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B84 VS. B37 MAIZE HYBRID PERFORMANCE

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Efficiency of the half-sib recurrent selection (HSRS) method applied to the Iowa Stiff Stalk Synthetic (BSSS) can be evaluated indirectly through the performance of hybrid combinations with inbreds developed from different cycles of selection of the mentioned population. Efficiency was estimated by comparison of the performance of hybrids derived by crossing inbreds B84 (BSSSC7) and B37 (BSSSC0) to 20 unrelated inbred lines. The results obtained indicated that hybrids with inbred B84, on the average, overyielded hybrids with inbred B37 by 11.30%. In relation to the success of recurrent selection this increase amounts to 1.61% per cycle of selection. Although moisture determined in hybrids as an indicator of maturity was greater in hybrids with inbred B84 (0.90%* on average), the value of performance indices was 6.98% higher in the hybrids with inbred B84 showing that higher grain yield was not just a result of later maturity. Estimates of the coefficient (bx_i) in the linear regression equation were similar for both series of hybrids. The value of the rank correlation coefficient for grain yield (0.759**) indicates the existence of similar differences between hybrid rank in both series. All the above mentioned points to B84 as an inbred line with better general or specific combining abilities than inbred line B37 indicating the effectiveness of HSRS applied to BSSS.

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INTRODUCTION

Different methods of recurrent selection of maize are applied with the aim of increasing the frequency of favorable alleles while maintaining genetic variability of the initial source population. One of the basic assumptions is that the application of a particular method of recurrent selection to the selected or developed initial material shall, at a certain stage, result in the development of inbred lines with appropriate performance *per se*, as well as with superior combining ability. Such inbred lines are expected to be widely used in breeding programs with adequate commercial effects.

The Iowa Stiff Stalk Synthetic (BSSS) was among the first developed populations. It was derived from 16 maize inbred lines resistant to lodging in the 1930's. The primary purpose of synthetic development was to develop the initial material for breeding for resistance to lodging and high yield (SPRAGUE, 1946). Different methods of recurrent selection, including half-sib recurrent selection (HSRS), using the double cross hybrid - Iowa 13 as a tester were applied to this synthetic (HALLAUER and MIRANDA, 1988). Both this synthetic population *per se*, as well as inbred lines derived from different cycles of HSRS, first of all, B14 and B37 ($BSSSC_0$), B73 ($BSSSC_5$) and B84 ($BSSSC_7$), certainly belong to the group of most world-wide used genetic sources for hybrid development. The values of inbred lines developed from different cycles of selection of BSSS do not result only from direct participation in the hybrid combinations, but also from their use as a source for derivation of various versions by pedigree selection. Inbreds developed in such a way (A632, A634. CM105, H84, H93, etc.) have been widely applicable in commercial breeding programs (HALLAUER, 1984). According to ZUBER and DARRAH (1980), 42.2% of USA maize hybrid seed production in 1979 was based on inbreds with BSSS germplasm.

BSSS is certainly the maize population most frequently used for theoretical or empirical studies, as summarized by HALLAUER and MIRANDA (1988). Many aspects related to the efficiency of direct (improvement of combining abilities) or indirect selection effects (increase of yield *per se*) were intensely studied first of all by comparing population performances of different cycles. However, the efficiency of the applied HSRS method can be indirectly assessed from performances of inbred lines selected from appropriate cycles of selection.

The objective of this study was to evaluate agronomic traits of hybrids developed by crossing inbreds B84 ($BSSSC_7$) and B37 ($BSSSC_0$) to 20 unrelated inbred lines. The results obtained and genetic parameters, estimated on the basis of the results, should point to differences between the two mentioned inbreds, which occur or can be explained by the effects of the HSRS method applied to BSSS after seven completed cycles of selection.

