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FORAGE YIELD OF RED CLOVER GROWN FOR COMBINED FORAGE AND SEED PRODUCTION

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Abstract

The impact of precipitation on forage yield, hay yield and water content in the green forage of red clover *(Trifolium pratense* L.*)* was examined in field trials. The crop was grown for combined forage and seed production. The experiment was established on alluvium soil in a randomized block design. During period 2010-2012 four red clover cultivars (K-39, K-17, Una, and Viola) were analyzed for first cut in their second year. Significant differences between cultivars were observed for green forage yield, hay yield, and water content in the green forage, regardless of precipitation in the production year. It was determined that the green forage yield in 2010 was significantly higher compared to 2011 and 2012. year. Thereby the hay yield had no significant difference concerning 2010 and 2011. year, while significant reduction was reported in 2012. year. Green forage yield was positively correlated with both hay yield and the water content of green forage.

Key words: *red clover, forage yield, hay yield.*

Introduction

In order to increase and intensify livestock production, the solution should be searched in highly producive plant species, with good quality, which fit in the system of continuous production of livestock feed (green forage conveyor) (Pejić et al., 2005). Together with efforts to reduce energy consumption and environmental pollution, intensify sustainable agricultural systems and conserve biodiversity Rochon et al. (2003) proposed increases in forage legume acreage. Being nitrogen fixers, these plants are minimally treated with nitrogen fertilizers, whose residues easily leach from the soil, causing contamination of ground waters, local streams and ponds (Janzen and McGinn, 1991). One such plant is red clover *(Trifolium pratense* L.*)* which due to its high stable yields, varied use, relatively modest growing requirements and good forage quality plays an important part in the production of protein-rich livestock feed. As a perennial legume, red clover has a high ability to regenerate; therefore, depending on growing conditions, it can produce up to even three cuttings per year. Under natural water supply conditions, with adequate cultural practices used, green forage yields of up to 147.7 t ha^{-1} can be achieved during the utilization period (mostly three years) (Vasiljević et al., 2010). Rochon et al. (2003) point out the advantages of the legume green forage usage which reflect in high protein content, high digestability and low level of tannins and flavonoids. However, green forage yields of red clover vary widely depending on weather conditions, most notably the amount and distribution of rainfall during the year. For these reasons, in order to obtain high and stabile yields of red clover and utilize its genetic potential of cropping, the possibilities of its production in different agroecological conditions must be known. Beside that, the red clover seed production in the Republic of Serbia is insufficient to ensure the needs of the local market (Barać et al., 2011). In the Republic of Serbia, the combined production of red clover for both

forage and seed has proved to be the most cost-effective production method (Lugić et al., 1996), with the first and second cuttings in the second year stand being used to produce forage and seed, respectively (Duronić, 2010). This manner of production involves harvesting the first-cut material at the stage of budding or at the beginning of flowering.

The objective of this study was to determine green forage yield, dry matter yield, water content of green forage as well as their interdependence, in the combined forage-and-seed production of red clover cultivars in years with different rainfall amounts.

Materials and methods

The experiment was established in 2009, 2010 and 2011 in Čačak (43°54'39.06" N, 20°19'10.21" E, 246m a.s.l.), on alluvial soil, acid reaction (pH 4.8), which contains 3.18% organic matter, 0% $CaCO_3$, 22.08 mg P_2O_5, 30.0 mg K_2O 100 g^{-1} soil. Along with tillage, 300 kg ha^{-1} $N_{15}P_{15}K_{15}$ was incorporated into the soil. The experiment was set up in a completely randomized block design with four replications, with a plot size of $5m^2$ (5x1m). Red clover cultivars, including K-17, K-39 (Institute of Forage Crops Krusevac), Una (Institute of Field and Vegetable Crops Novi Sad) and Viola (a Polish cultivar) were planted at a 20cm row spacing, at a rate of 18 kg seed ha^{-1}. Mechanical weed control was performed on two occasions. The crop was grown without irrigation. The test cultivars were cut at the same time (budding phase), on May 13, 2010, May 14, 2011 and May 19, 2012.

