YIELD PERFORMANCE OF VARIETY
VS. VARIETY BLENDS
IN SOYBEANS

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CHAPTER I

INTRODUCTION

The cultivated form of the soybean originated in China. The soybean is an important food crop both in China and the United States. It provides human food, animal feed, and material for many industrial uses. About sixty percent of the total world's supply of soybeans is produced in the United States.

The soybean, *Glycine max* (L.) Merrill, is a member of the family *Leguminoseae* and subfamily *Papilionoideae* Hermann. Nine species have been assigned to the genus under two subgenera, *Glycine* and *Soja* (Moench) F. J. Herm. (17). *G. max* (L.) Merrill, the cultivated form, and *G. soja* Siebold and Zuccarini, a wild species, belong to the subgenus *Soja* (Moench) F. J. Herm.

For present day soybean production, one can select a high-yielding cultivar on past performance and plant it on his entire area, or one could divide the area and grow two or more high-yielding cultivars in pure stands. In recent years, interest has been expressed in growing a seed mixture of cultivars (blends) to obtain stability of production from unpredictable environments.

Selection of varieties for a blend should be made not only on the basis of time of maturity, which permits convenience in harvest, but also should be based on other qualities such as disease resistance and yielding potential. For best results in yield, it is best to blend varieties which have high yield potential when grown in a pure stand. The disease resistance of different varieties is a good hedge against hazards, but, when choosing varieties on the basis of disease resistance and yielding potential, the percentage of each variety is sometimes limited. For best results in choosing varieties to be included in a blend, all weaknesses and strengths should be considered so that they will, on paper, offset each other (9).

There are several important points to keep in mind when preparing a blend. First, one should start with identification of superior variety combinations. Next, quality seed of known genetic purity should be used. Finally, the blend should be prepared in the desired ratio based on the germination percentage for each variety component.

The primary objective of this study was to compare yield performance of varieties versus variety blends for selected cultivars in the three soybean maturity groups commonly grown in Oklahoma.

CHAPTER II

REVIEW OF LITERATURE

Blends are defined as the mechanical mixture of seeds from two or more varieties (12). A blend is generally spoken of as a type of crop insurance. If one variety in a blend is stressed or killed because of some adversity, then another variety in the blend would hopefully compensate for these weaknesses. Thus, the crop would not be a total loss as would be the case had the entire field been planted to a single variety (12). The use of blends as a hedge against hazards is understandable, but this compensating ability also puts a limit on the percentages of each variety in the blend (11). Too high a percentage of one variety in a blend would not be advisable for fear that it may have an unknown weakness to an adversity that may prevail in a given growing season.

Performance means of blends are often equal to the means of the components, but they can sometimes exceed the higher components. Blends rarely are inferior to the means of the components grown in pure stands (13). Thus, advantages perceived have included higher yields, lower yield variability from season to season, a better spreading of production over the growth period, less susceptibility to disease or lodging, and an improved quality of the crop product (1,18,23,29).

When a blend is to be used, a decision must be made as to the variety components and the ratios of these component varieties in the blend. Varieties selected for blends should be high-yielding when grown in pure stands, and should be similar in maturity to permit a convenient harvest and avoid possible shattering of an overripe component.

Fehr (11) suggested that the highest yielding varieties in a blend should compose between seventy and ninety percent of the blend. When two varieties in a blend yield approximately the same, initial testing can be limited to a 3:1, 1:1, and 1:3 ratio plus the pure stand plots of the component varieties. Fehr (9,11) feels that this is adequate for determining how the variety will interact in a blend.

All too often the highest yielding cultivar for a location is found to be susceptible to an important production hazard, such as disease, insect, or soil deficiency. A blend of a high-yielding but susceptible cultivar with a low-yielding but resistant cultivar may produce a good yield potential without sacrificing adequate protection. The maximum frequency of the susceptible cultivar that could be tolerated in a blend would be determined by the nature of the production problem and the probability of its occurrence (12). When the maximum frequency for the susceptible cultivar has been established, it would then be necessary to determine the frequency, up to the maximum, that would give the highest blend yield. The optimum frequency of the susceptible cultivar for the highest yield of the blend may not be the maximum frequency permissible for protection (2,25).

When the varieties and ratio of these varieties in the blend are finally determined, the blend must then be prepared, not by the weight or volume of the seed, but by germination rates of each seed lot. Then, in the case of soybeans, the seeds must be mixed very gently, since soybeans are easily split by frequent or rough handling (11).

Before discussing results of studies conducted on blends, interplant competition should be defined and discussed. Competition may affect performance when two or more different varieties are grown side by side. Competition occurs when each of two or more organisms seeks the measure it wants of any particular environmental factor and when the immediate supply of the factor is below the combined demand of the organisms (7). Competition in blends of varieties occurs more often when the varieties in the blend have more differences, as in height, maturity, lodging, etc. (16,22). Data from a study by Fehr (10) indicated that paired-rows were effective for determining the good and poor competitors for each cultivar-pair tested.

In studies conducted by Schutz and Brim (24) involving four varieties of soybeans, drastic effects were noted of competition for seed yield, seed number, and efficiency in both hill and row plots. A net gain in performance, which they called over-compensation, was observed between certain pairs of genotypes. Over-compensatory effects varied in magnitude for different combinations.

Hinson and Hanson (16) grew four soybean varieties in pure stands and three mixtures at different within row spacings. Relative yield was found to be affected considerably by both spacing and competition. Response to photoperiod appeared to be the primary factor determining the relative ability of genotypes to utilize space efficiently and compete with other genotypes in mixtures. Although yield was influenced by competition, the mean performance of mixtures and the components of mixtures grown in pure stands was essentially the same. Competition effects for yield in soybeans were found to be insignificant in rows spaced far apart (91 cm), but, in narrow row planting (46 cm), competition effects for yield were important (19).

Chapman et al. (6) found that a significant positive yield interaction occurred in a mixture of two wheat varieties when they were grown at high, but not at low, population densities.

A mixture of four similarly adapted barley varieties grown for 16 years brought practical extinction for two of the component varieties. One of these had a significantly better yield and leaf disease record than any of the others when grown in pure stands. The variety which ultimately dominated the mixture had the poorest leaf disease record and a mean yield below the median for the component varieties. This suggests that the bulked population method of breeding will not necessarily perpetrate either the highest yield or the most disease resistant progenies. The otherwise intangible character of competitive ability may measure other very important plant characters (28).

Blending of two or more corn hybrids did not appear to increase grain yield over the mean of the component hybrids grown separately. Blending corn hybrids was found to increase yield stability (14,27).

