Originalni naučni rad - Original scientific paper

ALFALFA SEED YIELD COMPONENTS DEPENDING ON CUTTING SCHEDULE

Đura Karagić, Dragan Milić, Slobodan Katić, Sanja Vasiljević

Institute of Field and Vegetable Crops, Novi Sad

Summary: To ensure high and stable seed yields, in regions with semi humid climate, it is necessary to prevent the luxuriant growth of alfalfa plants and their subsequent lodging. The most effective method of controlling rank growth in alfalfa is cutting.

Effect of cutting schedule on alfalfa seed yield was studied in four-year experiments (2001-2004). Four cutting schedules with variable dates of initial cutting were tested: first cutting for hay was carried out on May 5 (budding) in the c_1 schedule, on May 15 (start of flowering) in the c_2 schedule, on May 25 (full flowering) in the c_3 schedule, and on May 5 and June 5 in the c_4 schedule. Second regrowth was used for seed production in the c_1-c_3 schedules, and third regrowth in the c_4 schedule. The study involved the seven most widely grown alfalfa cultivars in Serbia, six domestic and one French.

The single late cut (c_3 schedule) achieved the best balance among the yield components and thus the highest seed yield (468 kg/ha). Significant positive correlations were found between seed yield on one side and the number of fertile shoots per unit area and the number of pods per inflorescence on the other, r = 0.608 and r = 0.837, respectively.

Key words: pods, *Medicago sativa* L., pollination, lodging, seed production, stem

Introduction

In regions with semi-humid climate, weather conditions in the year of growing are the main source of variation in alfalfa seed yield. In years with high rainfall, alfalfa plants are lush and they lodge easily. Lodged plants are not suitable for pollination and low seed yields are consequently produced. To ensure high and stable seed yields, it is necessary to prevent the luxuriant growth of alfalfa plants and their subsequent lodging (Huyghe et al., 2001). Cutting is the most effective practice to limit the luxuriant growth. Also, cutting date is used for timing the beginning and duration of flowering period in seed crops, with the intention of synchronizing flowering period with maximum activity of pollinating insects.

The climatic conditions of Serbia favor the production of alfalfa seed from the second regrowth. The first regrowth is used for production of hay. With early first and second cuts, seed may be also produced from the third regrowth.

Materials and methods

Effect of cutting schedule on alfalfa seed yield and yield components was studied in four-year experiments (2001-2004). The experimental site was located in northern Serbia, at 45°20′ N, 19°51′ E, at 80 m above sea level. This area has a continental semiarid to semi humid climate, a mean monthly air temperature of 11.0°C, an annual sum of precipitation of around 600 mm, and a highly uneven distribution of precipitation. Table 1 shows the mean monthly air temperatures and monthly sums of precipitation for the period March-September. The trial was established according to a randomized block design with four replicates. Alfalfas were sown on April 8, 2000 at a row-to-row spacing of 25 cm and with a seeding rate of 15 kg ha^{-1} seed. The size elementary plot unit was 10 m^2 (2x5 m) with eight rows per plot.

Four cutting schedules with variable dates of initial cutting were tested: first cutting for hay was carried out on May 5 (budding) in the c_1 schedule, on May 15 (start of flowering) in the c_2 schedule, on May 25 (full flowering) in the c_3 schedule, and on May 5 and June 5 in the c_4 schedule. Second regrowth was used for seed production in the c_1-c_3 schedules, and third regrowth in the c_4 schedule.

The study involved the seven most widely grown alfalfa cultivars in Serbia, six domestic and one French (Table 6). The cultivars were tested for seed yield, total number of shoots per unit area, number of fertile shoots, plant height, number of pods per inflorescence and the number of seeds per pod.

Alfalfa seed was harvested in a single passage of a Hege harvester, following desiccation with *diquat* performed when about 70% of pods on normally developed plants were at the stage of physiological maturity. Seed yield was calculated on the basis of measurements of processed seed per elementary unit. The obtained results were statistically processed by the analysis of variance. Significance of differences between mean values was tested by the LSD test.