MATERIALS AND METHODS

Two inbred lines, developed from different cycles of selection of BSSS (HSRS program with the hybrid Iowa 13 used as the tester), were used in this research:

- B37 ($BSSSC_0$), selected from S_1 inbreds of the initial cycle of selection, has been used for commercial purposes since 1958,
- B84 ($BSSSC_7$), selected in a similar way from the 7^{th} cycle of selection, has been used in hybrid combinations since 1978.

These two inbred lines were crossed to the following 20 unrelated inbreds:

A - Public inbred lines: C103; Mo17; A619; Va35; A81-20; L161; A660; H99; N143; Oh43Ht; (inbreds developed at US universities originating mainly from the Lancaster population, which is traditionally used as an opposite heterotic source for crosses to inbreds of BSSS origin).

B - Developed at the Maize Research Institute, Zemun Polje, Belgrade, Yugoslavia from local populations (V395/34; P3/72-1; S144; V1/72-1) or from crosses of US germplasm to local Yugoslav germplasm (H64/2-1-4; ZPL201; ZPL 1601/5; V312A; AS75/4-5 ZPL 1662).

Two parallel trials were set up according to a 4-replicate randomized complete block design in three locations (Zemun Polje - dryland farming, Zemun Polje - irrigation and Bijeljina). Hybrid combinations with the inbred B37, or inbred B84 were included in the first, and second trial, respectively. Hand planting was performed with density higher than planned and final thinning was done to the planting density of 54,900 plants/ha. The elementary plot size amounted to $5.10m^2$ with 28 plants per plot. The usual maize growing practices were applied. Harvesting was done by hand. The data obtained were processed by analysis of variance and covariance (random model - two factorial analysis). The average values of grain yield and grain moisture percentage were used to compute the performance index: PI = [(grain yield/moisture %) x 100]. The significance of differences among pairs, as well as, rank correlation (Spearman's rank coefficient, according to HADŽIVUKOVIĆ, 1973), were determined for grain yield and PI.

RESULTS AND DISCUSSION

The differences for grain yield between hybrid pairs are presented in Table 1. Only the combinations B37 with L161 (0.262 t/ha) and H99 (0.107 t/ha) had higher yields than the crosses of these two inbreds to B84, which can be explained by the specific combining abilities of these two inbreds. All other inbreds crossed to B84 overyielded their crosses to B37. The average difference for grain yield between both series of hybrids amounted to 1.312 t/ha. This represents a direct indicator of the genetic gain after seven cycles of HSRS with BSSS. On average, crosses to B84 overyielded crosses to B37 by 11.30%. With relation to the success of recurrent selection this increase amounts to 1.61% per cycle of selection, confirming the results of many authors who studied the efficiency of recurrent selection (RUSSELL 1984, 1985, 1986, IVANOVIĆ and STOJNIĆ 1988, HALLAUER 1989,