In a winter barley study, blending appeared to have potential as a means of increasing crop production, but the identification of the correct line combination was difficult to achieve (22).

In a five year soybean study done by Mumaw and Weber (21), seed weight decreased slightly when varieties were grown in association as compared to pure line performances. Seed numbers increased in branching types resulting in a net yield increase. Increased seed number was the primary factor accounting for the yield advantage of blends. Thus, on the basis of their results, soybean blends as a production practice generally could not be recommended, but, on the basis of yield alone, evidence would not discourage entirely the use of certain blends as a cultural practice.

Probst (23) and Caviness (4) found that soybean blends showed no superiority in yield over the highest yielding variety in any one year. There was a marked variety X season interaction for yield and, in this respect, blending had a stabilizing effect on yield and appears to be of importance in approaching maximum yield each year. Lin and Torrie (20) studied soybeans grown in alternate rows and found that blends yielded more consistently.

Walker and Fehr (30) were not able to define precisely the number of pure lines needed for stable production because of the variability in stability among entries within each level of heterogeneity. All the pure lines, mixtures, and multiple pure stands had regression coefficients not significantly different from unity. Stable production depended more on the particular cultivars or mixtures chosen than on the number involved. Their results showed that most pure lines were less stable than mixtures, thus, farmers would have a greater probability of achieving stable production by growing several varieties in mixtures or as multiple pure stands rather than by using only one cultivar.

Results of most studies reviewed on blends were in agreement. Blends have a place in agriculture, but which varieties to use in a blend and at what ratio will be hard to determine since there are innumerable combinations (3,15).

CHAPTER III

MATERIALS AND METHODS

The materials used in this study consisted of seven soybean varieties released by various state experiment stations and the USDA. The varieties 'Crawford' and 'Calland' are in Group IV and Group III maturity groups, respectively. They are considered early maturity for Oklahoma and will be referred to as Group IV varieties in this thesis since Calland matures with Group IV varieties in Oklahoma. 'Dare' and 'Forrest' are in Group V, a medium maturity group, and 'Pickett 71', 'Davis', and 'Sohoma' are in Group VI, a late maturity group for Oklahoma. These varieties were selected on the basis of above average performance over a number of years of testing in Oklahoma. The varieties within each maturity group were blended together in 1:1, 1:2, and 2:1 proportions. The three Group VI varieties were combined in all possible two-variety blends. The blend proportions were based on percent live seed after laboratory germination tests were conducted. The entries were identified by using an identification number consisting of four digits. The first and third digits indicated which varieties were used in the blend. The second and fourth digits indicated the ratio of varieties used in making the blend as indicated in Table I.

This study was planted at three locations in Oklahoma, Bixby, Ft. Cobb, and Webbers Falls. The varieties and blends were planted in a randomized complete block design with three replications. Each plot

TABLE I

LIST OF IDENTIFICATION NUMBERS, VARIETY OR BLEND, PERCENT GERMINATION, AND NUMBER SEEDS PLANTED

Identification Number	Variety or Blend	Percent Germination	Number Seeds Planted
	Early Maturing Group		
1000	Crawford	98.0	306
2000	Calland	65.5	458
1121	1 Crawford: 1 Calland		154:230
1122	1 Crawford: 2 Calland		102:306
1221	2 Crawford: 1 Calland		204:152
	Medium Maturing Group		
3000	Dare	96.0	312
4000	Forrest	83.0	362
3141	1 Dare: 1 Forrest		156:182
3142	1 Dare: 2 Forrest		104:242
3241	2 Dare: 1 Forrest		208:120
	Late Maturing Group		
5000	Sohoma	88.0	340
6000	Pickett 71	89.0	338
7000	Davis	95.0	316
5161	1 Sohoma: 1 Pickett 71		170:170
5162	1 Sohoma: 2 Pickett 71		114:226
5261	2 Sohoma: 1 Pickett 71		226:112
6171	1 Pickett 71: 1 Davis		170:158
6172	1 Pickett 71: 2 Davis		112:210
6271	2 Pickett 71: 1 Davis		226:106
5171	1 Sohoma: 1 Davis		170:158
5172	1 Sohoma: 2 Davis		114:210
5271	2 Sohoma: 1 Davis		226:106

consisted of four rows 6.1 m long, with .9 m between the rows.

Vegetable Research Station, Bixby, Oklahoma

The Bixby test was grown under dryland conditions on a Reinach silt loam soil - a member of the loamy, mixed, thermic Pachic Haplustolls. A soil test at Bixby indicated that no fertilizer was needed. The test was planted June 28, 1978, under excellent soil moisture conditions. Plants in the blends containing Sohoma and Davis were tagged according to flower color during peak bloom so they could be identified and separated at harvest. Components of all other blends, except Sohoma: Pickett 71, were identified and separated at harvest on the basis of pubescence color. Plants of Sohoma and Pickett 71 could not be identified with certainty so their blends were studied on the whole and not as component parts. At harvest the two inner rows of the four-row plots were harvested. The Group IV varieties and blends were harvested October 22, 1978, and the remaining plots were harvested November 11, 1978.

Caddo Research Station, Ft. Cobb, Oklahoma

The Ft. Cobb test was conducted under irrigation and was planted with excellent soil moisture conditions on June 15, 1978, on a Meno fine sandy loam - a member of the loamy, mixed, thermic Aquic Arenic Haplustalfs. The test site received a broadcast application of 8-32-16 fertilizer at the rate of 168 Kg/ha as indicated by a soil test. Plant tagging and harvest were conducted as described above. The Group IV varieties and blends were harvested October 20, 1978, and the remaining plots were harvested November 9, 1978.

Charles Pearson Farm, Webbers Falls, Oklahoma

The Webbers Falls test was conducted under dryland conditions and was planted with less than adequate soil moisture June 12, 1978, on a Mason Silt loam - a member of the fine-silty, mixed, thermic Typic Argiudolls. This location was not harvested due to poor stands caused by the drought conditions in the area.

Harvest and Analysis

Each four row plot at Bixby and Ft. Cobb had an excellent stand with component variety plants appearing at random in the plots containing blends. The two inner rows of each plot were harvested by hand. Each blend was separated into its component varieties and threshed separately with a Swanson small plot thresher. The threshed seed was then dried, cleaned, weighed, and counted.

The data were subjected to the analysis of variance (26) and Duncan's Multiple Range test (8).

CHAPTER IV

RESULTS AND DISCUSSION

Analysis of Variance

With one exception, the analysis of variance for yield indicated no significant differences among entries (Tables II, III, and IV). The exception occurred at Bixby in the Group IV varieties and blends. For seed weight, significant differences among means were indicated in the Group VI entries at both locations.

