A Comparison of Calves by Hereford and Limousin Bulls

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CONTENTS

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INTRODUCTION

CROSSBREEDING is now accepted by the majority of commercial cattlemen. The questions that remain are related to selection of breeds that will maximize productivity as well as profit. Not only will breeds selected to produce crossbred calves initially affect these traits, but will affect future generations as well. A commercial breeder who initiates a crossbreeding program, and retains replacement females generated within his herd, must be aware of the consequences associated with choice of breed of sires used in the preceding generations.

Early work at the Black Belt Substation *(4)* showed that Angus x Hereford cows were the most productive crossbred cows when measured in terms of pounds of calf weaned per cow bred. These results were confirmed in a later study at the same station by Patterson et al. *(12)* where Charolais and Hereford bulls were bred to Hereford and to Angus x Hereford cows. In a study at the Upper Coastal Plain Substation, Patterson et al. *(13)* showed that Charolais cross cows were superior to Hereford and Hereford x Holstein cows in total productivity but were inferior to Brown Swiss x Hereford cows.

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[2]The authors gratefully acknowledge the assistance of John A. McGuire in analysis of the data.

Alenda et al. *(1,2)* found that Charolais additive effects were larger for both pre- and post-weaning weights than those from Angus and Hereford cows. However, they reported *(1)* opposite maternal and grand maternal heterosis effects, lending support to the theory that the rearing environment of the mother influences her own maternal ability.

Gregory et al. *(8)* reported that Brahman, Brown Swiss, and Gelbvieh cross cows were superior to Hereford x Angus cross cows when measured by weight weaned per cow calving. With the exception of Gelbvieh, the exotic cross cows, which included Charolais, Chianina, Limousin, Maine-Anjou, and Simmental, were inferior to the Hereford x Angus cross cows when the same measurement of overall productivity was used. These same workers *(9)* found that Sahiwal, Brahman, Charolais, Chianina, and Limousin cross females were significantly older at puberty than Hereford x Angus females. However, only Charolais, Chianina, Limousin, and Simmental cross females had a lower percent pregnancy at 18 months of age than did Hereford x Angus females.

Cundiff et al. *(6)* reported that, in the postweaning period, Jersey, Red Poll, and Sahiwal cross steers gained slower and had lower final weights than Hereford x Angus cross steers, while Brahman, Tarentaise, and Pinzgauer cross steers gained about the same and had from 1 to 2 percent heavier final weights than the Hereford x Angus cross steers. Limousin cross steers gained slower than the Hereford x Angus cross steers but were only 1 percent lighter in final weight. Brown Swiss, Charolais, Chianina, Gelbvieh, Maine-Anjou, and Simmental cross steers gained faster and were 4 to 9 percent heavier than Hereford x Angus cross steers in final weight. These workers also reported that when fed to a grade end point of USDA Choice, Hereford x Angus cross steers were significantly more efficient than Brahman, Brown Swiss, Charolais, Chianina, Gelbvieh, Sahiwal, and Tarentaise cross steers. However, when fed for constant time (238 days) or to a constant weight (545 to 1,036 pounds), the larger, faster gaining steers were more efficient than Hereford x Angus cross steers.

Carcass data for the same steers indicated that most of the differences in carcasses were because of differences associated with mature weight *(11)*. In addition, the slower maturing breeds tended to have a higher percentage of their carcass

weight in the round, with Chianina crosses highest at 27.3 percent and Jersey crosses lowest at 24.6 percent. There were some differences in marbling, reflected in differences in percentage grading Choice. Chianina, Limousin, Brahman, Gelbvieh, and Sahiwal crosses had from 24 to 44 percent grading Choice. Maine-Anjou, Pinzgauer, Simmental, Tarentaise, Brown Swiss, Charolais, and Red Poll crosses had from 54 to 68 percent grading Choice, while Hereford x Angus and South Deavon crosses had 76 percent and Jersey crosses were highest with 85 percent grading Choice. Tenderness scores were less for Brahman and Sahiwal crosses than for breed crosses of European origin. However, these differences did not keep any of the breed crosses from being in the generally high level of acceptability as determined by taste panel.