The rainfall amount for the prevegetation period and the begining of vegetation before the first cutting, November 2010 – May 2011, was 284.6 mm, and for the period November 2011 – May 2012, 286.5 mm, which is 174.7 mm and 172.8 mm less than the same period in 2009-2010. year, respectively.

Table 1. The amount and distribution of rainfall by month (P) and mean monthly temperatures (T) for the period 2009 – 2012.

Month		I	II	III	VI	V	VI	VII	VIII	XI	X	XI	XII	$\bar{x}$ i $\sum$
2009	P (mm)	50	32	42.5	12.5	43	98.4	41.0	35.5	30	91.5	**72**	**97**	645.4
	T (ºC)	0.7	2.6	8.1	14.8	20.2	21.4	24	24.7	19.2	11.6	8.7	3.7	13.3083
2010	P (mm)	**33**	**52**	**54.5**	**52**	**98.8**	81	90.0	28.5	25	63	**54.6**	**37**	669.4
	T (ºC)	0.9	3.0	7.9	13.3	17.9	21.3	23.5	23.7	17.3	10	10.3	1.8	12.575
2011	P (mm)	**22**	**29**	**31**	**15.5**	**95.5**	47	30.5	9.5	42	21	**2.5**	**29**	374.5
	T (ºC)	0.7	0.7	7.6	13.1	16.7	22	23.8	23.7	21.6	11.8	3.7	3	12.366
2012	P (mm)	**60**	**70**	**10**	**47**	**68**	38	22	0	-	-	-	-	-
	T (ºC)	1.8	2.5	6.8	12.2	17.3	24.1	26.6	25.4	-	-	-	-	-

First-cut green forage (GF) yield in the second year of cultivation was determined by measuring the total weight of the plot immediately after cutting and recalculated to GF yield in t ha^{-1}. After drying at 65 ° C, the measured sample (500g) was used to calculate hay yield (t ha^{-1}) and the water content of the green forage.

The results were subjected to a single-factor analysis of variance (ANOVA) using the SPSS 4.5 software. Significant differences between mean values were tested by the LSD test. The interdependence of green forage yield, hay yield and water content in the green forage was evaluated by calculating the simple correlation coefficient.

Results and discussion

The highest yield of red clover green forage in combined forage and seed production was reported in year of the highest amount of rainfall (2010) (Tab 2.). With the significant reduction of rainfall amount during the prevegetation period and start of vegetation before the first cutting, it also came to the significant reduction of green forage yield (2011 and 2012).

As a confirmation of this report Hanson (1991) observed a reduction in alfalfa forage yield at inadequate soil moisture. Bošnjak (1993) reported an average 56-61% increase in green forage yield of alfalfa in dry years under irrigated conditions, with the effect of irrigation early in the season being somewhat more modest.

Table 2. Green forage yield (GFY) hay yield (HY) and water content of green forage (WGF) at the time of cutting in red clover cultivars in 2010-2012.

		GFY (t ha^{-1})	HY (t ha^{-1})	WGF (%)
Year	2010	48.8 a	7.19 a	85.29 a
	2011	39.9 b	7.62 a	80.85 b
	2012	19.1 c	4,07 b	78.73 c
Cultivar	K-39	33.7 bc	5.94 b	81.31b
	K-17	38.3 ab	6.40 b	82.44a
	UNA	39.6 a	7.18 a	81.09 b
	VIOLA	32.2 c	5.65 b	81.65 b
2010	K-39	48.0 ab	6.91 b	85.53 a
	K-17	52.5 a	7.58 ab	85.74 a
	UNA	52.3 a	8.00 ab	84.67 a
	VIOLA	42.5 abc	6.27 bc	85.20 a
2011	K-39	34.6 c	7.01 b	79.75 cd
	K-17	40.5 bc	7.00 b	82.77 b
	UNA	46.3 ab	9.24 a	79.95 cd
	VIOLA	38.0 bc	7.22 b	80.95 c
2012	K-39	18.4 d	3.92 d	78.65 d
	K-17	21.8 d	4.62 cd	78.8 d
	UNA	20.2 d	4.31 d	78.65 d
	VIOLA	16.2 d	3.45 d	78.80 d
LSD	Year (A)	*	*	*
	Cultivar (B)	*	*	*
	AxB	*	*	*

The values denoted with different small letters within columns are significantly different at (P<0.05) in accordance with the LSD test

* - F test significant at p<0.05; ns - F test non-significant.