Based on the Duncan's multiple-range test, significant yield differences among means were only indicated in the Group IV varieties at Bixby (Tables V, VI, and VII). Significant differences for seed weight were indicated in all tests with the exceptions of the Group IV and V entries grown at Ft. Cobb. Seed weights at Bixby for the Group IV and V entries were significant according to the Duncan's multiple-range test but not according to the analysis of variance F test. The differences can be considered real because a significant F test for entry mean square is not necessary when using the Duncan's multiple-range test (8). Mean seed weights of all blends were generally equal to or intermediate to that of the parents used in each blend. Thus, no interaction for seed weight occurred due to blending the varieties.

TABLE II

MEAN SQUARES FROM THE ANALYSIS OF VARIANCE FOR GROUP IV VARIETIES AND BLENDS

Source	d.f.	Yield (Kg/ha)		Seed Weight (gms/100)	
		Bixby	Ft. Cobb	Bixby	Ft. Cobb
Replications	2	6.306	19.518	0.425	0.843
Entries	4	23.674*	50.561	0.439	0.476
Error	8	5.496	36.177	0.141	0.300

* Significant at the 0.05 level of probability.

TABLE III

MEAN SQUARES FROM THE ANALYSIS OF VARIANCE FOR GROUP V VARIETIES AND BLENDS

Source	d.f.	Yield (Kg/ha)		Seed Weight (gms/100)	
		Bixby	Ft. Cobb	Bixby	Ft. Cobb
Replications	2	17.721	67.326*	2.066**	0.705
Entries	4	8.996	12.306	.452	0.902
Error	8	15.292	16.479	.139	0.576

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE IV

MEAN SQUARES FROM THE COMBINED ANALYSIS OF VARIANCE FOR GROUP VI VARIETIES AND BLENDS

Source	d.f.	Yield (Kg/ha)		Seed Weight (gms/100)	
		Bixby	Ft. Cobb	Bixby	Ft. Cobb
Replications	2	16.236	17.463	2.816*	0.215
Entries	11	13.444	21.552	4.458**	5.283**
Error	22	15.494	22.973	0.464	0.560

*,** Significant at the 0.05 and 0.01 levels of probability, respectively

TABLE V

DUNCAN'S MULTIPLE-RANGE TEST FOR MEAN YIELD AND SEED WEIGHT FOR GROUP IV VARIETIES AND BLENDS

Entry	Yield (Kg/ha)		Seed Weight (gms/100)	
	Bixby	Ft. Cobb	Bixby	Ft. Cobb
1000	2023 a[1/]	3353 a	15.3 ab	17.3 a
2000	1680 b	2903 a	14.6 b	16.7 a
1121	1573 b	3602 a	15.0 ab	16.8 a
1122	1559 b	3078 a	14.7 b	16.4 a
1221	1741 ab	3078 a	15.5 a	17.4 a

[1/]Means followed by the same letter in a column are not significantly different at the 5% probability level.

TABLE VI

DUNCAN'S MULTIPLE-RANGE TEST FOR MEAN YIELD AND SEED WEIGHT FOR GROUP V VARIETIES AND BLENDS

Entry	Yield (Kg/ha)		Seed Weight (gms/100)	
	Bixby	Ft. Cobb	Bixby	Ft. Cobb
3000	1714 a[1/]	3266 a	12.4 a	13.3 a
4000	1848 a	3165 a	11.4 b	13.6 a
3141	1989 a	3347 a	12.0 ab	14.7 a
3142	1956 a	3051 a	11.7 ab	13.5 a
3241	1781 a	3031 a	11.8 ab	13.4 a

[1/]Means followed by the same letter in a column are not significantly different at the 5% probability level.

TABLE VII

DUNCAN'S MULTIPLE-RANGE TEST FOR MEAN YIELD AND SEED WEIGHT FOR GROUP VI VARIETIES AND BLENDS

Entry	Yield (Kg/ha)		Seed Weight (gms/100)	
	Bixby	Ft. Cobb	Bixby	Ft. Cobb
5000	1935 a[1/]	3152 a	15.8 a	16.6 a
6000	1855 a	2796 a	12.2 d	12.5 d
7000	1525 a	3219 a	12.7 cd	15.3 ab
5161	1828 a	3199 a	12.2 d	14.0 bc
5162	2016 a	3145 a	12.0 d	13.1 cd
5261	1808 a	3246 a	13.0 cd	14.2 bc
6171	1593 a	3071 a	12.1 d	14.2 bc
6172	1814 a	2661 a	12.4 d	14.0 bc
6271	1888 a	3064 a	12.0 d	14.1 bc
5171	1680 a	3253 a	14.4 b	16.0 a
5172	1680 a	3145 a	13.8 bc	16.1 a
5271	1814 a	3132 a	14.3 b	16.2 a

[1/]Means followed by the same letter in a column are not significantly different at the 5% probability level.

Grain Yield

Little differences in yield were noted among the Group IV varieties and blends at either location (Table V). Variety 1000 (Crawford) tended to yield more than variety 2000 (Calland), but was significantly better only at Bixby. The blend 1121 (1:1 ratio) was the highest yielding entry at the Ft. Cobb location but was not significantly better statistically than either of its component parents (Table V). In all the Group IV blends, the percentage of Crawford plants counted at harvest was higher than the intended proportion put into each blend (Figs. 1 and 2). For instance, Crawford plants in blend 1121 at Bixby constituted 72% of the plants at harvest while intended to be only 50% of the blend at planting (Fig. 1). It is possible that Crawford had a competitive advantage over Calland to the extent of affecting the survival of Calland plants. However, the two varieties in the blends yielded in relative proportion to their plant numbers counted at harvest. This indicated that any competitive advantage of Crawford over Calland did not continue later in the growing season after initial survival was affected. The most likely explanation is that the germination test did not accurately predict the field emergence of one or both of the varieties. A review of the stand count data indicates that Calland emerged far less than expected.