Comparisons between calves sired by Limousin and those sired by several other breeds were summarized by Frahm and Belcher in 1978 *(7)*. They reported that cows bred to Limousin bulls had slightly longer gestation lengths than those bred to most other bulls, but Limousin cross calves generally had smaller birth weights than other exotic crosses although larger than Angus, Hereford, and Jersey crosses. This smaller birth weight was reflected in less calving difficulty and a lower percent calving loss than with calves sired by other exotic bulls. They also reported lower weaning weights and slower post-weaning gains for the Limousin-sired crossbred steer calves compared to other exotic crosses. However, they reported that Limousin cross cattle produced carcasses with a higher dressing percentage, with less fat and more lean compared to most breed crosses. Other carcass characteristics, such as tenderness and quality grade, favored the other breed crosses.

In a later study, Crockett et al. *(5)* compared calves by Beefmaster, Brahman, Brangus, Limousin, Maine-Anjou, and Simmental bulls out of Angus, Brangus, and Hereford cows. These workers found that Limousin-sired calves were smaller at birth than Brahman- and Maine-Anjou-sired calves, were about the same as Beefmaster- and Simmental-sired calves, but larger than Brangus-sired calves. At weaning, calves by Brahman, Maine-Anjou, and Simmental bulls were heavier than calves by Limousin bulls. There were no differences at weaning between calves by Beefmaster, Brangus, and Limousin bulls. In this study, cows bred to Limousin bulls were intermediate in unassisted live births. Average daily gain in the feedlot was highest for Maine-Anjou-sired steers, with steers

by Brahman, Limousin, and Simmental bulls intermediate. Carcass data indicated that the exotic breeds sired calves that had less fat, less marbling, and better yield grades than did calves by the Brahman and Brahman-derivative bulls.

EXPERIMENTAL PROCEDURES

The objectives of this study were: *(1)* to evaluate the performance of progeny of selected beef cattle breeds and crosses, and *(2)* to compare the performance of the selected breeds and crosses on different growing and finishing regimes.

Data were collected on 220 calves produced from 281 matings over a 5-year period from 1973 though 1977 at the Black Belt Substation, Marion Junction, Alabama. The cows used were produced in a previous study and the results reported by Patterson et al. *(12)*. The cows were Hereford, ¾ Hereford-¼ Angus, ½ Charolais-½ Hereford, and ½ Charolais-¼ Hereford-¼ Angus. They were artificially inseminated (AI) with semen from above average Hereford and Limousin bulls. Hereford bulls were used for clean up breeding following AI, thus a larger number of calves were sired by Hereford bulls.

During the winter months, cows were fed 2.0-2.5 pounds of 41 percent cottonseed meal or equivalent per head daily plus johnsongrass hay *ad libitum*. Caley (wild winter) peas were grazed for approximately 50 days in late winter and early spring; permanent pasture, primarily dallisgrass with some white clover, was grazed from late spring until late fall.

Creep feed was provided all calves during the winter and in two of the five summers because in those years drought conditions made additional feed necessary.

All calves were numbered and male calves castrated within 24 hours after birth. Sex, birth weight, calving difficulties, birth date, and dam's number were recorded. Calves were weaned when their average age was approximately 250 days, at which time they were weighed and assigned slaughter and stocker grades.

In the last 4 years, two post-weaning management systems for growing steer calves to slaughter weights were used. In system I, steers were placed directly in the feedlot at weaning where they were full-fed a 30 percent roughage-70 percent concentrate ration for an average of 191 days. Steers on system II remained on a permanent pasture of dallisgrass after weaning for an average of 117 days. While on pasture, steers were

supplemented with hay, corn, and cottonseed meal when necessary. As soon as winter grazing became available, the steers were transferred to a winter annual pasture of wheat and ryegrass mixture for an average of 114 days. In the first 2 years, because of dry and cold weather, grazing was not ready until January 20 and March 7, respectively. Following winter grazing, the steers were placed in the feedlot for an average of 75 days and were fed the same ration used in system I. System II required an average of 306 days post-weaning, 115 days longer than system I. Finished steers in both systems were slaughtered and data obtained on carcass weight, ribeye area, fat thickness, kidney fat, and USDA yield and quality grade.

Analysis of Data

The data were analyzed by the method of least squares as described by Harvey *(10)*. Tests of significance among individual least squares means were made using Fisher's protected least significant difference as described by Chew *(3)*.