Tab. 1. Basic climatic parameters for the period 2001-2004
Tab. 1. Osnovni klimatski pokazatelji za period 2001-2004. godine

Parametar *Pokazatelj*	Year *Godina*	Month - *Mesec*							Sum/ Average *Suma/ prosek*
		March *Mart*	April *April*	May *Maj*	June *Jun*	July *Jul*	August *Avgust*	September *Septembar*	
Precipitation *Padavine* (mm)	2001	73	127	75	233	56	30	162	756
	2002	11	26	87	27	33	55	46	285
	2003	9	8	23	31	60	30	84	245
	2004	16	112	89	97	63	39	42	458
Mean air temperature *Srednja mesečna temperatura* (°C)	2001	10.9	11.2	17.8	18.2	22.3	22.7	16.1	17.0
	2002	8.9	11.7	19.1	21.7	23.6	22.2	17.0	17.7
	2003	6.0	10.9	20.6	24.0	22.6	24.6	17.2	18.0
	2004	9.0	14.8	15.5	20.7	21.9	20.4	13.9	16.6

Results and discussion

The average seed yield in the period 2001-2004 was 343 kg ha^{-1}, significantly higher than Serbian average of 250 kg ha^{-1}. Maximum variation in seed yield level was caused by weather conditions in the year of growing. In 2002, which had favorable ecological conditions, the yield of seed was 4.3 times higher than in 2001, which had highly unfavorable conditions. Numerous authors (Žarinov i Kljuj, 1990; Stjepanović, 1998; Bolanos-Aguilar et al., 2002; Karagić et al., 2003) agree that variation in alfalfa seed yield is primarily due to weather conditions in the year of growing. Among them, the total amount and distribution of rainfall were most important. However, yield level may be stabilized to a certain measure by adjusting cutting schedule.

Tab. 2. Seed yield depending on cutting schedule (kg ha^{-1})
Tab. 2. Prinos semena lucerke u zavisnosti od sistema kosidbe

Cutting schedule *Sistem kosidbe* (C)	Year - *Godina* (Y)				Average *Prosek*
	2001	2002	2003	2004	
c_1	163	573	372	234	335
c_2	167	589	203	297	314
c_3	225	1041	192	415	468
c_4	108	656	57	199	255
Average - *Prosek*	166	715	206	286	343

LSD	C	Y	C x Y
0.05	19.53	21.48	39.06
0.01	25.72	28.34	53.45

The highest seed yield, 468 kg ha^{-1}, was achieved with the system of late cutting (c_3). This yield was highly significant (higher by 28-46%) in relation to the other systems. When the first cutting is performed later in the season, plant regeneration will coincide with the time of year characterized by higher air temperatures and lower soil moisture, speeding up plant development (Kalu and Fick, 1981). The late cutting system ensured a low crop density, i.e. a reduced number of shoots per unit area. Simultaneously, this system produced the largest number of productive shoots (Table 3) and the largest portion of productive shoots in the total number of shoots. Regrowth rate was significantly faster in relation to the other systems, but the plants were shorter and they had a reduced number of internodes. Dry matter content in the stem was significantly higher in relation to the early and medium cutting systems (Karagić, 2004).

Tab. 3. Number of fertile stems per 1 m^{-2} depending on cutting schedule
Tab. 3. Broj produktivnih izdanaka po 1 m^{-2} u zavisnosti od sistema kosidbe

Cutting schedule *Sistem kosidbe* (C)	Year - *Godina* (Y)				Average *Prosek*
	2001	2002	2003	2004	
c_1	167	186	380	257	248
c_2	222	303	390	192	277
c_3	242	344	267	208	265
c_4	161	242	227	277	227
Average - *Prosek*	198	269	316	234	254

LSD	C	Y	C x Y
0.05	17.72	19.11	35.45
0.01	23.34	27.57	49.68

Owing to these characteristics, plant sensitivity to lodging was reduced and conditions for alfalfa flowering and activity of pollinating insects improved, resulting in highest number of pods per raceme (Table 4). Significant positive correlations were found between seed yield and the number of pods per raceme, r = 0.837.

The early and medium schedules produced lower yields (335 kg ha^{-1} and 314 kg ha^{-1}, respectively). In these schedules, the regrowth of the seed crop coincided with a period of high soil moisture and low air temperatures, resulting in the tallest plants (Table 5), lush and dense growth which is prone to lodging. The results obtained in the year 2003, which was extremely dry, were significantly different from the average values. The highest yield was achieved with the early schedule (372 kg ha^{-1}), the seed yield being significantly positively correlated with plant height (r = 0.668).

