig. at the P<0.05 level

According to Lloveras et al. (2008); Abdel-Rahman & Abu Suwar (2012); Berti & Samarappuli (2018); Atis et al. (2019), and Xu et al. (2021), the seeding rate has no significant effect on the forage yield. Their results are consistent with ours. By observing the overall analyses (Table 5 and 6), it can be noticed that there was not a significant statistical difference in the obtained FFY (62.6 t ha^{-1} and 63.9 t ha^{-1}) and DMY (17.3 t ha^{-1} and 17.4 t ha^{-1}) when applying either 8 or 16 kg ha^{-1}, respectively. Based on these initial results, there is no justification for using higher seeding rates than 16 kg ha^{-1} if proper establishment methods are applied. Higher seeding rates lead to higher plant density right after the establishment of the plant stand. However, stand thinning occurs due to competitiveness among plants, resulting in no significantly higher yield compared with lower seeding rates. Abasov et al. (2019) observed that with an increase in the seeding rate, there was a decrease in plants mass and leaf number and mass. Increasing the number of plants per unit area, in accordance with higher seeding rates, is usually associated with reductions in the available air and soil for plants, increasing the competition between plants for soil nutrients, light, and carbon dioxide (Abdel-Rahman & Abu Suwar, 2012). It has been observed that when alfalfa is seeded at excessive rates, intra-specific competition among plants increases, resulting in higher plant mortality (Hall et al., 2004, 2010). Increasing the seeding rate has resulted in a near-linear increment in plant density from 100 to 800 plants m-2 within three months after sowing. However, plant density decline was detected when higher rates than 17 kg ha^{-1} were applied six months after establishment (Hall et al., 2004). Volenec et al. (1987) noticed that alfalfa yield increased when plant density was increased up to 172 plants/m^2, and a minimum density threshold of around 35-45 plants/m^2 should be achieved in the subsequent years in order to maintain a high yield from the stand. On the contrary, Hakl et al. (2021), in their experiments, observed some yield benefits when lucerne plant density was over 300 plants/m^2 but only under excellent soil conditions and a favourable water regime. It is obvious that so many studies have been conducted trying to investigate the proper seeding rate, which would result in a measurable benefit in alfalfa productivity, but there will be uncertainties as long as different locations, climate, and growing conditions exist. In order to determine the optimal seeding rate, it can be established that a good seedbed preparation, seeding depth, spatial arrangement of plants, and knowledge of climate and soil conditions are crucial.

Unlike the seeding rate, there were significant differences in the FFY and DMY obtained between the row spaces and cultivars (Table 5 and 6). According to the results, in the first production year, a significantly higher average FFY and DMY were achieved when sowing at a distance of 20 cm (73.7 t ha^{-1} and 20.3 t ha^{-1}), compared with 40 cm (52.8 t ha^{-1} and 14.4 t ha^{-1}), respectively. Compared with our results, Atis et al. (2019) obtained a higher FFY (94.0 t ha^{-1}) and near the same DMY (20.1 t ha^{-1}) in the first productive year at the same row spacing (20 cm) and seeding rate of 15 kg ha^{-1}. Zhang et al. (2008) and Hui-gang et al. (2019) observed the highest alfalfa hay yield with the 15 cm row spacing treatment compared with other higher row spaces included in the trials, whose results are in line with ours. Chocarro and Lloveras (2014) also compared three different row spaces (20, 40, and 60 cm) under irrigated conditions in a Mediterranean environment and confirmed that in the first production year, the highest DM yield (18.8 t ha^{-1}) was obtained from the narrowest rows. Moreover, in the agro-ecological conditions of Serbia in the first assessed year, Stanisavljević et al. (2012) emphasized the highest dry forage yield (6.34 t ha-1 and 6.56 t ha^{-1}) when sowing at the closest examined distance (20 cm) between rows and seeding rate of 15 and 18 kg ha^{-1}, respectively. Furthermore, the results in the present experiment are consistent with the reports of Delgado et al. (2013), according to whom the forage production was higher when row spacing was 20 cm (7.486 kg ha^{-1}) than with 40 cm and 60 cm spacing (7.189 and 6.661 kg ha^{-1}, respectively). When increasing the row distance (from 20 to 70 cm), a significant reduction in the alfalfa FFY and DMY was noticed as a consequence of a higher weed expansion which had caused strong competition with alfalfa plants for water, sunlight, and soil nutrients (Celebi et al., 2010). Reducing the distance between sowing rows up to an optimal distance (around 13 cm) also underlined a linear increase in intercepted and accumulated photosynthetically active radiation during the crop cycle and radiation use efficiency, which positively correlated with aerial biomass production (Mattera et al., 2013). It is evident from our and other studies that the spatial distribution of plants plays an essential role in stand establishment, which leads to a measurable benefit in the alfalfa forage productivity when smaller row distances (15-20 cm) are applied while sowing. Since the alfalfa is a perennial crop whose yields decrease over time, the most crucial aspect of forage production is not the row distance manipulation by itself but also this in combination with the crop density and quantity of seed per unit area used. Understanding the relationship between these agro-technology issues is essential to gaining satisfactory FFY and DMY.