Table 1. B84 versus B37 maize hybrid performance

Crossed by	B 84 (BSSSC7)				B 37 (BSSSC0)				Differences in %B84 - B37	
	GY t/ha	R	% H_2O	PI	GY t/ha	R	% H_2O	PI	GY	PI
C103	14.808	3	19.4	76.3	12.898	1	20.0	64.5	1.910	11.84
Va35	13.376	9	22.9	58.4	11.895	7	23.7	50.2	1.481	8.22
A619	12.347	13	24.9	49.6	11.243	13	22.2	50.6	1.104	-1.06
ZPL201	14.254	2	22.8	62.5	13.087	4	22.3	58.7	1.167	3.83
V395/34	14.442	1	20.3	71.1	13.545	2	20.4	66.4	0.897	4.75
ZPL 1601/5	13.850	4	26.3	52.7	12.423	5	25.6	48.5	1.427	4.13
ZPL 1662	13.098	7	26.2	50.0	12.295	8	24.6	50.0	0.803	0.01
A81-20	12.271	15	20.0	61.4	11.159	15	19.8	56.4	1.112	5.00
P3/72-1	13.394	11	26.0	51.5	11.638	6	23.3	49.9	1.756	1.57
S144	12.949	12	21.3	60.8	11.433	10	21.8	52.4	1.516	8.35
V312A	11.604	17	25.5	45.5	10.636	18	25.8	41.2	0.968	4.28
L161	11.557	10	23.5	49.2	11.819	20	22.4	52.8	-0.262	-3.58
V1/72-1	12.722	8	20.9	60.9	12.110	12	19.9	60.9	0.612	0.02
A660	13.037	14	23.4	55.7	11.234	9	19.7	57.0	1.803	-1.31
H99	12.297	5	23.4	52.6	12.404	14	22.9	54.2	-0.107	-1.61
N143	12.766	16	22.2	57.5	10.837	11	21.5	50.4	1.929	7.10
Oh43Ht	11.559	18	20.8	55.6	10.011	19	20.1	49.8	1.548	5.77
H64/2-1-4	12.058	19	21.3	56.6	9.867	16	20.1	49.1	2.191	7.52
AS75/4-5	11.659	20	21.5	54.2	9.271	17	22.7	40.8	2.388	13.39
Mo17	14.353	6	23.4	61.3	12.347	3	20.4	60.5	2.006	0.81
Average	12.920		22.8	56.7	11.608		21.9	53.0	1.312**	3.70**
LSD 0.05	0.301		0.44	2.12	0.241		0.44	2.06		
LSD 0.01	0.395		0.58	2.80	0.316		0.58	2.72		

** $p < 0.01$; GY - grain yield; PI - Performance index;
R - rank according to grain yield performance;

STOJNIĆ 1990). Fig. 1a shows the differences in grain yield between appropriate pairs of test crosses of inbreds B84 and B37 to selected unrelated inbreds. Only three combinations within the B84 trial yielded less than the average yield in the B37 trial. At the same time, only the two top yielding combinations within this trial had grain yields higher than the average grain yield (12.920 t/ha) obtained within the B84 trial. With regard to relative yield increase (Fig. 1b), the yield of only two hybrids based on B84 was higher by 20% than the yield of the same hybrids based on B37, while the greatest number of combinations gave a 5 to 10% higher yield in combinations with B84. Based on hybrid ranked according to yield (Fig. 1c) it may be observed that the five top yielding hybrids based on B84 overyielded the five top yielding hybrids with B37 by 11.42%. Among the five top yielding combinations in both trials, four inbreds occurred as common parental components with inbreds B84 and B37 (C103, V395/34, ZPL201 and ZP1601/5). Furthermore, the

