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CORELLATIONS AMONG ALFALFA YIELD COMPONENTS

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Presented in this paper are the results of our study of correlations among yield components in ten alfalfa genotypes under open pollination (*polycross*) conditions. The study was conducted between 2000 and 2002 at the Rimski Sancevi Experiment Field of the Institute of Field and Vegetable Crops in Novi Sad. Highly significant correlations were found between pod number per inflorescence and seed number per inflorescence (r= 0.645) as well as between seed number per pod and seed number per inflorescence (r= 0.685). Similarly, the correlation between inflorescence number per stem and seed yield was significant and positive (r= 0.589). Negative correlations existed between ovule number per ovary on the one hand and seed yield and inflorescence number per stem on the other (r=- 0.617 and r=- 0.598, respectively).

The highest seed yield was achieved with the cultivar Europe (651.4 kg ha $^{-1}$) and the lowest with the genotype Le-6 (426.25 kg ha $^{-1}$). The difference was highly significant (CV= 14,93%).

Key words: alfalfa, genotypes, open pollination, genetic variability, correlations, seed yield.

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INTRODUCTION

In the world in general and in our country in particular, alfalfa seed yields are still low and considerably variable according to year. Increasing the genetic potential for seed yield and seed production of alfalfa cultivars is one of the most important objectives of alfalfa breeding.

In the different agroecological conditions in our country, alfalfa seed yields average 250-300 kg ha^{-1}, with the highest reaching up to 800-1,000 kg ha^{-1}, depending on weather conditions, cultural practices, abundance of insect pollinators, and other factors (LUGIĆ *et al*., 2000; ĐUKIĆ, 2000; KARAGIĆ *et al*., 2003, 2004).

In view of the importance of advancing alfalfa seed production in our country, the objective of this study was to investigate correlations among alfalfa seed yield components and the variability of alfalfa seed yield under open pollination (polycross) conditions. The results of the study were then to be used to select the highest-yielding genotypes for further breeding work and new cultivar development.

MATERIALS AND METHODS

Chosen for our analysis of correlations among alfalfa seed yield components were 10 genetically divergent genotypes of his crop that are part of our breeding program aimed at developing alfalfa cultivars with an increased potential for forage and seed yields.

The study included the domestic cultivar NS-Slavija (1990), a French one called Europe (1961, INRA, 86600 Lusignan), and another eight genotypes originating from France, Denmark and the U.S.

The study was conducted at the exeriment field of the Forage Crops Department of the Institute of Field and Vegetable Crops in Novi Sad. A trial was set up in the spring of 1999 (Ao) on a slightly calcareous chernozem soil using a randomized block design with six replications. The basic plot size was 2.5 m^2, the row-to-row distance 80 cm, and the distance between the blocks 1 m. The seeding rate was 1.25 g m^{-2} per genotype and the sowing depth around 1.5 cm. During 2000 (A_1) and 2002 (A_3), samples were take from the second cut (C_2) to study yield components and seed yield.

Based on the seed yield component results, coefficients of correlation (r) were calculated for the fertility of male and female gametophytes, inflorescence number per stem, pod number per inflorescence, seed number per pod, seed number per inflorescence, inflorescence length, flower number per inflorescence, and seed yield.

Analysis of genetic variability of seed yield (g m^{-2}, or kg ha^{-1}) was done at full pod maturity, after threshing and manual processing. ANOVA and the *t*-test were used to determine significance among the mean values and the coefficient of variation was calculated ($CV_{\%}$).

METEOROLOGICAL CONDITIONS

Particularly important for alfalfa seed production are air temperatures during June, July and August, i.e. air temperatures during flowering, pod formation, maturation and seed harvesting. During the April-August period of 2000, the average air temperature was 20.2ºC, which was 2.0ºC above the long-term average (18.2ºC). The temperature in June was 21.4ºC, or 1.6ºC more than the long-term average. During the 2002 growing season, the mean daily air temperature was 19.7ºC, or 1.5ºC above the long-term average (Tab. 1).

Table 1. Mean monthly air temperatures (^oC) and rainfall amounts (l m^{-2}) at Rimski Šančevi in 2000 and 2002

Month/10-day period		Air temperature (°C)			Rainfall (l m^{-2})		
		2000	2002	Average 1948-86	2000	2002	Average 1948-86
April	I	10.3	8.3		17	2	
	II	16.6	12.6		1	11	
	III	18.0	14.2		6	13	
	Average/Sum	15.0	11.7	11.6	24	26	47
May	I	17.7	18.3		18	7	
	II	19.7	19.6		5	21	
	III	18.2	19.4		16	59	
	Average/Sum	18.5	19.1	16.4	39	87	57
June	I	20.4	18.8		0	5	
	II	22.3	22.9		23	12	
	III	21.4	23.7		5	10	
	Average/Sum	21.4	21.8	19.8	28	27	81
July	I	24.5	23.8		21	9	
	II	19.1	24.8		7	21	
	III	22.7	22.2		1	3	
	Average/Sum	22.1	23.6	21.5	29	33	63
August	I	23.5	23.2		0	49	
	II	26.3	21.0		2	6	
	III	22.5	22.3		3	0	
	Average/Sum	24.1	22.2	21.8	5	55	47
Average/Sum		20,2	19.7	18.2	125	228	295

