

Alfalfa seed production in semi-humid climate of the southeast Europe

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Abstract

The main characteristic of the seed production of alfalfa (*Medicago sativa* L.) in South East Europe is an extremely wide variation of yield, depending on weather conditions in a specific year, from 50 kg ha⁻¹ to 1000 kg ha⁻¹. In the most important agricultural region of Serbia, during thirteen years (1997-2009) and on four locations, there were measured alfalfa seed yields and monitored basic meteorological data, such as maximum, minimum and average daily air temperatures, insolation, rainfall and number of days with rainfall. The effect of ecological factors on seed yield was pronounced. The lowest average yield was obtained in 2005 (49 kg ha⁻¹), the highest in the year 2008 (530 kg ha⁻¹), while the yield in 1998 was somewhat lower than the long term-average for the Serbia (283 kg ha⁻¹). Highly significant positive correlations were obtained between seed yield on one side and mean and maximal air temperatures and solar radiation on the other: 0.633^{**}, 0.676^{**} and 0.355^{**}, respectively. Highly significant negative correlations existed between seed yield and precipitation data: for growing season (May-August), $r = -0.667^{**}$; for June-August, $r = -0.660^{**}$, and for July-August, $r = -0.761^{**}$, respectively. The main limiting factor of alfalfa seed production in semi-arid climatic conditions of southeast Europe is a high rainfall during the growing season of alfalfa seed stand (May-August), especially in the stages of flowering and maturity (July-August).

Key words: *Medicago sativa* L., seed, yield, lodging, environment, correlation.

Introduction

Alfalfa is the most important forage legume due to its high forage yields of excellent quality. The area under alfalfa in the South East Europe takes between 3.5 % and 5 % of the total arable land. In Croatia, it is grown on 42.000 ha (Stjepanović *et al.*, 2009), in Hungary 150.000 ha and in Romania on 500.000 ha (Valentina, pers. comm.). In Serbia, with its central position in the South East Europe, alfalfa is cultivated on about 200,000 ha (www.fao.org). According to the data of the Department of Statistics, the production of the certified alfalfa seed in 2009 was carried out 2.900 ha, while it is estimated that the non-certified alfalfa seed is produced on more than 1.000 ha (Karagić *et al.*, 2007).

Alfalfa has a genetically determined potential render extremely high forage yields, which are often in a negative correlation with seed yields (Bolanos-Aguilar *et al.*, 2002). Good alfalfa

cultivars are characterized by slender, soft and easily digestible stems. Such plant morphology and mechanical features of the stem make them prone to lodging.

Because of these characteristics, alfalfa seed yield is strongly affected by ecological factors and it varies significantly in dependence of weather conditions, more than the other crops. Average long-term variations in seed yield are 14,5% in corn, 17,6% in winter wheat and up to 57% in alfalfa (Zarinov & Kljuc, 1990).

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 (Huyghe *et al.*, 2001). In conditions of high soil moisture, there are no effective cultural practices to avoid the lodging of seed crop and seed losses. The most efficient measure is the selection of suitable production region. Moderate soil moisture content in combination with high air temperatures is required for seed production (Goloborodko & Bodnarcuk, 1998).

The objectives of this paper were to analyze the alfalfa seed yields obtained in Serbia and to establish correlations between the seed yields and the ecological factors.

Materials and Methods

Impact of weather condition on alfalfa seed yield was studied in thirteen experimental years (1997-2009) on four locations. The experimental sites were located in northern Serbia, at 45°83' N, 20°46' E (Kikinda), 45°77' N, 19°11' E (Sombor), 45°20' N, 19°51' E (Novi Sad), and 44°58' N, 19°36' E (Mitrovica). This area has a continental semi-arid to semi-humid climate, a mean monthly air temperature of 11.0°C, a total annual precipitation of around 600 mm, and a highly uneven distribution of precipitation. Table 1 shows the monthly mean air temperatures and monthly sums of precipitation for the period May-August.