Separate analyses were made for reproductive traits, preweaning traits, post-weaning traits, and carcass traits. These analyses are given in the appendix.

RESULTS AND DISCUSSION

Reproductive Performance

Since all the Limousin cross calves were produced by AI and part of the Hereford cross calves were produced by natural service, reproductive performance by breed of sire could not be calculated accurately. The reproductive performance by breed of dam is presented in table 1. There were no differences

TABLE 1. REPRODUCTIVE PERFORMANCE BY BREED OF DAM

Comparison	Cows	Calved	Calves that died	Calves weaned
	No.	*Pct.*	*Pct.*	*Pct.*
By breed of dam				
Hereford	62	82.3	2.0	80.6
¾ Hereford-¼ Angus	79	88.6	4.3	84.8
½ Charolais-½ Hereford	45	84.4	7.9	77.8
½ Charolais-¼ Hereford-¼ Angus	95	85.3	3.7	80.0
By sire of dam				
Hereford	141	85.8	3.3	83.0
Charolais	140	85.0	6.7	79.3
All cows (total or average)	281	85.4	5.0	81.1

TABLE 2. REPRODUCTIVE PERFORMANCE[1] BY YEARS

Year	Cows	Calved	Calves that died	Calves weaned
	No.	*Pct.*	*Pct.*	*Pct.*
1973	62	90.3 a	3.6 a	87.1 a
1974	67	82.1 ab	1.8 a	80.6 a
1975	57	93.0 a	1.9 a	91.2 a
1976	62	84.6 ab	9.1 b	76.9 ab
1977	43	74.4 b	12.5 b	65.1 b
All years (total or average)	281	85.4	5.0	81.8

[1]Means followed by different letters differ at $P < .05$.

in percent of cows calving, percent calves born dead or that died before weaning, or in percent of cows weaning calves due to breeding of the cow.

Poor conception rates resulted from the use of AI, particularly in some years. In addition, AI delayed conception which eventually produced an overall low percent calf crop. This is best seen in table 2 which gives the reproductive performance by years. A combination of lower percentage of cows calving and a higher death loss resulted in a lower percent calf crop in 1977 compared to all years except 1976 and it approached significance.

Calf Weights and Grades

The number of calves weaned, birth weights, weaning weights, and stocker grades are given in table 3 so that various comparisons are presented.

TABLE 3. LEAST SQUARES MEANS[1] FOR PRE-WEANING TRAITS OF CALVES

Comparison	No. of calves[2]	Birth wt.[3]	250-day adj. weaning wt.	Stocker grade[4]
	No.	*Lb.*	*Lb.*	
By breed of sire				
Hereford	158	76.3 a	556.2	14.0
Limousin	62	82.9 b	568.4	14.2
By breed of dam				
Hereford	48	73.4 a	518.4 a	13.7 a
¾ Hereford-¼ Angus	65	72.9 a	527.7 a	13.9 a
½ Charolais-½ Hereford	35	86.3 b	607.0 b	14.6 b
½ Charolais-¼ Hereford-¼ Angus	72	85.8 b	596.1 b	14.3 b
By sire of dam				
Hereford	113	73.1 a	523.0 a	13.8 a
Charolais	107	86.1 b	601.6 b	14.5 b

[1]Means followed by different letters differ at $P < .01$.
[2]Number of calves weaned.
[3]Includes calves born dead or died before weaning—7 by Limousin bulls and 3 by Hereford bulls.
[4]Grade code: 13 = average Choice; 14 = high Choice.

Calves by Limousin bulls were heavier at birth than calves by Hereford bulls. This increase in birth weight probably contributed to the higher death loss of calves by Limousin bulls. There was no difference in adjusted weaning weight nor in stocker grade at weaning associated with breed of sire. This is surprising because all of the Limousin-sired calves were crossbreds while those by Hereford bulls were either straight Hereford or backcrosses. One would expect a difference caused by hybrid vigor to favor the Limousin-sired calves, but this did not occur. These results are in keeping with reports in the literature *(5,7,8)* where Limousin bulls were compared to other breeds.

