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Performance of straightbred and crossbred swine

James Booker Nance Jr.

To the Graduate Council:

I am submitting herewith a thesis written by James Booker Nance Jr. entitled "Performance of straightbred and crossbred swine." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Harold J. Smith, Major Professor

We have read this thesis and recommend its acceptance:

C. S. Hobbs, R. G. Spitze

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

March 16, 1959

To the Graduate Council:

I am submitting herewith a thesis written by James Booker Nance, Jr. entitled "Performance of Straightbred and Crossbred Swine." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Harold J. Smith
Major Professor

We have read this thesis
and recommend its acceptance:

Charles S. Hobbs

W. D. Spitze

Accepted for the Council:

Dale Wantling
Dean of the Graduate School

PERFORMANCE OF STRAIGHTBRED AND CROSSBRED SWINE

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

James Booker Nance, Jr.

March 1959

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James Booker Nance, Jr.

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CHAPTER I

INTRODUCTION

The swine producer has available several breeding systems that can be used in improving the performance of his herd. Improved performance may be attained through an expression of heterosis, or hybrid vigor. Numerous experiments have indicated that heterosis usually results from the mating of genetically divergent animals, with resultant offspring manifesting the heterosis through larger litters, greater viability, faster gains and increased desirability of carcass.

A breeding system widely used in obtaining some degree of heterosis is straightbreeding, or the mating of unrelated animals within a breed. More reliable systems are: (1) linecrossing, the crossing of inbred lines within a breed; (2) crossbreeding, the crossing of different breeds; and (3) linecrossbreeding, the crossing of inbred lines between breeds.

The practicality of the various systems will depend upon the size of operation, availability of breeding stock and the knowledge of the breeder concerning the systems. The development of inbred lines requires a workable knowledge of genetics as well as considerable time, testing and expense. This system, therefore, is largely prohibitive for the average breeder. The application of crossbreeding, however, is not as exacting or costly and is used rather extensively by swine producers.

In order to obtain maximum hybrid vigor from crossbreeding, it is important to utilize breeds which will complement each other most favorably; that is, breeds whose cross-offspring will exhibit a favorable combination of desirable traits of each parent breed.

Although experimental work at other stations has been extensive in regard to the study of performance traits of some straightbred and crossbred swine, little has been conducted under Tennessee conditions. The performance of experimental animals has varied between stations due to differences in genetic make-up of parental animals and differences in environment. Also limited data is available for the performance of some breeds in crosses.

Performance traits of hogs which are especially important to market hog producers are litter size at birth and market weight, pig and litter weight at market, feed efficiency, average daily gain, cost per 100 pounds of gain and carcass quality and desirability. These traits are important since they determine the actual pounds of pork which can be marketed, as well as indicating the cost and efficiency of production and the quality of the product.

The objectives of this study were (1) to compare certain performance traits of hogs produced by two breeding systems, straightbreeding and crossbreeding, and (2) to compare the relative performance of straightbreds and of various crosses.

CHAPTER II

LITERATURE REVIEW

Heterosis is much sought-after in swine breeding since the degree of heterozygosity exerts a major influence on the important performance characters (Dickerson, 1952; England and Winters, 1953). There is little disagreement in the literature concerning the fact that hybrid vigor is most readily obtained by mating animals which are genetically divergent (Winters et al., 1944; Stewart and Comstock, 1948; Sierk and Winters, 1951b; Durham et al., 1952; and craft, 1953).

The genetic mechanism responsible for heterosis is by no means clearly defined, although it can reasonably be assumed to be due to a suppression of unfavorable recessives (Sierk and Winters, 1951b). Craft (1958) presented a more detailed explanation in which hybrid vigor, and also the depressing effects of inbreeding, is explained in Mendelian terms on the basis of two principal theories. The first is called the dominance theory. It is based on the observed association between recessiveness and detrimental effect, and assigns the increased vigor characteristic of crossbreds to complementary effects of favorable dominant genes brought into the cross by each parent. Inbreeding uncovers recessives and thereby results in deterioration, but crossing hides the effects of "bad" genes. Thus, in the crossbred, some of the detrimental recessives coming from one parent are hidden by their dominant alleles coming from the other parent: an increase in vigor is the result. Since the number of genes for most of the important traits in swine is large, and linkage of desirable and less

desirable genes is possible, the probability of a single breed, or an inbred line becoming homozygous for only the dominant or beneficial genes is remote. The second theory is that something about hybridity itself contributes to vigor. Thus, in Mendelian terms, there would be loci at which the heterozygote is superior to either of the homozygotes and the increased vigor is in proportion to the number of such loci. This idea is called over-dominance. Heterosis effects are such as to make the net superiority of a crossbred as a whole animal somewhat higher than it is for each character separately.