Table 1. Basic meteorological parameters of four locations in Serbia (1997-2009)

Climatic factor	Locality	Month				Average/ Total
		May	June	July	August	
Mean air temperature (°C)	Kikinda	17,6	21,0	22,6	22,3	20,9
	Sombor	17,6	20,7	22,1	22,0	20,6
	Novi Sad	17,7	20,8	22,3	22,2	20,7
	Mitrovica	17,7	20,7	22,1	22,0	20,6
	Average	17,7	20,8	22,3	22,1	20,7
Precipitation (mm)	Kikinda	48,5	70,9	58,6	54,2	232,2
	Sombor	49,1	81,2	78,8	55,0	264,1
	Novi Sad	62,2	92,8	76,2	58,4	289,6
	Mitrovica	56,4	80,1	66,5	55,2	258,2
	Average	54,1	81,3	70,0	55,7	261,0

Rather near the meteorological stations there has been established a long-term trial with two alfalfa cultivars (NS Banat ZMS II and NS Mediana ZMS V) in the spring of 1996. Both cultivars were sown with a row spacing of 12.5 cm and with a seeding rate of 15 kg ha⁻¹. The trial was set up according to a randomized block design with four replicates. The plot size was 10 m² (2 x 5 m) with 16 rows per plot. The alfalfa seed is produced in the period starting with the second and ending with the fifth year of growth. On each location the sowing is repeated every fourth year. The first cut is done in the stage of full flowering (late May), when the cut biomass is removed from the field, while the seed is produced in the second growth.

Alfalfa seed was harvested in a single passage of a Hege harvester, after desiccation with Diquat performed when about 70% of pods on normally developed plants were in the stage of physiological maturity (mid-August). Seed yield was calculated on the basis of measurements of processed seed per plot. The obtained results were statistically processed by the analysis of variance. The differences among mean values were compared using the least significant difference test (LSD). Because the analyses of variance did not show significant differences in seed yield between the tested cultivars, the values are reported as means of the two varieties. The simple correlation coefficients were calculated between the seed yields of the tested cultivars and the monitored meteorological parameters, with 104 pairs, and for three periods: seed stand period (from May till August), the period of budding to harvest (June-August), and for the period of flowering to harvest (July-August).

Results and Discussion

The maximum variation in seed yield was caused by weather conditions in the growing year. In 2008, which had favorable ecological conditions, the seed yield was 10.8 times higher than in 2005, which had extremely unfavorable conditions (Table 2). The highest average seed yield was on the location of Kikinda (348 kg ha⁻¹), while the differences in seed yields between the other locations were not significant.

Table 2. Alfalfa seed yield depending on location in the period 1997-2009

Year (Y)	Location (L)				Average
	Kikinda	Sombor	Novi Sad	Mitrovica	
1997	217	220	50	360	212
1998	300	270	250	310	283
1999	44	120	50	180	99
2000	450	480	510	380	455
2001	290	244	220	246	250
2002	330	230	300	270	283
2003	310	480	300	230	330
2004	340	210	250	200	250
2005	70	15	50	60	49
2006	320	160	220	100	200
2007	530	400	480	390	450
2008	880	300	580	360	530
2009	440	500	500	560	500
Average	348	279	289	280	299

LSD	Y	L	Y x L
0.05	22.06	17.11	41.15
0.01	31.18	23.82	64.63

Table 3. Correlation between alfalfa seed yield and some climatic factors (1997-2009)

Climatic factor	Analyzed period		
	May-August	June- August	July - August
Mean air temperature	0,575	0,611	0,633
Max air temperature	0,676	0,649	0,632
Min air temperature	-0,156	-0,118	-0,161
Insolation	0,154	0,355	0,307
Precipitation	-0,667	-0,660	-0,761
No. of rainy days	-0,628	-0,636	-0,692

Highly significant positive correlations were obtained between seed yield on one side and mean and maximal air temperatures and solar radiation on the other: 0.633** (July-August), 0.676** (May-August) and 0.355** (June-August), respectively (Table 3). Highly significant negative correlations existed between seed yield and precipitation data: for growing season (May-August), $r = -0.667^{**}$; for June-August, $r = -0.660^{**}$, and for July-August, $r = -0.761^{**}$, respectively. Numerous authors (Žarinov & Ključ, 1990; Huyghe *et al.*, 2001; Bolanos-Aguilar *et al.*, 2002; Karagić *et al.*, 2007; Stjepanović *et al.*, 2009) 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.

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