The Group V varieties, 3000 (Dare) and 4000 (Forrest), had comparable yields at each location (Figs. 3 and 4) although yield levels at the two locations differed considerably due to the irrigation at Ft. Cobb. In all blends, Dare tended to have a higher percentage of plants at harvest than expected from the initial proportion of seed. Also, the proportion of yield contributed by Dare was larger than its percentage

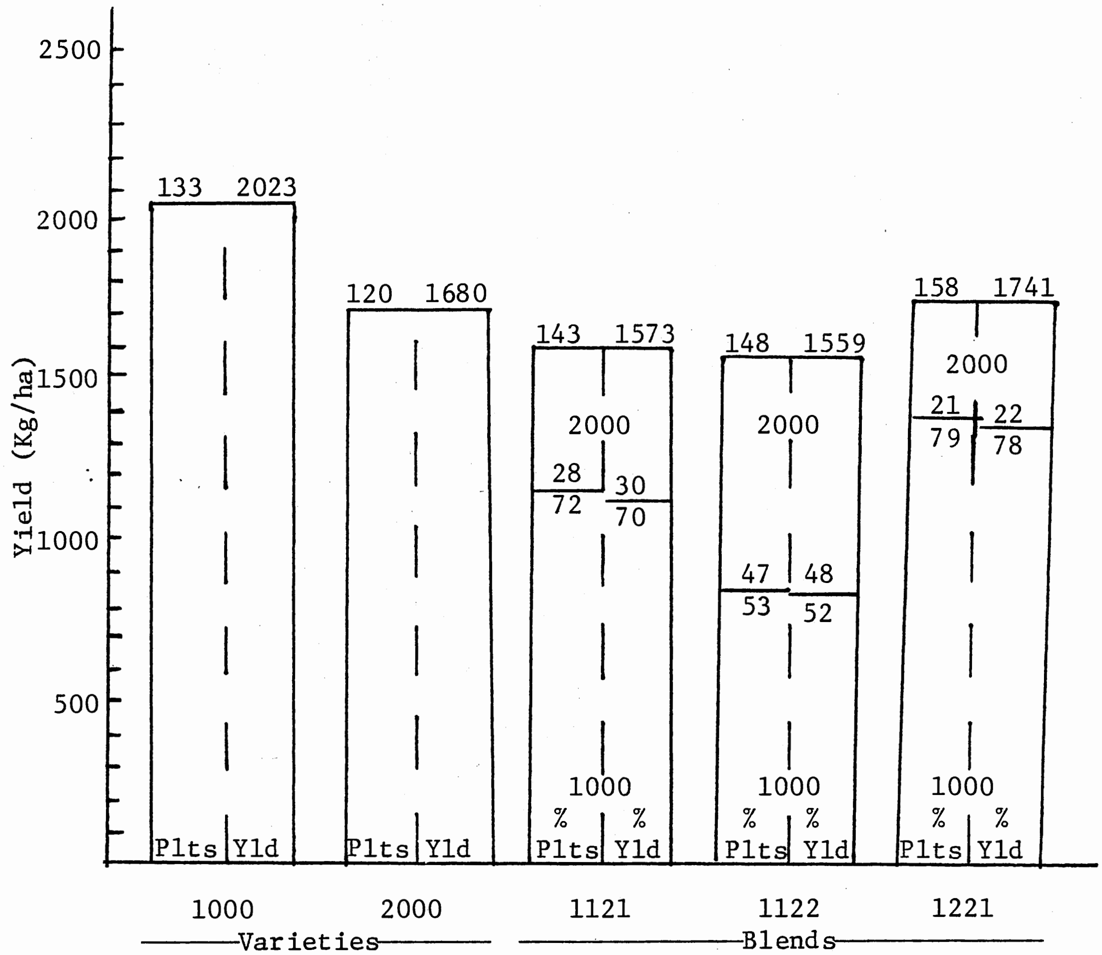

Figure 1. Frequency distributions of percent plants and yield for Group IV, Bixby

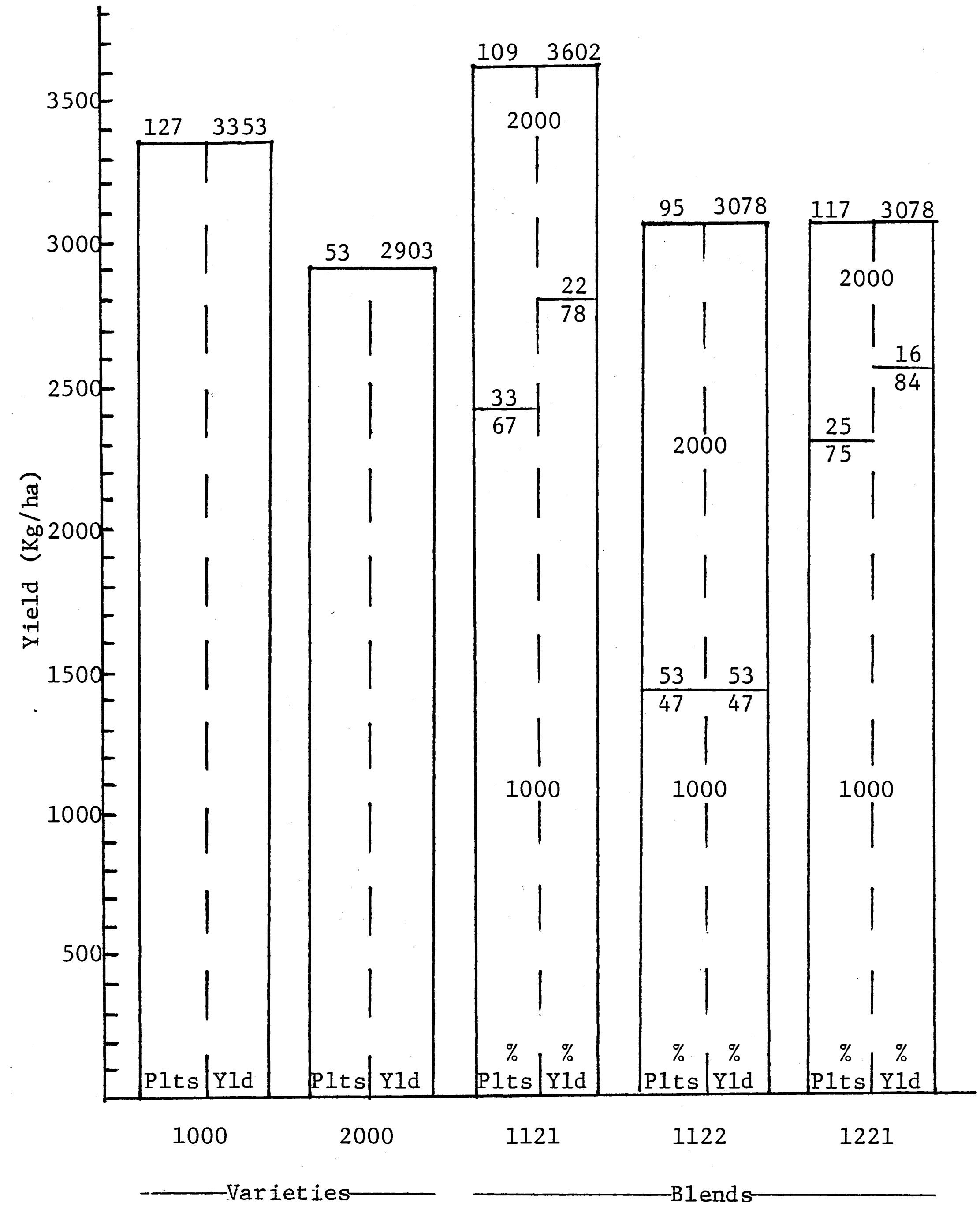

Figure 2. Frequency distributions of percent plants and yield for Group IV, Ft. Cobb

