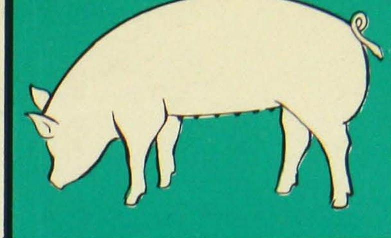
1972
Extension Bulletin 371

Swine Improvement through Crossbreeding



Agricultural Extension Service
University of Minnesota
C. J. Christians

Crossbreeding is widely accepted by commercial swine producers. Nearly 90 percent of Minnesota commercial producers raise crossbred hogs for slaughter. Although breed selection is important in a sound crossbreeding program, genetic improvement will basically come through the selection of superior sires from within each breed.

Crossbreeding is used to combine desirable characteristics of different breeds and to capitalize on hybrid vigor (heterosis). Heterosis may be defined as the average superiority of the crossbred progeny or offspring over the average of their parents. When crossbred pigs perform well above the average of the two parental breeds, heterosis is present (figure 1). Superiority may be less than one of the breed's perfromance; however, it must be above the parental average. When the crossbred pigs perform at parental breed average, no heterosis occurs (figure 2). Purebreds may exceed crossbreds in some traits, but when all traits are combined into general performance, crossbreds generally are superior to purebreds.

Heterosis occurs when genetically different lines or breeds are crossed. It occurs in traits with the lowest heritability. Traits such as litter size, litter weaning weight, and survival rate respond most to crossbreeding (figure 1). Carcass traits are highly heritable and are *not* improved by crossbreeding (figure 2). If the crossbred is to produce an excellent carcass both parents must have superior carcass characteristics.

Table 1 summarizes crossbreeding work conducted by the Regional Swine Breeding Laboratory at Ames, Iowa. Using a boar of a different breed does not increase litter size (table 1). The mother breed in the original cross will influence the litter size. You can ex-

Table 1. Crossbred advantage for commercial pork production

	Purebred boar	
Trait	**Purebred sow**	**XBred sow**
	XBred pigs	**XBred pigs**
Litter size	none	12%
Survival	7%	14%
Pig weaning weight	10%	10%
5 month pig weight	14%	14%
Litter weaning weight	18%	35%
5 month litter weight	22%	40%
Feed efficiency	negligible	negligible
Meatiness	none	none

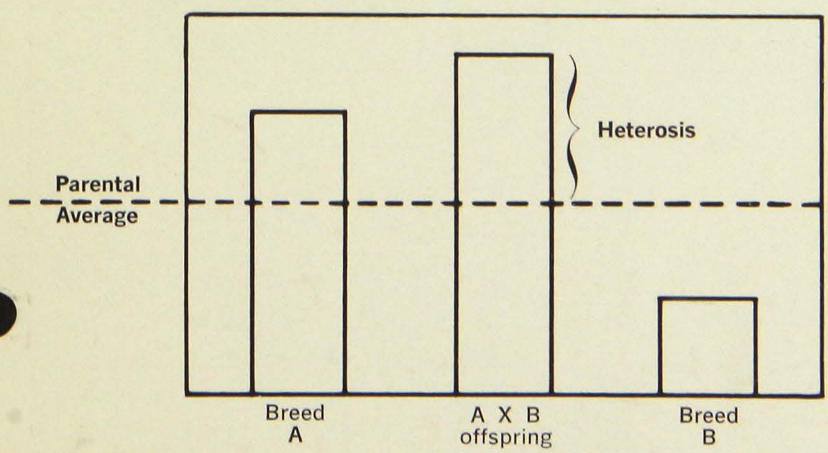


Figure 1. Crossbred pig heterosis

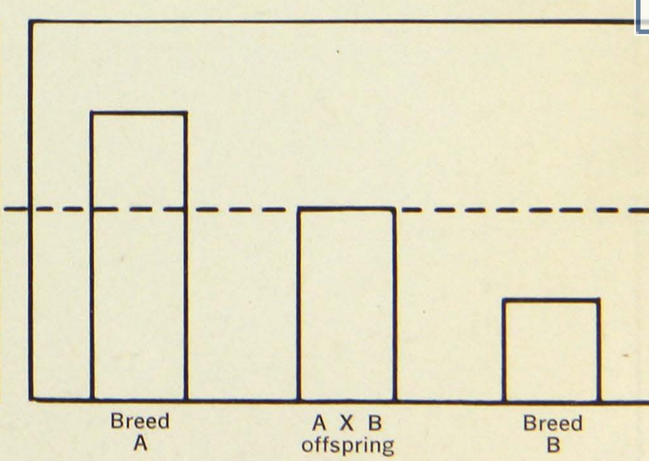


Figure 2. No heterosis

pect a 12 percent increase in litter size when mating a crossbred sow to a purebred boar of another breed. This improvement is probably related to increased number of eggs shed at ovulation and to embryo survival.