There were significant differences among breeds of dam for birth weight, adjusted weaning weight, and stocker grade. However, most of these differences showed up in comparisons between cows sired by Hereford bulls and cows sired by Charolais bulls, table 3. There was a weaning weight difference of 80 pounds in favor of cows sired by Charolais bulls compared to those sired by Hereford bulls. Using the percent weaned from table 1 for these two groups times their adjusted weaning weights gives 430.7 and 474.9 pounds of calf weaned per cow exposed for the Hereford-sired and Charolais-sired cows, respectively. At $65 per hundredweight, the Charolais-sired cows produced $28.73 more income per cow than those sired by Hereford bulls. Since the calves out of the Charolais-sired cows had higher stocker grades, they probably would sell for a higher price per hundredweight, resulting in an even greater difference per brood cow.

Post-weaning Performance

By System

The performance data and profit for the two systems are given in table 4. Overall performance was acceptable for both systems. However, average daily gain (ADG) for the permanent pasture-supplement phase was only 1.09 pounds. The poor performance during this phase would not have had much effect overall if winter grazing had been available earlier or had the calves been weaned later. The average weaning date for calves in this study was September 11, which was 2 months before the earliest date that winter grazing was ready. On the average, winter grazing began January 6 and ended April 30.

TABLE 4. LEAST-SQUARES MEANS FOR POST-WEANING WEIGHTS, GAIN, AND PROFIT BY SYSTEM

System	Steers	Initial weight	Summer-fall pasture gain	Winter pasture gain	Feedlot gain	Feedlot ADG	Post-weaning ADG	Feed/lb. gain	Final weight	Profit[1]
	No.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Dol.*
I	41	604.2	0	0	521.4 b[2]	2.73	2.73 b	7.7	1,125.6 a	70.20
II	41	590.6	127.6	264.5	221.2 a	2.95	2.00 a	8.8	1,203.9 b	44.13

[1]Return over initial value, pasture, and feed cost. No charge was made for labor, interest, or variable cost. Selling price was seasonably adjusted.

[2]Means followed by different letters differ at $P < .01$.

Since ADG for winter grazing was 2.31 pounds, which is very good, having a longer winter grazing period and a shorter permanent pasture period would have improved performance in system II and probably would have increased profit. ADG for the feedlot phase was good for both systems, 2.73 pounds and 2.95 pounds for systems I and II, respectively. One would expect the ADG to be lower for steers in system I compared to system II steers since they were on feed for a much longer time. Normally, steers that gain faster are more efficient. However, steers on system II were heavier and therefore had greater maintenance requirements. This difference in feed efficiency contributed to the larger profit for system I compared to system II. In addition, because of the age difference, it was expected the system II steers would be heavier at the same quality grade than steers on system I.

The profits given in table 4 are based on seasonally adjusted prices less the initial cost of the steers plus feed and pasture charges. There were no charges made for interest, labor, or other variable costs, but had these charges been made, the differences in favor of system I would have been greater.

By Breed of Sire

Steers by Limousin bulls gained faster on pasture and in the feedlot and were heavier at slaughter than were calves by Hereford bulls, table 5. Apparently, the Hereford-sired steers were faster maturing than the Limousin-sired steers which resulted in the slower post-weaning ADG.

TABLE 5. LEAST-SQUARES MEANS FOR POST-WEANING WEIGHTS AND GAINS BY BREED OF SIRE

Breed of sire	Steers	Initial weight	Summer-fall-winter pasture ADG[1]	Feedlot ADG	Post-weaning ADG	Final weight
	No.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Hereford	53	587.3	1.62 a[2]	2.61 a[3]	2.23 a[3]	1,095.1 a[3]
Limousin	29	607.5	1.89 b	3.01 b	2.55 b	1,234.2 b

[1]Only 26 Hereford and 15 Limousin steers were included in the calculation of these means.
[2]Means in this column followed by different letters differ at $P < .05$.
[3]Means in these columns followed by different letters differ at $P < .01$.

By Breed of Dam

Most of the differences in weights associated with breed of dam, table 6, were differences that were present at weaning.