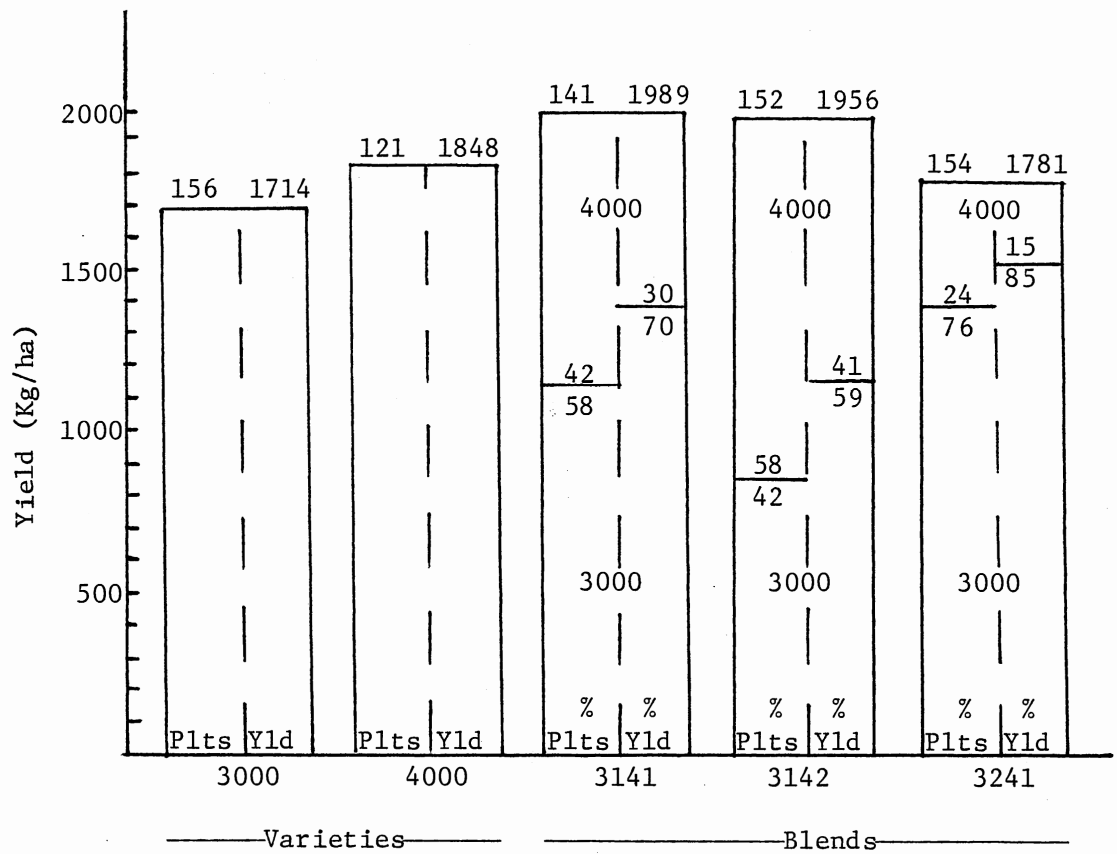

Figure 3. Frequency distributions of percent plants and yield for Group V, Bixby

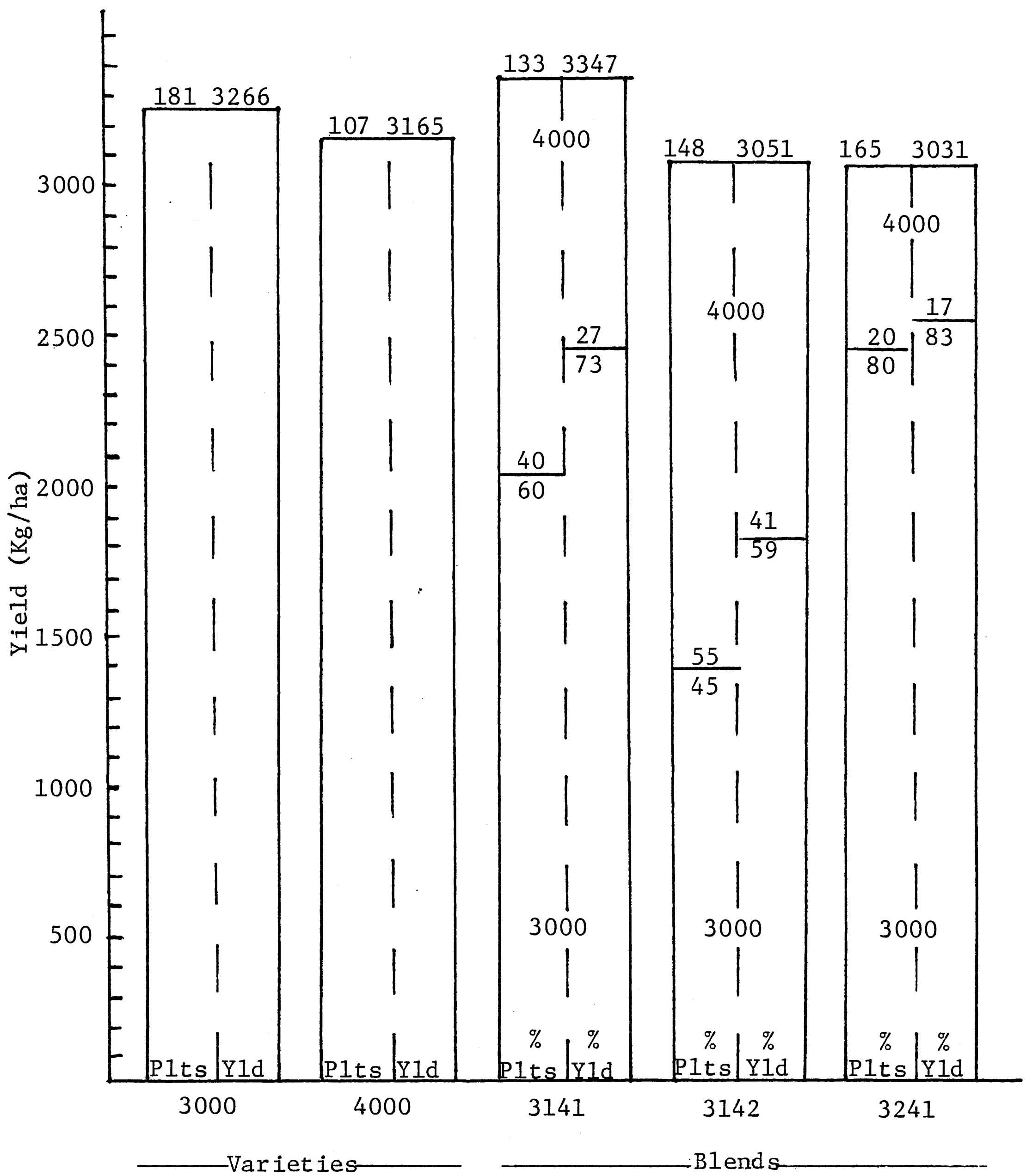

Figure 4. Frequency distributions of percent plants and yield for Group V, Ft. Cobb

plants counted at harvest. For example, in blend 3141 at Bixby (Fig. 3), Dare (3000) contributed 70% of the blend yield with only 58% of the plants. Thus, Dare appeared to have competitive advantage over Forrest throughout the growing season, early, during stand establishment, and later, where relative plant yield was affected. Although additional seed of Forrest was planted to presumably compensate for differences in germination (96% for Dare vs. 83% for Forrest), a much lower proportion of final stand was realized from the Forrest seed.

Group VI varieties 5000 (Sohoma) and 6000 (Pickett 71) and their corresponding blends were very similar in yield at both locations (Table VII). The plants of Sohoma and Pickett 71 in the blends could not be distinguished with certainty during the growing season or at harvest. Thus, their