As for precipitation, there was 125 l m^{-2} of rainfall during April-August of 2000, which was 170 l m^{-2} less than the long-term average of 295 l m^{-2}, while in June and July of the same year there was 28 and 29 l m^{-2} of rainfall, respectively, or 50% less than the said average. In the growing seasaon of 2002, there was 228 l m^{-2} of rainfall, which was 67 l m^{-2} below the average (Tab. 1).

RESULTS AND DISCUSSION

Along with dry matter yield and quality, seed yield is one of the major focal points of alfalfa growers and, especially, breeders. In alfalfa cultivar development, the choice of the starting material significantly affects breeding success, all the more so if correlations among the major quantitative traits are well-known (Tab. 2).

Table 2. Coefficients of correlation yield components and seed yield in alfalfa genotypes

Trait	Ovules/ ovary	Inflor./ stem	Pods/ inflor.	Seeds/ pod	Seeds/ Inflor.	Inflor. length	Flowers/ Inflor.	Seed yield
Pollen fert.	–0.445	0.394	0.271	–0.309	–0.014	–0.014	0.283	0.323
Ovules/ovary	–	–0.598*	–0.249	–0.096	–0.173	0.256	–0.148	–0.614**
Inflor./stem.	–	–	–0.02	–0.108	–0.264	–0.01	0.367	0.589*
Pods/inflor.	–	–	–	0.117	0.645**	0.081	–0.155	0.076
Seeds/pod	–	–	–	–	0.685**	–0.032	–0.163	0.109
Seeds/inflor.	–	–	–	–	–	0.02	–0.265	0.296
Inflor. length	–	–	–	–	–	–	0.151	0.253
Flowers/inflor.	–	–	–	–	–	–	–	0.312

$\alpha_{(0.05;\ 15\ st.\ sl.)} = 0.482$
$\alpha_{(0.01;\ 15\ st.\ sl.)} = 0.606$

The correlation coefficients calculated from our results revealed a strong positive correlation between seed number per pod and seed number per inflorescence (r=0.685) as well as between pod number per inflorescence and seed number per inflorescence (r=0.645). There was also a significantly positive relationship between inflorescence number per stem and seed yield (r=0.589).

The correlation coefficient values for the fertility of the female gametophyte showed a significant negative correlation between ovule number per ovary and seed yield (r= –0.614) as well as between ovule number per ovary and inflorescence number per stem (r= –0.598). Correlations among the other yield components were not significant.

According to ĐUKIĆ and KRALJEVIĆ-BALALIĆ (1992), there is a strong positive correlation between pollen fertility and seed yield (r= 0.51) and very little correlation between ovule number per ovary and seed yield (r= 0.25). ALEKSIĆ and ĐUKIĆ (2004) have also reported highly significant positive correlations between pollen fertility and inflorescence number per stem (r= 0.60) and ovule number per ovary and inflorescence number per stem (r= 0.71).

GARTNER et DAVIS (1966) found no correlation between ovule number per ovary and seed number per pod. Along the same line, DATTÉE (1972, 1976) pointed out that with diplod and tetraploid alfalfa forms the number of ova is not a limiting factor in seed production.

ĐUKIĆ and BOLANOS (1998) reported that seed yield per plant was positively correlated with seed number per pod (r= 0.76) and seed number per inflorescence (r= 0.78).

Our analysis of variance showed highly significant differences among the ten genotypes studied in the mean values of seed yield per plant, resulting in a high coefficient of variation for this trait (CV= 14.93%), tab. 3.

Table 3. Seed yield (kg ha^{-1}) of alfalfa genotypes

Genotype	Year		$\overline{X}$
	A_1C_2	A_3C_2	
NS-Slavija	620.74	385.93	503.33
Rs-2	857.40	272.05	564.72
Ao-3	637.84	305.67	471.75
Di-4	691.51	324.33	507.92
Europe	873.13	429.67	651.40
Le-6	510.33	342.18	426.25
Ja-7	817.86	474.18	646.02
Ci-8	987.73	298.11	642.92
V-117	865.96	368.93	617.44
Ri-11	650.07	339.17	494.62
$\overline{X}$	751.26	354.02	552.64
CV(%)	19.91	17.57	14.93
LSD 0.05	78.79	34.54	-
0.01	106.40	46.65	

In the present study, combined alfalfa utilization (seed production in second cut, forage production in first and third) produced an average seed yield of 552.64 kg ha^{-1}, which is significantly more than the average seed yield of alfalfa obtained in our country. The highest seed yields were obtained with the cultivar Europe (651.4 kg ha^{-1}) and the genotypes Ja-7 (646.02 kg ha^{-1}), Ci-8 (642.92 kg ha^{-1}) and V-117 (617.44 kg ha^{-1}) and the lowest with the genotype Le-6 (426.25 kg ha^{-1}), so the differences were highly significant (Tab. 3).