TABLE 6. LEAST-SQUARES MEANS FOR POST-WEANING WEIGHTS AND GAINS BY BREED OF DAM

Breed of dam	Steers	Initial weight	Summer-fall-winter pasture ADG[1]	Feedlot ADG	Post-weaning ADG	Final weight
	No.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Hereford	20	531 a[2]	1.74	2.79	2.40	1,111 a[2]
¾ Hereford-¼ Angus	24	579 b	1.70	2.66	2.30	1,129 a
½ Charolais-½ Hereford	10	658 c	1.88	3.13	2.52	1,234 c
½ Charolais-¼ Hereford-¼ Angus	28	621 c	1.76	2.68	2.35	1,185 b

[1]Only one-half of the steers are included in the calculation of these means.
[2]Means in these columns followed by different letters differ at $P < .01$.

The exception was steers out of ½ Charolais-½ Hereford cows that gained faster in the feedlot than the other steers. The increased gain resulted in this group being the heaviest at slaughter followed by those out of ½ Charolais-¼ Hereford-¼ Angus cows. Evidence of compensatory gain is shown in that steers out of Hereford cows made up most of the difference that existed at weaning when compared to steers out of ¾ Hereford-¼ Angus cows.

Carcass Data

There were no differences in carcass characteristics due to post-weaning system, table 7, although carcass weight approached significance. However, steers by Limousin bulls produced heavier carcasses that had less fat and better yield grades than steers by Hereford bulls. There was no difference in quality grade due to breed of sire.

Other than steers out of part Charolais cows producing heavier carcasses than the other steers, the only other difference associated with breed of dam was that steers out of cows with some Angus breeding tended to be fatter, had poorer yield grades, and produced carcasses with higher quality grades.

TABLE 7. LEAST-SQUARES MEANS FOR CARCASS TRAITS

Comparison	Carcasses	Hot carcass weight	Quality grade[1]	Fat thickness	Yield grade[2]
	No.	*Lb.*		*In.*	
By system					
I	41	699.8	10.8	0.53	2.8
II	41	732.8	11.5	.53	2.9
By breed of sire					
Hereford	53	666 a[3]	11.3	.57 b[3]	3.1 b[4]
Limousin	29	766 b	11.1	.45 a	2.7 a
By breed of dam					
Hereford	20	680 a	10.5 a[4]	.52	2.6
¾ Hereford-¼ Angus	24	685 a	12.1 b	.56	3.2
½ Charolais-½ Hereford	10	770 c	10.8 a	.43	2.7
½ Charolais-¼ Hereford-¼ Angus	28	731 b	11.3 ab	.54	3.0

[1]10 = average Good; 11 = high Good: 12 = low Choice.
[2]1 = leaner; 5 = fatter.
[3]Means in these columns followed by different letters differ at $P < .01$.
[4]Means in these columns followed by different letters differ at $P < .05$.

SUMMARY

A total of 220 calves was weaned as a result of 281 matings between Hereford and Limousin bulls with cows that were sired by Hereford and Charolais bulls. The steer calves were carried to slaughter weights under two post-weaning regimes. The following results were obtained during a 5-year study:

1. There were no differences in reproductive performance due to breed of dam.
2. Limousin-sired calves were heavier at birth than calves by Hereford bulls.
3. There were no differences in weaning weight or stocker grade due to breed of sire.
4. Calves out of ½ Charolais-½ British cows were heavier at birth and weaning and had higher stocker grades at weaning than calves out of British bred cows.
5. It required 115 more days to finish steers if they were stockered prior to finishing compared to steers that went directly into the feedlot. However, the steers that had been grazed were heavier at slaughter than the direct feedlot steers.
6. Steers that went directly into the feedlot were more profitable than those that utilized grazing before being finished in drylot.
7. Limousin-sired steers gained faster post-weaning than Hereford-sired steers.
8. There were no differences in carcass characteristics associated with post-weaning finishing regimes.
9. Limousin-sired steers produced carcasses that were heavier, had less fat, and had better yield grades than Hereford-sired steers.
10. Other than heavier carcasses from steers out of ½ Charolais-½ British cows, there were no consistent differences in post-weaning performance traits or in carcass traits due to breed of dam.