Cultivar Una, regardless of year and rainfall, had a significantly higher GF yield (39,6 t ha^{-1}) as compared to cv. K-39 (33.7 t ha^{-1}) and cv. Viola (32,2 t ha^{-1}). Cv. Viola also had lower green forage yield as compared to cv. K-17. Vasiljević et al. (2010) report differences in the first-cut green forage yield of red clover in its second year, ranging from 22.4 t ha^{-1} (Nike) to 40.0 t ha^{-1} (Una). The same authors obtained significantly lower forage yields in foreign cultivars and observed intense thinning in their stands until the end of the growing season in the second year, as compared to domestic cultivars. According to Radović et al. (2004), red clover cultivars show better performance under the agroecological conditions in which they were selected. The same authors highlight the advantage of local red clover cultivars over foreign cultivars due to their better adaptation to the existing agroecological conditions. The interaction between year and cultivar reveals that cv. Una had higher yield as compared to cv. K-39 only in 2011. It indicates that cv. Una had the most favourable reaction in soil moisture deficiency.

Regardless of the differences in green forage yield, the different rainfall amount between years didn't significantly affect hay yield in 2010 and 2011 at any of the cultivars, while significant fall in hay yield was reported within all of the cultivars in 2012. This is caused by the fact that higher amount of rainfall influenced on a significant increase of water proportion in the fodder at the time of cutting within all of the cultivars in 2010. Additionally, expressed lack of rainfall in the second part of vegetation period in 2011 and very low

temperatures in february 2012 affected on bad preparedness of the plants, which led to the significant yield reduction in 2012. Cv. Una also had the highest hay yield, significantly higher as compared to the other cultivars. That is subsequence of its somewhat higher hay yield during 2011 (significancy of year/cultivar interaction).

Significantly higher water content of the forage at the time of cutting was reported at cv. K-37 as compared to the others in 2011 (year/cultivar interaction). Concerning that all of the cultivars were cut at the same time, this can be caused by slow growth of cultivar K-37. Seguin et al. (2002) report that soil moisture deficiency induced changes in the dry matter quality of red clover, including an increasing content of acid detergent fiber (ADF) and neutral detergent insoluble protein, but decreasing content of acid detergent lignin (ADL) and reduced dry matter digestibility.

Table 3. Coefficients of correlation between green forage yield (GFY), hay yield (HY) and water content of green forage (WGF)

	HY	WGF
GFY	0.91*	0.72*
HY		0.38*

* - Significant at $p < 0.05$

Green forage yield was positively correlated with hay yield (r=0.91), as well as with the water content in the green forage (r=0.72) (Tab. 3.). Hay yield was also positively correlated with water content in the green forage. According to Duncan and Woodmansee (1975), the correlation between rainfall amounts and green forage yield of grasses and legumes was significant at the stage of their intensive growth, which was accompanied with soil moisture deficiency. Bošnjak et al. (1995) observed complete correlation (r = 0.99) between GF yield and annual rainfall in alfalfa.

Conclusions

The highest green forage yield of red clover in combined production of fodder and seed was reported in year with the highest rainfall (2010). With the significant reduction of rainfall amount during the prevegetation period and start of vegetation till the first cutting (2011 and 2012), it also came to the significant reduction of green forage yield and water content in green forage. Additionally, expressed lack of rainfall during the second part of vegetation period in 2011, and very low temperatures in 2012 affected on bad preparedness of the plants, which led to the significant yield reduction in 2012.

Regardless on rainfall amount (years), there were significant differences between the cultivars in green forage yield, hay yield and also in water proportion in green forage. The highest green forage and hay yield obtained cv. Una, while the highest water content at the cutting had cv. K-17. This is mainly consenquence of their deviation from the other cultivars in 2011 which tells that cv. Una had acted more favourably on the conditions of lower rainfall. It further indicates that their different reaction on the different levels of soil water supply should be taken in consideration when choosing cultivars in certain agroecological conditions. Green forage yield positively corelated with hay yield and also with water content in green forage.

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