In the first year of study (A_1), the second cut (C_2) produced 751.26 kg ha^{-1} seed on average. Compared with the average seed yields of alfalfa in Serbia (250-350 kg ha^{-1}), all of the genotypes in the study produced high seed yields. The

highest was found in the genotype Ci-8 (987.73 kg ha^{-1}) and the lowest in Le-6 (510.33 kg ha^{-1}), so the differences among the genotypes were highly significant.
In the second year of study (third year of utilization) (A_3), the seed yield was considerably lower, ranging from 474.18 kg ha^{-1} (Ja-7) to 272.05 kg ha^{-1} (Rs-2), or 354.02 kg ha^{-1} on average (Tab. 3).

The study results indicate that the expression of seed yield is highly influenced by year as well as by genotype *x* year interaction.

Many researchers have pointed out the importance of genotype x environment interaction for alfalfa seed yield and yield components (BOLANOS-AQUILAR *et al*., 2001; HILL and BAYLOR, 1983; ROD, 1979). According to observations made by HACQUET (1990) in field conditions, the biological potential for alfalfa seed yield is around 2,000 kg ha^{-1}. The discrepancy between the potential and actual yields of this crop can be explained by the morphology of the plant and its continual growth, i.e. by its specific flowering, method of pollination, and other factors.

Thanks to its genetic characteristics and growing requirements, alfalfa can form over 58.000 flowers per m^2. Provided pollination is complete (100%), up to 4,400 kg ha^{-1} of seed could be obtained (TYSDALU, 1946). In actual production conditions, however, the seed yields of this crop are many times lower.

CONCLUSION

Based on our analysis of correlations among alfalfa seed yield components and of genetic variability of alfalfa seed yield, the following conclusions can be made:

Under open pollination (*polycross*) conditions, we found highly significant correlations between pod number per inflorescence and seed number per inflorescence (r= 0.645) as well as between seed number per pod and seed number per inflorescence (r= 0.685). The relationship between inflorescence number per stem and seed yield was significantly positive (r=0.589) and negative correlations were found between ovule number per ovary and seed yield (r=–0.614) and ovule number per ovary and inflorescence number per stem (r=–0.598).

Depending on weather conditions, seed yields varied from 751,26 kg ha^{-1} (year 2000) do 354.02 kg ha^{-1} (year 2002), averaging 552.64 kg ha^{-1}. The highest yields were obtained with the cultivar Europe (651.40 kg ha^{-1}) and the lowest with the genotype Le-6 (426.25 kg ha^{-1} semena), making the differences among the genotypes used in the study highly significant.

The cultivars and genotypes under study are characterized by good combining abilities and a high genetic potential for seed yield, which was positively correlated with all of the traits except ovule number per ovary.

The best genotypes from our study in terms of seed yield (Rs-2, Europe, Ja-7, Ci-8, and V-117) can be included in our further breeding program for developing high-yielding alfalfa synthetics.

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KORELACIONI ODNOSI KOMPONENTI PRINOSA SEMENA LUCERKE

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I z v o d

U radu je dat prikaz rezultata istraživanja korelacionih odnosa komponenti prinosa semena 10 genotipova lucerke u uslovima slobodne oplodnje (*polycross*). Istraživanja su obavljena u Naučnom institutu za ratarstvo i povrtarstvo u Novom Sadu u Rimskim Šančevima od 2000. do 2002. godine. Na osnovu rezultata istraživanja, ustanovljene su visoko značajne korelacione veze između broja mahuna po cvasti i broja zrna po cvasti (r= 0,645), kao i broja zrna po mahuni i broja zrna po cvasti lucerke (r= 0,685). Takođe, odnos između broja cvasti po stabljici i prinosa semena bio je značajno pozitivan (r= 0,589). Nasuprot tome, utvrđena je negativna korelacija između broja ovula po ovarijumu i prinosa semena (r= –0,614), kao i broja ovula po ovarijumu i broja cvasti po stabljici lucerke (r= –0,598).

Najveći prinos semena lucerke ostvaren je sa sortom Europe (651,40 kg ha^{-1}), a najmanji sa genotipom Le-6 (426,25 kg ha^{-1} semena), pa su razlike bile visoko značajne (CV=14,93%).

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