Even if litter size at farrowing is not increased, purebred sows will wean 7 percent more crossbred pigs than purebred pigs because of increased survival rate resulting from heterosis. Survival rate is one of the real benefits of a systematic crossbreeding program. When crossbred sows are bred to another boar breed, 14 percent more pigs survive to weaning as compared to the purebreds. This increase is due to larger, stronger pigs at birth.

An individual crossbred pig weaning weight is improved by 10 percent over a purebred pig. The crossbred sow has little effect on growing ability of the pig. This implies milk production is similar. There is an 18 percent advantage in litter weaning weight and a 22 percent increase in 5-month weight primarily because of the increased number of crossbred pigs that survive as compared to purebred pigs. Crossbred litters produced from crossbred sows are 40 percent heavier at 5 months of age than purebred litters.

Because of the lower death loss and increased pig growth rate, most commercial swine producers prefer a crossbred brood sow to a purebred sow.

Crossbred pigs reach market weight faster than purebred pigs. Feed efficiency is not improved by crossbreeding except that which is related to the improved growth rate.

Backfat thickness is not reduced nor is loin eye area improved appreciably through crossbreeding. Some studies indicate some increase in carcass length; however, most carcass characteristics are not influenced and no heterosis should be expected.

Even though traits of intermediate and high heritabilities are not influenced by crossbreeding, you can improve the overall efficiency by selecting superior parents which wean more pigs per sow unit.

Crossbreeding can increase:

* Litter size (crossbred sows wean larger litters).
* Survival.
* Growth rate.

Crossbreeding will not:

* Increase feed efficiency.
* Increase meatiness.

SYSTEMS OF CROSSBREEDING

If crossbreeding is of value, the crossbreds must be superior to the parental breeds. A successful crossing program depends on your selection of superior parents. Each individual born receives half of its genetic makeup from each parent. The sire contributes 50 percent of the offspring's genes. Sires used in the last two crosses contribute 75 percent of the offspring's genes while the last three sires used contribute 87.5 percent of the genes. Therefore, all the expected genetic improvement comes from the selection of superior sires in a crossing program.

Commercial swine producers follow a number of crossbreeding systems of which the two-breed or three-breed rotation crosses are the most popular.

Two-Breed Rotational Cross

The two-breed rotational cross uses boars of two different breeds in alternate generations retaining crossbred sows for maternal stock (figure 3). This crossing program is superior to a single breed cross where two breeds are crossed and a purebred dam is always used to produce crossbred pigs. The single breed cross system does not capitalize on the heterosis in the crossbred sow since only straightbred sows are used.

The two-breed rotational cross is a simple program to follow once you choose the two breeds you wish to cross. Furthermore, you need only secure boars from two different breeds.

Breeds should complement each other. The initial sow breed selection should be noted for its prolificacy, mothering ability, and gainability. The second breed should have excellent growth rate and meatiness.

Select replacement crossbred gilts from the larger, faster growing, healthier litters that have a high weight for age and low backfat probe. Breed these gilts to boars of the second breed which have superior growth rate, low backfat, and muscular form. Central test station information on littermates should be above average and excellent in those traits in which the crossbred sow is inferior.