relative competitive ability and relative contribution to the blend yields could not be determined directly. Comparable germination percentages were obtained for Sohoma and Pickett 71 (88 and 89%), however, actual percentage emergence was considerably lower for Sohoma. Thus, one could hazard a guess that Sohoma did not compete as well as Pickett 71 in their blends.

Group VI varieties 6000 (Pickett 71) and 7000 (Davis) and their blends yielded comparably at each location (Figs. 5 and 6). The proportion of plants of the component varieties counted at harvest corresponded fairly closely to the initial percentages planted. Also, the yield contribution of the components in the blends corresponded to their plant percentages at harvest. Therefore, Pickett 71 and Davis competed equally with each other in blends.

The Group VI varieties 5000 (Sohoma) and 7000 (Davis) in blends yielded somewhat differently at the two locations although no statistical

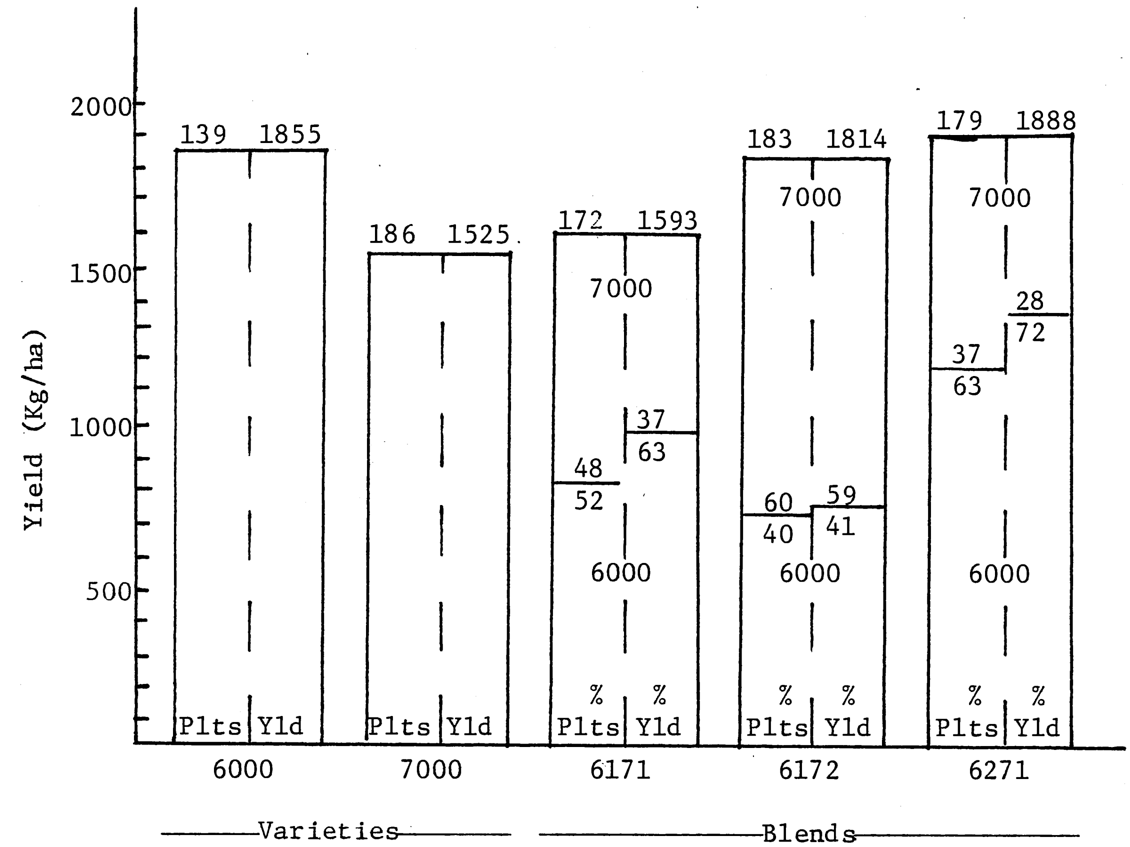

Figure 5. Frequency distributions of percent plants and yield for Group VI (6000-7000), Bixby