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APPENDIX

APPENDIX TABLE 1. MEAN SQUARES FOR REPRODUCTIVE PERFORMANCE OF COWS

Source of variation	d.f.	Percent calving	Percent died	Percent weaned
Year	4	0.2334	0.4501**	0.5221**
Breed of dam	3	.0419	.0611	.0862
Year x dam	12	.1044	.1276	.1066
Error	261	.1247	.1154	.1516

**P < .01

APPENDIX TABLE 2. MEAN SQUARES FOR PRE-WEANING TRAITS OF CALVES

Source of variation	d.f.	Birth weight	250-day adj. weaning weight	Stocker grade
		Lb.	*Lb.*	
Year	4	486.2**	15,172.3**	1.39
Breed of sire	1	1,656.9**	5,366.1	2.02
Breed of dam	3	2,595.7**	80,124.8**	5.05**
Sire x dam	3	96.6	1,176.2	.32
Error	208	135.3	3,244.1	.62

**P < .01.

APPENDIX TABLE 3. MEAN SQUARES FOR POST-WEANING WEIGHTS AND GAINS

Source of variation	d.f.	Initial weight	d.f.	Pasture ADG	d.f.	Feedlot ADG	d.f.	Post-weaning ADG	d.f.	Final weight
		Lb.		*Lb.*		*Lb.*		*Lb.*		*Lb.*
Year	3	15,867.0*	3	0.9263**	3	1.1706**	3	0.3720*	3	39,372.7*
Breed of sire	1	4,894.6	1	.2544*	1	1.9390**	1	1.1831**	1	230,498.8**
Breed of dam	3	30,604.0**	3	.0365	3	.5483	3	.1111	3	36,260.1*
Post-weaning system	1	2,491.9	0		1	.5608	1	5.6151**	1	82,757.4**
Sire x dam	3	5,864.2	3	.0483	3	.0882	3	.0138	3	4,175.0
Sire x system	1	577.3	0		1	1.1128*	1	.3725	1	5,480.5
Dam x system	3	3,839.7	0		3	.7013	3	.1232	3	3,240.7
Sire x dam x system	3	1,283.8	0		3	.7508	3	.1272	3	7,945.4
Error	63	4,499.9	30	.0683	63	.2884	63	.1114	63	11,162.1

*$P < .05$.
**$P < .01$.

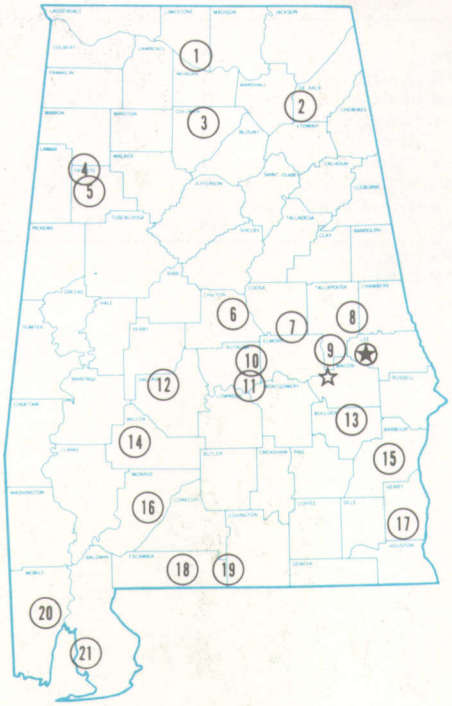
APPENDIX TABLE 4. MEAN SQUARES FOR CARCASS TRAITS

Source of variation	d.f.	Hot carcass weight	Carcass grade	Fat thickness	Yield grade
		Lb.		*In.*	
Year	3	18,895.6*	1,9552	0.0304	0.1553
Breed of sire	1	116,896.9**	.4882	.2112**	2.0146*
Breed of dam	3	21,824.3**	7.3048*	.0410	.9863
Post-weaning system	1	14,570.2*	6.8021	.0211	.0534
Sire x dam	3	1,626.1	.8585	.0205	.1827
Sire x system	1	3,395.9	3.1032	.0212	.3543
Dam x system	3	1,086.0	4.1221	.0342	1.0652
Sire x dam x system	3	2,440.2	6.7916*	.0430	.6788
Error	63	5,116.9	2,4848	.0225	.4096

*P < .05.
**P < .01.

Alabama's Agricultural Experiment Station System
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center, Covington and Escambia counties.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.