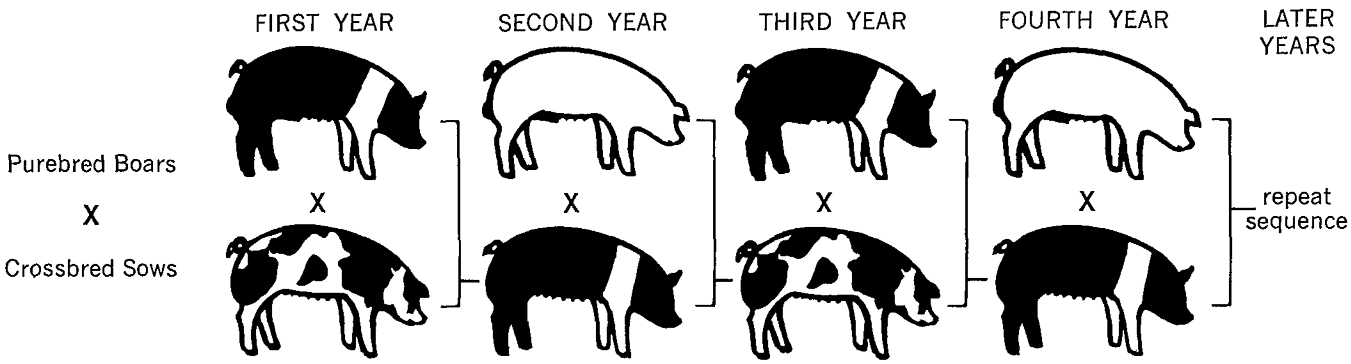
The main disadvantage of a two-breed rotational crossing program is that after a few generations heterosis is no longer maximized for survival and growth. About ⅓ of the crossbred female's genes are inherited from the breed of sire to which she is mated (table 2).

During the second generation, only 50 percent heterosis is realized for pig performance and only 50 percent

Table 2. Two breed rotation expected breed makeup and heterosis

		Generations						
		1	2	3	4	5	6	7
% Genes	Landrace	50	75	37	69	34	67	33
	Poland China	50	25	63	31	66	33	67
% Heterosis	Pig	100	50	75	62	69	66	67
	Sow	0	100	50	75	62	69	66

Figure 3. Two-breed cross using purebred boars and crossbred sows.



maternal heterosis is obtained in the third generation as compared to a system where another breed is introduced. Some producers feel heterosis runs out after continuous crossing. The second generation does not perform as well as the first generation, the third generation does, however, increase to 75 percent heterosis. The percent heterosis stabilizes after the seventh generation at approximately ⅔ of the maximum heterosis.

Three-Breed Rotational Cross

The three-breed rotational cross is probably the most popular crossbreeding system in Minnesota. It combines the strong traits of a third breed that are not available in only two breeds.

Three breeds are systematically rotated each generation with replacement crossbred gilts selected each generation (figure 4). These gilts are mated to the breed of boar farthest removed in the pedigree.

In the second generation, maximum heterosis is realized in both the pigs and crossbred sow(table 3). In the third generation, only 75 percent of the heterosis is achieved since ¼ of the dam's genes are of the sire breed to which she is mated. After about seven generations, maximum heterosis stabilizes at approximately 86 percent—which is about 20 percent above the two-breed rotational cross. The three-breed rotational cross may be expanded to a four- or even five-breed cross in order to introduce some traits of different breeds not available in the original breeds. The heterosis percentage could be increased in the fourth generation, however, it is unlikely that the use of more than three breeds will give any great advantage.

Figure 4. Three-breed rotational cross.

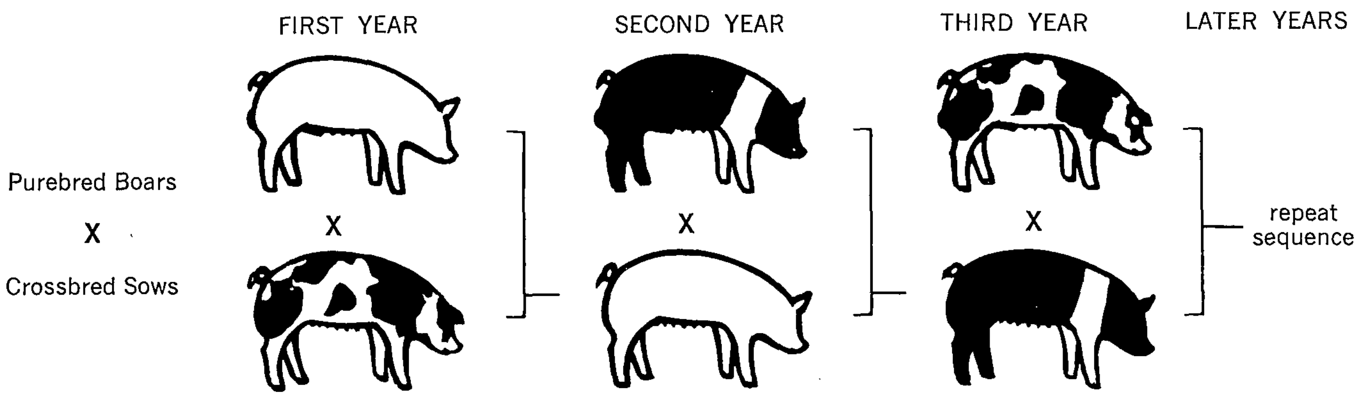


Table 3. Three breed rotation breed composition and expected heterosis

		Generation							
		1	2	3	4	5	6	7	8
% Genes	Yorkshire	50	25	63♂	31	15	58♂	28	14
	Duroc	50♂	25	12	57♂	28	14	58♂	28
	Hampshire	0	50♂	25	12	57♂	28	14	58♂
% Heterosis	Pig	100	100	75	88	88	84	86	86
	Sow	0	100	100	75	88	88	84	86