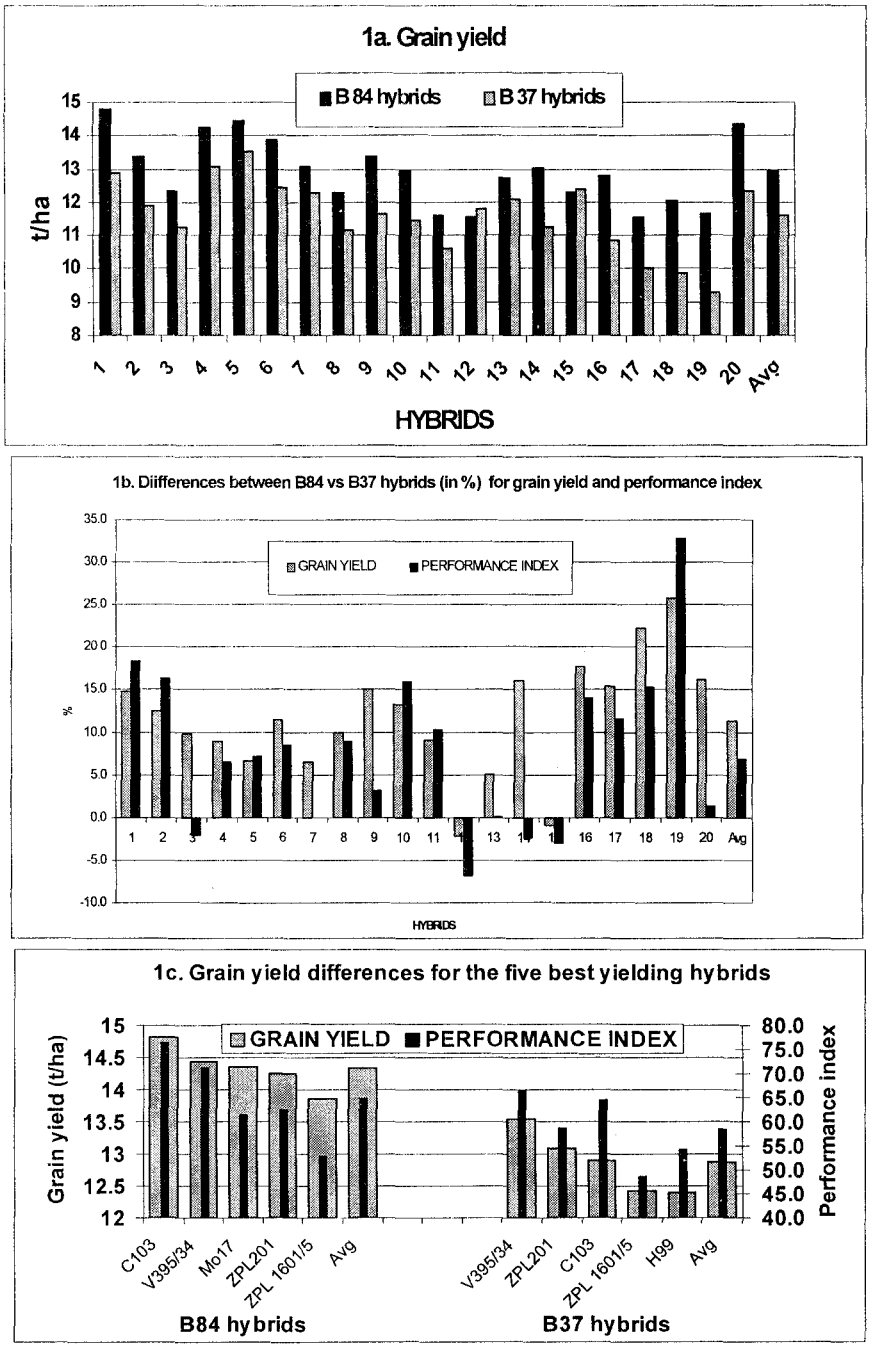
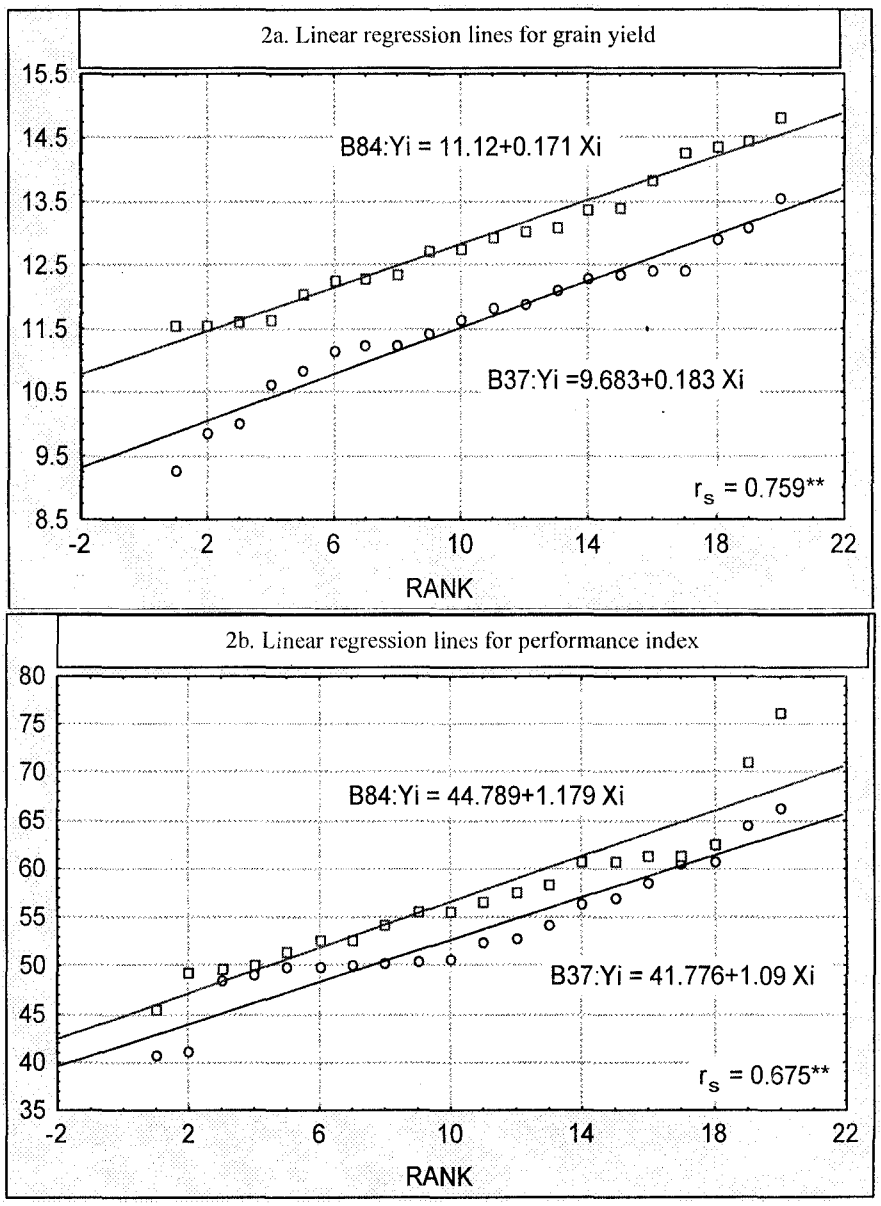