Tab. 4. Number of pods per raceme depending on cutting schedule
Tab. 4. Broj mahuna po cvasti u zavisnosti od sistema kosidbe

Cutting schedule *Sistem kosidbe* (C)	Year - *Godina* (Y)				Average *Prosek*
	2001	2002	2003	2004	
c_1	5.19	13.01	10.61	10.44	9.81
c_2	4.90	13.29	8.50	10.96	9.41
c_3	7.29	15.64	10.11	12.37	11.35
c_4	5.31	13.97	6.68	10.34	9.07
Average - *Prosek*	5.67	13.98	8.98	11.03	9.91

LSD	C	Y	C x Y
0.05	0.533	0.713	1.266
0.01	0.702	0.911	1.505

Tab. 5. Plant hight in flowering period depending on cutting schedule (cm)
Tab. 5. Visina biljaka u fazi cvetanja u zavisnosti od sistema kosidbe

Cutting schedule *Sistem kosidbe* (C)	Year - *Godina* (Y)				Average *Prosek*
	2001	2002	2003	2004	
c_1	111	77	54	89	83
c_2	112	90	55	97	88
c_3	92	81	46	102	80
c_4	88	63	38	60	62
Average - *Prosek*	101	78	48	87	79

LSD	C	Y	C x Y
0.05	1.926	2.103	3.982
0.01	2.536	2.927	5.773

The lowest seed yield, 255 kg ha^{-1}, was obtained with the c_4 schedule. Two cuttings for hay preceding seed production from the third regrowth (c_4) tend to reduce growth vigor of plants. Two cuts at the beginning of budding exhaust the plants in a certain way (Erić, 1988). Additionally, shortage of available soil water in the period of regrowth, intensive growth and budding of the third cut affects negatively the forming of alfalfa generative parts. Compared with optimum water supply, dry conditions reduce the number of fertile stems two times, which significantly reduces seed yield (Goloborodko and Bodnarčuk, 1998; Iannucci et al., 2002).

Tab. 6. Seed yield depending on cutting schedule and variety in 2001-2004 (kg ha^{-1})
Tab. 6. Prinos semena lucerke u zavisnosti od sistema kosidbe i sorte u periodu 2001-2004.

Variety *Sorta* (V)	Cutting schedule *Sistem kosidbe* (C)				Average *Prosek*
	c_1	c_2	c_3	c_4	
NS Banat ZMS II	307	264	429	287	322
Kruševačka 22	340	296	423	261	330
Novosađanka H-11	263	264	428	242	299
Zaječarska 83	346	370	469	272	364
NS Slavija	359	336	532	228	364
NS Mediana ZMS V	298	273	423	273	317
Europe Desprez	433	396	574	224	407
Average - *Prosek*	335	314	468	255	343

LSD	C	V	C x V
0.05	19.53	25.84	51.68
0.01	25.72	34.03	68.06

All varieties in the study produced maximum seed yields in the system of late cutting (c_3) (Table 3). Highest yields were achieved by Europe and Slavija (574 kg ha^{-1} and 532 kg ha^{-1}, respectively), the varieties least susceptible to lodging. On the other hand, varieties Europe and NS Slavija were very sensitive to drought and more intensive cutting schedule in c_4 treatment, thus they obtained lowest yields (224 and 228 kg ha^{-1}, respectively).

The lowest seed yield were obtained with Novosađanka (299 kg ha^{-1}), due to the presence of the yellow alfalfa (*M. falcata* L.) genes incorporated during breeding (*M. sativa* L. x *M. falcata* L.). The yellow alfalfa is susceptible to lodging and its seed yield capacity is low (Galilov, 1988).

Conclusion

Weather conditions in the year of growing exhibit most pronounced effects on alfalfa seed yield and yield components. Among these conditions, the total amount and distribution of rainfall play the decisive role. In this study, the yields of alfalfa seed ranged from 166 to 715 kg ha^{-1}.

Variations in alfalfa seed yield level may be controlled to some extent by the cutting scheduling. The late cutting in full flowering ensures a reduced stand density and maximum number of productive shoots. Also, plant height is reduced and number of pods per raceme significantly increased in relation to the systems of early and medium cutting. Consequently, plant sensitivity to lodging is considerably reduced while conditions for alfalfa flowering and activity of pollinating insects are improved, all that resulting in increased seed yield.

The effect of variety on alfalfa seed yield was significant. Highest seed yields were achieved by the varieties Europe and NS Slavija. The lowest seed yield was achieved by the variety Novosađanka. Genotype sensitivity to lodging was closely associated with seed yield - the lower the lodging rate, the higher the seed yield.