Two-Breed Rotational Cross Mated To A Third-Sire-Breed

Mating sows from a two-breed rotational cross system to a third breed to produce terminal market pigs may be one of the most desirable systems of producing feeder pigs. The feeder pig producer's goal is to sell a large number of fast growing, muscular pigs per sow unit (figure 5).

As a feeder pig producer you must select those breeds which are very prolific in the two-breed rotational cross.

Although the three-breed rotational cross will maximize heterosis in the sow, the addition of a third breed makes the system rather complicated. You could purchase the two-way cross gilts from a seed-stock producer and rely upon this source for replacements.

Sires of a third breed would be mated to these superior two-way cross gilts to produce a superior market pig. Since you would not keep replacement stock from the offspring, you could keep one sire for long periods and apply greater selection pressure. Keeping sows for a number of litters would maximize lifetime productivity and increase the number of litters produced per year. Since sows usually produce larger litters than gilts, the average number of pigs produced per sow would increase. The market pigs you produce would be consistent over a longer period of time and could establish a reputation at the market.

Since some studies indicate a tendency toward extremely heavy muscled gilts to have some reproductive difficulties, such as lower conception rate and farrowing problems, a two-breed rotational cross selected primarily for sow prolificacy may be a future common practice.

Each breed is selected on the basis of its strong trait in this crossing program and heterosis potential in both sow and pig performance is maximal in the second generation (table 4).

BREED EVALUATION

An accurate comparison of swine breeds for all economically important traits is difficult. Limited data are available for breed evaluation. Although some crossbreeding experiments suggest specific breed crosses, an accurate evaluation of breeds must be a continuous and endless process.

For accurate evaulation all breeds must be adequately sampled and handled exactly the same. There are some data that give us breed trends and can be helpful in evaluating breed averages.

The results in table 5 summarize data on litter size. These data are from the University of Wisconsin, Tennessee, and Iowa State breeding herds; regional swine breeding lab reports; USDA Technical Bulletin 836; and field record reports collected in Wisconsin and Minnesota.

Figure 5. Two-breed rotational cross mated to a third sire breed.

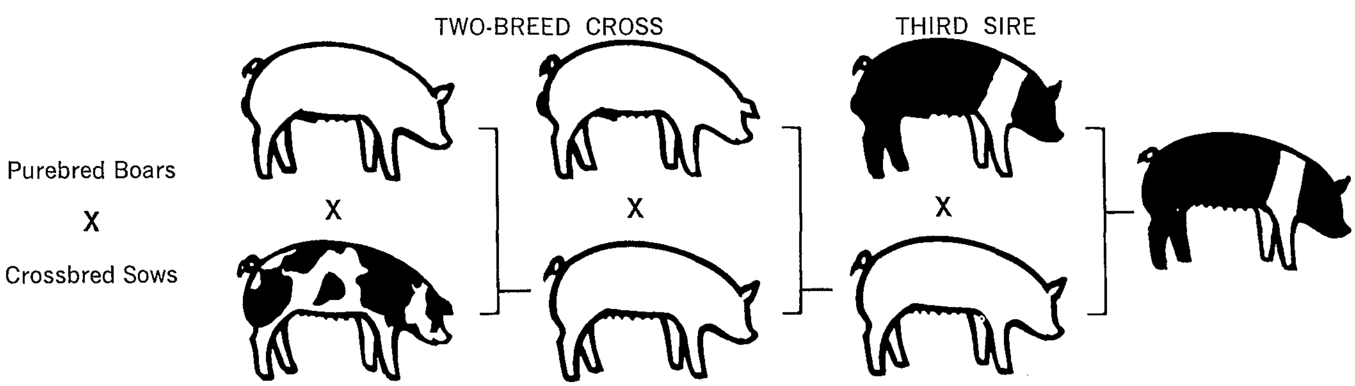


Table 4. Two breed rotation mated to 3rd breed, expected breed makeup and heterosis