Fig. 1. B84 vs B37 maize hybrid performance

five lowest-ranking hybrids had four common male components (H64/2-1-4, AS75/4-5, V312 and Oh43Ht). The difference in the grain yield level for the five lowest yielding hybrids was 15.44% in favor of B84 hybrids.



* p<0.01; rs = Spearman's rank coefficient

Fig. 2. B84 vs. B37 linear regression line

The inbred Mo17 was very often used as a tester when combining abilities of BSSS and inbreds derived from it were observed. The increase in grain yield obtained (16.25%) confirms the superiority of inbred B84 over inbred B37 (Table 1). Evaluating combining abilities of inbreds derived from different cycles of selection of BSSS using Mo17 as a common tester, RUSSELL (1985) found a slightly lower percentage of B84 superiority in relation to other inbreds from previous cycles of selection (B84>B73>B37>B14 = 12.6%; 8.9%; 7.8%). However, based on an ample ten-year experiment in which performances of hybrids B84 and B37 crossed to Mo17 were compared, HALLAUER (1989) found that genetic gain after seven cycles of HSRS amounted to 23.53%, *i.e.* 3.36% per cycle, not followed by grain moisture content increase. According to RUSSELL (1986), the response of inbreds from later cycles of selection to more intensive growing conditions, i.e. to increased planting density and higher rates of nitrogen fertilizers, was good.