Tab. 5 The influence of the seeding rate, row spacing, and cultivar on the total FFY (t ha^{-1})

Seeding rate (kg ha^{-1})	FFY (t ha^{-1})	Row spacing (cm)	FFY (t ha^{-1})	Cultivar	FFY (t ha^{-1})
8	62.6^{a}	20	73.7^{b}	Debarska	61.8^{ab}
16	63.9^{a}	40	52.8^{a}	Banat VS	64.5^{ab}
				NS Jelena	67.1^{b}
				Nijagara	59.7^{a}

* Different letters in a column indicate a significant statistical difference ($p<0.05$)

According to Table 5 and 6, the obtained results have shown significant differences between cultivars in both examined traits (FFY and DMY). The highest fresh forage and dry matter yield was registered with NS Jelena (67.1 t ha^{-1} and 18.5 t ha^{-1}, respectively). This cultivar belongs to dormancy group 6, and even though it is intended for growing in Mediterranean regions, it is suitable for breeding in our agro-ecological conditions with a temperate climate. In line with our results and meteorological data for the examined period (Figure 2), it meets the selection goals as a drought-tolerant cultivar suitable for intensive cutting regimes (Rhouma et al., 2017; Milić et al., 2019). In terms of yield performance, Banat VS was right behind NS Jelena cultivar with 64.5 t ha^{-1} and 17.5 t ha^{-1} fresh and dry matter yield, respectively. The breeding suitability of this cultivar could be explained by the report of Katić et al. (2013), according to whom this cultivar is intended for planting in soils rich in nutrients and neutral pH reaction, which corresponds to the alluvial soil type with pH (7.71) on which the experiment was set up. Nijagara showed the poorest yield performance (59.7 t FF ha^{-1} and 16.6 t DM ha^{-1}). The genetic potential of this cultivar was also assessed in a 3-year study by Katanski et al. (2020). They reported a lower average DMY (15.6 t ha^{-1}) applying the same seeding rates at a row spacing of 20 cm. In contrast, Milić et al. (2014) achieved a higher average DMY (21.7 t ha-1) by planting the same cultivar with a seeding rate of 15 kg ha^{-1} and spacing of 20 cm between rows.

Tab. 6 The influence of the seeding rate, row spacing, and cultivar on the total DMY (t ha^{-1})

Seeding rate (kg ha^{-1})	DMY (t ha^{-1})	Row spacing (cm)	DMY (t ha^{-1})	Cultivar	DMY (t ha^{-1})
8	17.3^{a}	20	20.3^{b}	Debarska	16.8^{a}
16	17.4^{a}	40	14.4^{a}	Banat VS	17.5^{ab}
				NS Jelena	18.5^{b}
				Nijagara	16.6^{a}

* Different letters in a column indicate a significant statistical difference ($p<0.05$)

Furthermore, numerous studies have investigated the forage yield between various alfalfa cultivars belonging to different fall-dormancy categories, grown under either rain-fed or irrigated conditions in a different climate zone (Rimi et al., 2010; Chedjerat et al., 2016; Milić et al., 2019b; Djaman et al., 2020; Baxevanos et al., 2021). From their results and ours, it is evident that there are significant differences between cultivars in terms of yields achieved. Therefore, choosing an appropriate dormancy group could be a valuable tool for increasing alfalfa yield within the knowledge about soil conditions and the anticipated climate change.

Conclusion

The results of this research indicate that in our or regions with similar ecological conditions it is advisable to use seeding rates lower than 16 kg ha-1 in order to have economically profitable alfalfa production without significant yield losses.

Optimizing the seeding rate within the choice of appropriate row spacing is the key to successful stand establishment. Higher average FFY and DMY were achieved with a 20 cm row spacing compared with sowing at a row distance of 40 cm. Our results suggest that sowing at smaller row distances (15-20 cm) leads to measurable benefits in the alfalfa forage productivity.

The statistical data analyses showed significant differences between assessed cultivars concerning the yields. Thus, the selection of an alfalfa cultivar from suitable fall dormancy category and good adaptability to recent climate change is an inevitable issue within a compatible agronomic production technology that should be considered.

These results have been obtained from the vegetation in the first production year and are not a proper indicator for the alfalfa productivity in general. There is a need for profound and continuous monitoring of the vegetation in the following years too. However, based on these results, it can be summarized that the successful establishment of an alfalfa stand depends on the selection of an appropriate cultivar (genetic factors) and the choice of an appropriate establishment practices (soil cultivation and seedbed preparation, sowing method, seeding rate, fertilization, irrigation, seeding date, and harvesting regime).

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Утицај сетвене норме, међуредног размака и сорте на принос луцерке у првој производној години

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Сажетак

Обична луцерка (*Medicago sativa* L.) је најраспрострањенија крмна махунарка, првенствено због високе хранљиве вредности и приноса. Циљ истраживања био је да се утврди оптимална сетвена норма и међуредни размак за производњу луцерке у условима сувог ратарења у Републици Северној Македонији. Луцерка је посејана у јесен 2020, по методи блок система са случајним распоредом третмана у три понављања. Испитиван је утицај две сетвене норме (8 и 16 kg ha^{-1}) и два међуредна размака (20 и 40 cm) на принос зелене крме (FFY) и суве материје (DMY) четири сорте луцерке. Резултати показују значајан утицај начина сетве (међуредни размак) и сорте на остварени принос крме. Већи просечан принос крме (73.7 t ha^{-1}) и суве материје (20.3 t ha^{-1}) остварен је на размаку од 20 cm. Имајући у виду да сетвена норма није значајно утицала на принос крме (FFY) и суве материје (DMY), у регионима умереног климата препоручљива је употреба сетвених норми мањих од 16 kg ha^{-1} за остваривање одговарајуће и економски исплативе производње луцерке. За повећање производње, значајан је и одабир одговарајућих сорти толерантних на климатске промене и примена адекватних начин заснивања луцеришта.

Кључне ријечи: сетвена норма, међуредни размак, сорта, принос крме, принос суве материје

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