Acknowledgements

This research was supported by Ministry of Science, Technology and Development of the Republic of Serbia (Project No. 0412).

Literature

Bolaños-Aguilar E.D., Huyghe C., Ecalle C., Hacquet J., and Julier B. (2002): Effect of Cultivar and Environment on Seed Yield in Alfalfa. Crop Sci. 42:45-50.

Erić, P. (1988). Uticaj načina gustine setve na prinos i kvalitet semena lucerke (*Medicago sativa* L.) sorte NS-Banat ZMS II na zemljištu tipa černozem. Doktorska disertacija, Univerz. u Novom Sadu, Polj. fakultet, 176.

Galilov. A.A. (1988). Semenaja produktivnost ljucerni želtoj v zavisimosti od sposoba poseva i normi viseva semjan. Nekatorie aspekti semenovodstva lucerni. Selekcija i semenovodstvo, br 3, 51-53.

Goloborodko, S.P. & Bodnarčuk, L.I. (1998). Semenovodstvo ljucerni. Fitocentr, Kiev, 172.

Huyghe C., Julier B., Bolaños-Aguilar E.D., Ecalle C., and Hacquet J. (2001): Effect of cultivar and environment on seed yield in alfalfa. Quality in lucerne and medics for animal production. Proceedings of the XIV EUCARPIA Medicago spp. Group Meeting, Zaragosa, Spain, 127-130.

Iannucci A., Di Fonzo N., Martiniello P. (2002): Alfalfa (*Medicago sativa* L.) seed yield and quality under different forage mamagement systems and irrigation treatments in a Mediterranean environment. Field Crop Research, 78 (1): 65-74.

Kalu, B.A. & Fick, G.W. (1981). Quantifying morphological development of alfalfa for studies herbage quality. Crop Science 21, 267-271.

Karagić, Đ. (2004). Komponente prinosa, prinos i kvalitet semena lucerke u zavisnosti od sistema kosidbe. Doktorska disertacija. Poljoprivredni fakultet, Univerzitet u Novom Sadu, 174.

Karagic Đ., Katic S., Mihailovic V., Vasiljevic S., and Milic D. (2003): Correlations between alfalfa seed yield and ecological factors. Proceedings of the 12th Symposium of the European Grassland Federation, Optimal Forage Systems for Animal Production and the Environment. Pleven, Bulgaria, Vol. 8, 372-376.

Stjepanović, M. (1998). Lucerna. Nova zemlja, Osijek, 145.

Žarinov & Kljuj (1990). Ljucerna, 2. Izdanie, pererabotano i dopolnenoe. Urožaj, Kiev, 238.

KOMPONENTE PRINOSA SEMENA LUCERKE U ZAVISNOSTI OD SISTEMA KOSIDBE

Đura Karagić, Dragan Milić, Slobodan Katić, Sanja Vasiljević

Institut za ratarstvo i povrtarstvo, Novi Sad

Izvod: Da bi se osiguralo postizanje visokih i stabilnih prinosa semena potrebno je sprečiti suviše bujan rast i poleganje lucerke. Najefikasnija mera kojom se utiče na bujnost lucerke je kosidba useva. Takođe, kosidbom se određuje kalendarski rok početka i dužina trajanja faze cvetanja semenskog useva, kako bi se cvetanje podudarilo sa maksimalnom aktivnošću insekata oprašivača, što je od presudnog značaja za prinos semena lucerke.

U cilju utvrđivanja komponenti prinosa, prinosa i kvaliteta semena lucerke u zavisnosti od sistema kosidbe semenskog useva izvršena su četvorogodišnja ispitivanja na Rimskim Šančevima. Ispitivana su četiri sistema kosidbe: rani sistem - kosidba krmnog otkosa 05. maja (u fazi butonizacije), srednje rani sistem - kosidba 15. maja (u fazi početka cvetanja), kasni sistem - kosidba 25. maja (u fazi punog cvetanja) i proizvodnja semena iz trećeg otkosa (kosidba 05. maja i 05. juna). Ispitivanje je izvršeno na sedam najrasprostranjenijih sorti lucerke u Srbiji, šest domaćih i jedna francuska.

Ključne reči: mahune, *Medicago sativa* L., oprašivanje, poleganje, proizvodnja semena, stabljika