		Generation						
		1	2	3	4	5	6	7
% Genes of Sow Line	Yorkshire	50	75	37	69	34	67	33
	Landrace	50	25	63	31	66	33	67
% Genes of Pigs	Yorkshire	50	25	37	13	35	17	33
	Landrace	50	25	13	37	15	33	17
	Hampshire	0	50	50	50	50	50	50
% Heterosis	Pig	100	100	100	100	100	100	100
	Sow	0	100	50	75	62	69	66

Table 5. Average litter size by breeds

Breed	Number of litters	Average litter size
Yorkshire	207	11.13
Landrace	192	10.52
Duroc	4,850	9.66
Chester White	2,129	9.53
Spotted	529	8.78
Hampshire	714	8.78
Berkshire	177	8.07
Poland China	3,298	8.07
Total	12,096	
Average		9.12

Some breeds show a larger average litter size than others. Breeds may be grouped in the following descending order: Yorkshire, Landrace; Duroc, Chester White; Hampshire, Spotted; and Poland China, Berkshire.

Since Yorkshire or Landrace breeds average well above the overall average, these breeds should be used as foundation sows in a crossbreeding program. The next breed choice would be to use either the Chester White or Duroc breeds in a systematic crossbreeding program.

Table 6 summarizes production data collected from the Minnesota Swine Evaluation Station since 1958. More than 7,000 pigs were evaluated from eight major breeds. These data should reflect the breed average over the past 12 years. Although the breed average may be below this past year's test station summary, the ranking of the various breeds has been consistent throughout the years. These data indicate the popularity of the Duroc, Hampshire, and Yorkshire breeds.

In a rotational crossing program, the Duroc breed should be the producer's first choice to improve growth rate and feed efficiency. Since Durocs rank low is carcass evaluation (table 7), strong selection pressure should be placed on boars that are from muscular lines with an individual low backfat probe.

Table 6. Minnesota swine evaluation station production data by breed

Breed	Number of pigs tested	Average daily gain	Feed efficiency
		pounds	(lbs. feed/cwt. gain)
Duroc	1,530	2.01	290
Landrace	258	1.97	298
Hampshire	1,577	1.92	300
Yorkshire	1,257	1.90	293
Poland China	863	1.87	308
Spotted	739	1.85	303
Berkshire	347	1.84	304
Chester White	469	1.79	300
Total	7,040		
Average		1.91	300

The Landrace, Hampshire, and Yorkshire breeds rank next in growth and feed efficiency. These three breeds were also the longest breeds evaluated.

If you select a two-breed rotation system, Yorkshire or Landrace should be your initial sow line. Both breeds are top in prolificacy and rank high in growth rate and feed efficiency. A second breed should be superior in growth and muscular traits. The Hampshire, Poland China, or Spotted breeds would fit these requirements for a sire line.

If you select a three-breed rotation cross for commercial production, the Yorkshire, Landrace, or Chester White breeds are prolific and rank above average in feed efficiency. They should be crossed with breeds noted for growth, such as Duroc, Hampshire, and Landrace. The crossbred female should be crossed with a third breed noted for growth and carcass merit such as the Hampshire, Poland China, or Spotted breeds.

Although breed selection is important in a sound crossbreeding program, genetic improvement will come basically through selection of superior sires within each breed. You must base this selection for your sires upon individual records complemented with littermate performance data.

Table 7. Minnesota swine evaluation station carcass data by breed

Breed	Number of pigs tested	Carcass length	Backfat thickness	Loin eye area	% Ham-loin
		(inches)		(sq. in.)	(live wt.)
Hampshire	1,577	30.4	1.37	4.58	28.65
Poland China	863	29.6	1.46	4.55	27.81
Spotted	739	29.6	1.50	4.28	27.70
Yorkshire	1,257	30.3	1.54	4.20	27.19
Berkshire	347	29.8	1.48	4.20	25.89
Chester White	469	29.6	1.58	4.07	27.48
Landrace	258	30.6	1.50	4.06	26.37
Duroc	1,530	29.3	1.54	3.90	26.38
Total	7,040				
Average		29.9	1.49	4.26	27.40

C. J. Christians is a professor, Department of Animal Science and extension animal husbandman.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Roland H. Abraham, Director of Agricultural Extension Service, University of Minnesota, St. Paul Minnesota 55101

10M — 5-72