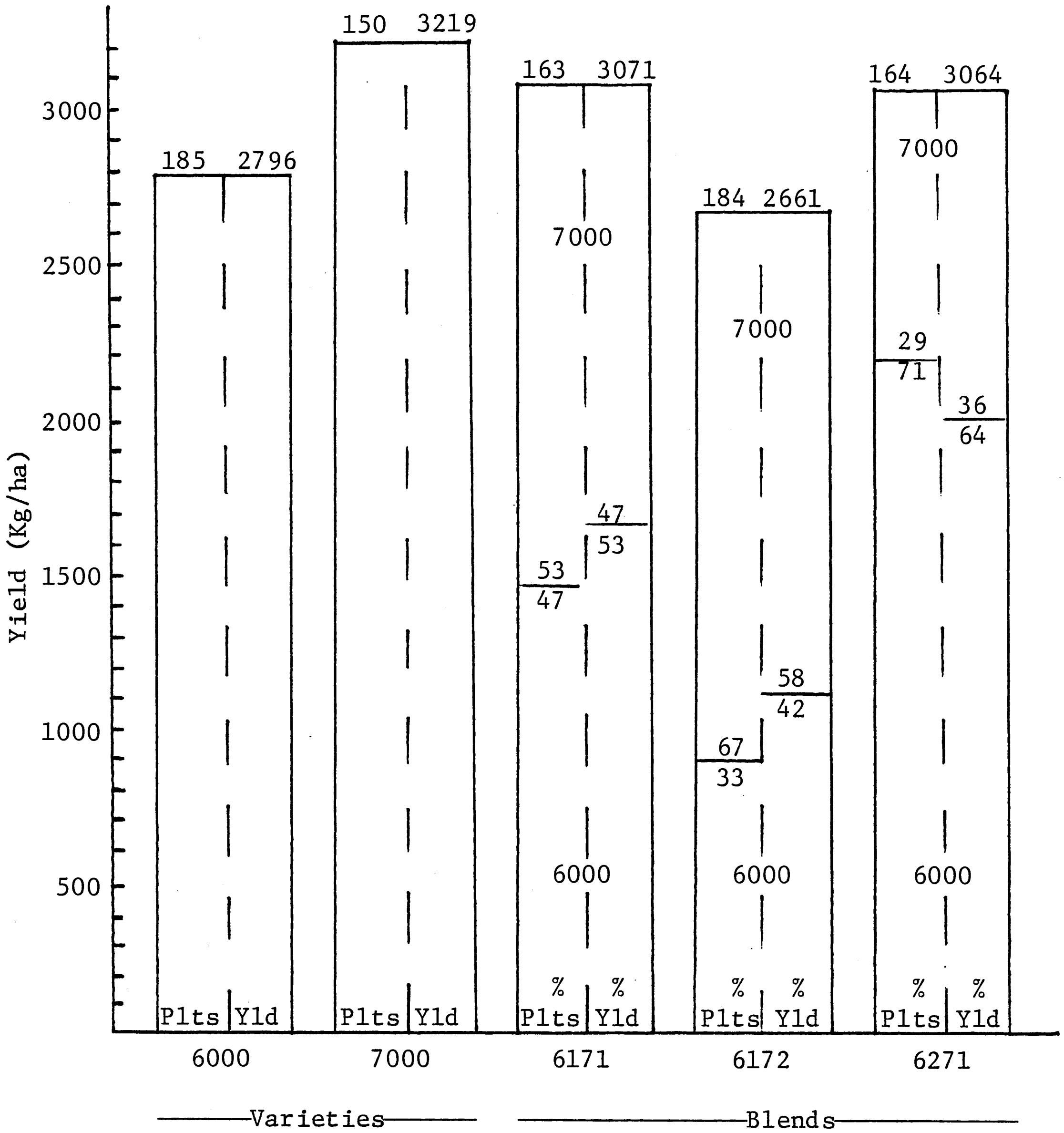

Figure 6. Frequency distributions of percent plants and yield for Group VI (6000-7000), Ft. Cobb

differences were obtained. At Bixby, the proportion of plants at harvest and the relative contribution to yield corresponded closely with initial varietal proportions in the blends (Fig. 7) and all blends were intermediate in yield to the two component varieties. At Ft. Cobb, Davis had a higher proportion of plants in the blends at harvest than initially planted (Fig. 8). Also, the contribution of Davis to blend yields was proportionately more than the percentage of plants counted at harvest. Thus, Davis appeared to be more competitive than Sohoma at both locations with differences more pronounced at Ft. Cobb. The initial seed quality differences as judged by the standard germination test (95% for Davis vs. 88% for Sohoma) probably account for the stronger competitiveness of Davis over Sohoma.

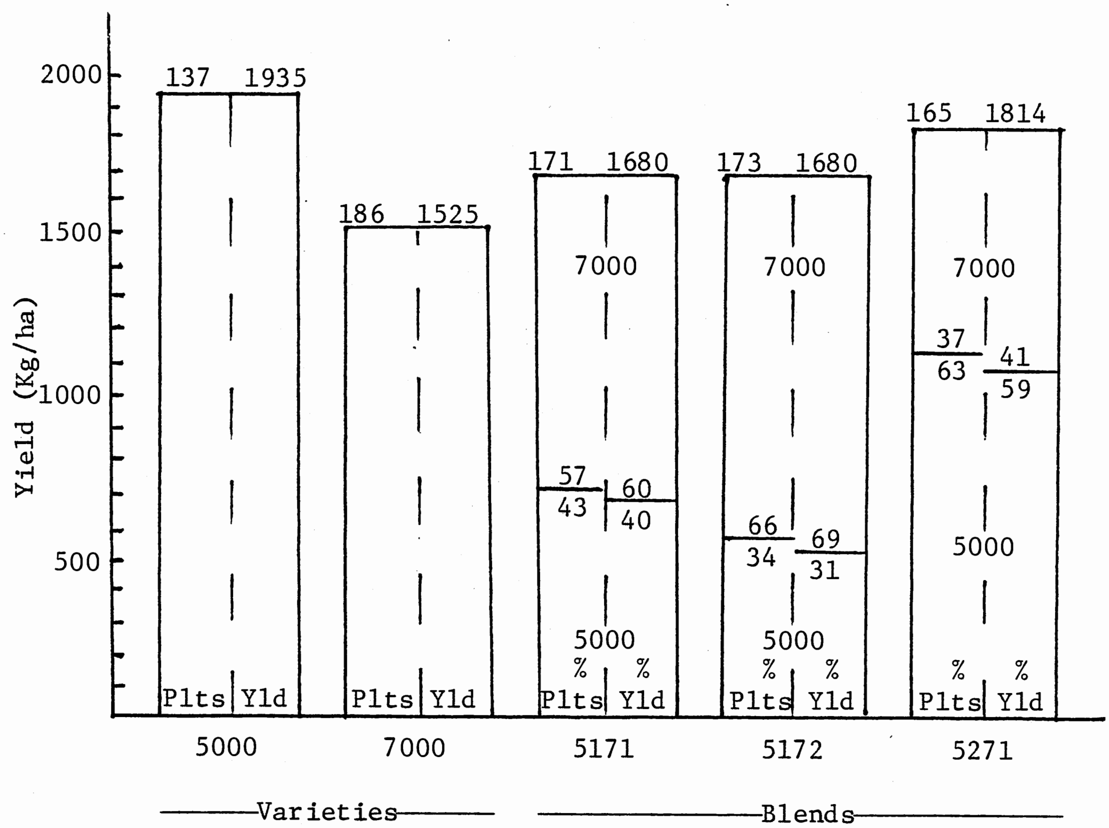

Figure 7. Frequency distributions of percent plants and yield for Group VI (5000-7000), Bixby