Differences among hybrids within both trials, ranked according to their yield, were more uniform than the differences obtained by the test of pairs. Fig. 2a clearly shows this uniformity. The regression lines were almost parallel (regression coefficients were b=0.171 and b=0.183 for hybrids with B84 and B37, respectively), indicating a similar average increase or decrease of the dependent variable (grain yield) for each unit of independent variable (hybrids). According to the regression equation, average initial grain yield level of hybrids based on the inbred B84 (a=11.20 t/ha) was 14.84% higher than the corresponding yield of hybrids based on the inbred B37 (9.683 t/ha). This difference is another indicator of higher general combining ability for grain yield in inbred B84 than in inbred B37. The value of the rank correlation coefficient (r_s= 0.759**) and its reliability point to a high degree of compatibility, i.e. similar differences among rated hybrids in both series.

Although inbreds B84 and B37 have growing seasons of similar duration when crossed to the same inbreds, grain moisture at harvest, as an indicator of growing season duration, can be different due to the mode of inheritance of this trait. According to the duration of growing season, average grain moisture indicates that hybrids with B84 are, after all, later maturity hybrids (the difference amounted to 0,90%). However, the estimates of PI showed that the higher yields of hybrids with the inbred B84 were not just the result of later maturity. These estimates, in the majority of cases, were higher for hybrids with B84, and this increase, on the average, amounted to 3.70 units, *i.e.* 6.98% (Table 1). Differences in PI, expressed in %, are clearly noticeable in Fig. 1b. The estimates of PI were only higher in hybrids with B37 in four cases. Furthermore, the relative yield increase was higher than the relative PI increase. Using multiple regression analysis HUSIĆ *et al.* (1993) found that grain yield in hybrids with either B37 or B84 was determined to the greatest extent by kernel row number, number of kernel rows per ear and 1000-kernel weight. Therefore, superiority of the inbred B84 could be a result of differences among these grain yield components.

Considering only the five top yielding hybrids within both series of hybrids, PI was 10.85% higher in hybrids with B84 (Figure 1c). Regression lines (Fig. 2b), made on the basis of PI estimates, ranked according to their descending values, showed that the relative value of PI (44.789 compared with 41.776), as well as, its expected increase (bx_i = 1.179 in relation to bx_i = 1.09), were higher for the series of hybrids with B84 than for hybrids with B37. Combinations with high yield and higher PI estimates are precisely the traits of agronomic importance that are desirable in each hybrid.

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POREĐENJE OSOBINA HIBRIDA KUKURUZA STVORENIH NA BAZI LINIJA B84 ODNOSNO B37

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Izvod

Efikasnost primenjene Half - Sib Recurrent Selection (HSRS) metode selekcije na Iowa Stiff Stalk Synthetic - u (BSSS) moguće je proceniti indirektnim putem preko performansi hibridnih kombinacija sa linijama dobijenim iz različitih ciklusa selekcije pomenute populacije. Procena efikasnosti je izvrešena na bazi poređenja performansi hibrida dobijenih na bazi ukrštanja linija B84(BSSSC7) i B37(BSSSC0) sa dvadeset nesrodnih linija. Rezultati ukazuju da su hibridi sa linijom B84 dali u proseku za 11.30% veći prinos zrna u odnosu na iste hibride sa linijom B37. Posmatrano sa stanovišta uspeha rekurentne selekcije ovo povećanje iznosi 1,61% po ciklusu selekcije. Iako je determinisana vlaga u hibridima kao pokazatelj dužine vegetacije bila veća u hibridima sa B84 (u proseku za 0.90%*) da veći prinos zrna nije rezultat samo relativno duže vegetacije ukazuju vrednosti za Performans indeks koje su za 6,98% bile veće također kod hibrida sa B84. Vrednosti koeficijenata (bxi) u jednačini linerne regresije bile su slične za obe serije hibrida. Koeficijenat korelacije ranga za prinos zrna (0,759**) potvrđuje da postoje slične razlike između ranga hibrida u obe serije. Sve prethodno pomenuto ukazuje da linija B84 ima bolju opštu kao i specifičnu kombinacionu sposobnost za prinos zrna u odnosu na liniju B37 ukazujući na efikasnost primenjene HSRS na BSSS populaciji kukuruza.

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