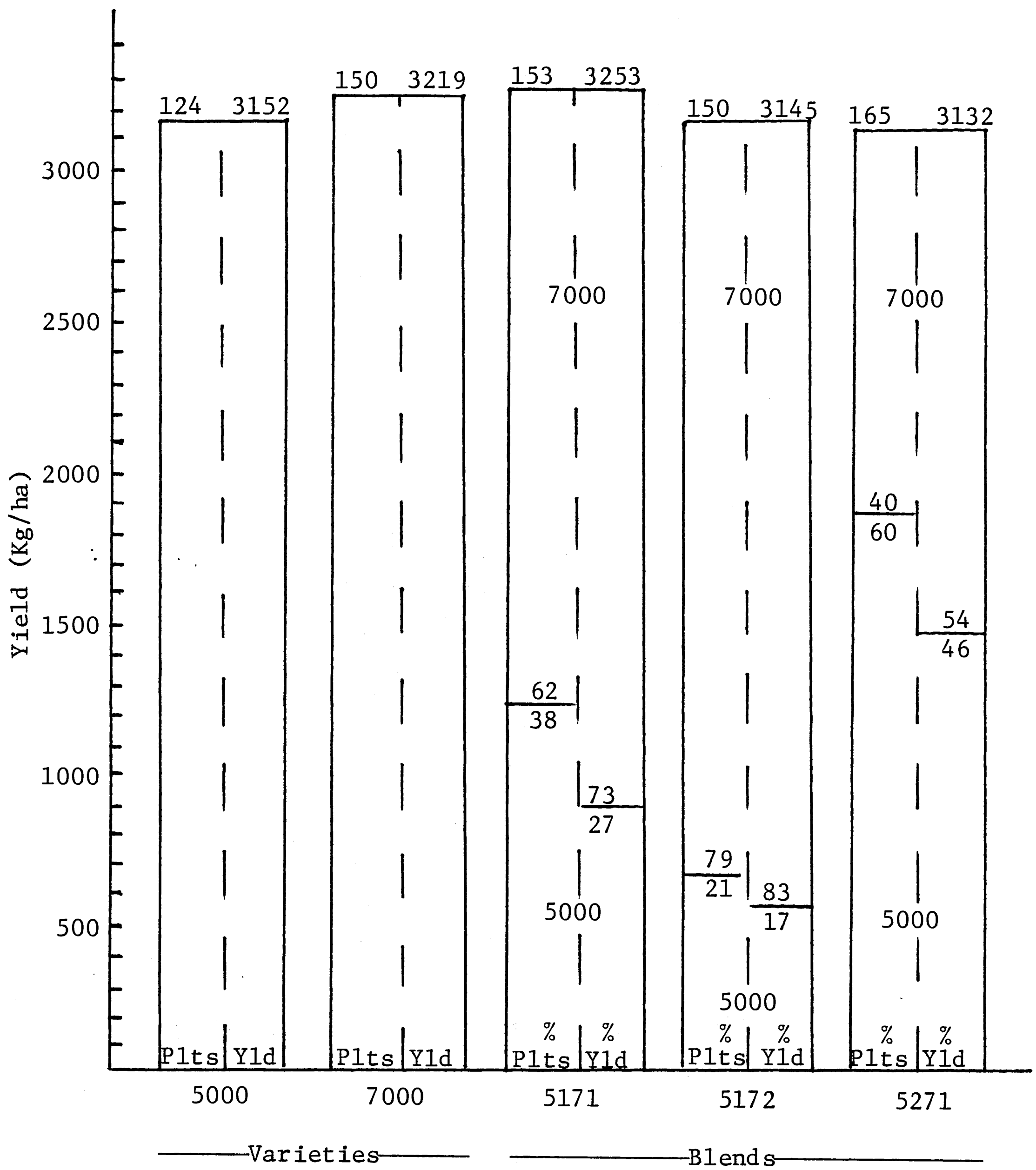

Figure 8. Frequency distributions of percent plants and yield for Group VI (5000-7000), Ft. Cobb

CHAPTER V

SUMMARY AND CONCLUSIONS

The primary objective of this study was to compare the yield performance of varieties versus variety blends in soybeans. The relative contributions of varieties to blend yields were also studied.

Seven soybean varieties representing the maturity groups normally grown in Oklahoma were used in two-variety blends of 1:1, 1:2, and 2:1 proportions within the maturity groupings. The blends and varieties were grown in replicated tests at two locations in Oklahoma in 1978. An additional location was planted but not harvested due to drought conditions. Grain yield and seed weight were determined and analyzed. Also, data on the yield and percentage of each variety in the blends were collected.

The results of this study agreed with many other studies conducted on both soybeans and other crops (5,14,22,25,27,28,30). Few differences in the yields of pure lines in comparison to blend yields occurred. Where differences occurred between the varieties, the blends were usually intermediate or equal in yield to one of the component varieties.

The variety seed lots available for use in this study varied considerably in seed quality as indicated by standard laboratory germination tests, thus, the relative seed quality of varieties in the blends varied depending on the two component varieties used. Seed quality differences were expressed in one of two ways. One affected the proportion of plants which survived to harvest. Certain varieties had a higher percentage of plants than was initially prepared in the blend. The second type of seed quality difference was indicated by the relative contribution of surviving plants to yield. Certain varieties contributed a higher percentage to blend yield than the proportion of plants it had in the blend at harvest. The relative competitive ability of two varieties in a blend was not affected by the proportion (1:1, 1:2, or 2:1) of each prepared in the blend. In general, the competitive ability was also consistent across the two locations. In actuality, it appears that any suggestions of competitive differences in this study can be traced to the differences in the quality of seed used for the various varieties. It is obvious that the standard germination test under optimum conditions is not a reliable predictor of field emergence. Extra seed planted does not compensate for poor quality seed, at least when grown in blends or mixtures of varieties. As has been known for many years, a strong seed produces a strong plant and a weak seed never catches up.

As has been the suggestion of many other studies, blends may rarely, if ever, increase yield. However, blends should not be ruled out as an agricultural practice to bring about stability of yield from season to season or location to location, to give less susceptibility to disease or lodging, and to generally serve as a kind of natural crop insurance.

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