While there is little doubt that systems of crossing breeds or strains have merit in the commercial production of hogs, basic improvement in market hogs rests on improvement in foundation stocks (Hillier, 1958), for it is purebreds which form the basis for all crossing programs. Consequently, the performance of crossbreds will depend to a great extent on the purebred animals selected as parents at the start of a crossing program.

Enough is known about genetics to indicate that indiscriminate crossing of breeds will lead to increased variation and what is commonly called "mongrelization". On the other hand, breed differences can be helpful in deciding which breeds to use for crossing (Hazel, 1958). For example, a producer who is farrowing and full-feeding pigs on concrete would not want to utilize the same breeds in a crossing program as would a producer with poor equipment who is running pigs on pasture (Hazel, 1958).

The combining ability of the breeds in crosses thus becomes an important consideration. According to Lasley and Tribble (1958), the effects of inbreeding suggest that performance traits in swine are affected greatly by "nicking", or combining ability. They further stated that if

this is true, the greatest improvement in performance through the application of breeding methods would be expected to come from crossing inbred lines (or breeds) of proven superior crossing ability rather than selection for the improvement of these traits by mating the best to the best.

Selection refers to differences in reproductive rates within a population, whereby animals with certain characteristics tend to have more offspring than animals without those characteristics. Therefore, genes of the favored animals tend to become more abundant in the population and those of the less favored animals to become less abundant (Lush, 1945). Selection is effective to the extent that the selected parents transmit genes whose average effects are superior to the mean of their generation (Dickerson et al., 1954). The effectiveness of selection for a trait depends primarily on three things: (1) the variations exhibited by individuals for the particular trait; (2) the amount of selection pressure applied by the breeder in choosing breeding stock; and (3) the heritability of the trait (Hillier, 1958).

Heritability is the fraction of the observed phenotypic variance which results from differences in heredity, or the percentage of the selection advantage which will be transmitted to the next generation (Rice et al., 1957; and Hillier, 1958). Heritability estimates for performance characters included in this study are as follows:

Character	Heritability per cent		References
	Range	Average	
Total number of pigs farrowed	0-25	13	Bernard, Chapman and Grummer (1954); Blunn and Baker (1949); Cockerham (1952); Cummings, Winters and Stewart (1946); Hetzer, Lambert and Zellar (1940); Lush and Molin (1942); Stewart (1945); Lasley (1957).

Character	Heritability per cent		References
	Range	Average	
Litter size at 56 days	0-32	15	Bernard, Chapman and Grummer (1954); Blunn and Baker (1949); Cockerham (1952); Cummings, Winters and Stewart (1946); Lush and Molln (1942).
Litter size at 154 days	0-9	4	Bernard, Chapman and Grummer (1954); Cockerham (1952).
Survival, birth to weaning	40	40	Cummings, Winters and Stewart (1946).
Pig birth weight	0-16	6	Baker, Hazel and Reinmiller (1943); Craig, Norton and Terrill (1956); Dickerson and Grimes (1947); Krider, Fairbanks, Carroll and Roberts (1946); Lush, Hetzer and Culbertson (1934); Nordskog, Comstock and Winters (1944); Hetzer (1942).
Pig weight at 56 days	0-15	5	Baker, Hazel and Reinmiller (1943); Cockerham (1952); Comstock, Winters, Jordon and Kiser (1942); Craig, Norton and Terrill (1956); Hetzer (1942); Krider, Fairbanks, Carroll and Roberts (1946); Nordskog, Comstock and Winters (1944).
Pig weight at 154 days	7-17	12	Bernard, Chapman and Grummer (1954); Cockerham (1952); Craig, Norton and Terrill (1956).
Pig weight at 180 days	14-65	30	Comstock, Winters, Jordan and Kiser (1942); Craig, Norton and Terrill (1956); Dickerson (1947); Hazel (1943); Krider, Fairbanks, Carroll and Roberts (1946); Whatley (1942); Whatley and Nelson (1942).
Pig rate of gain, birth-200 lb.	3-21	12	Nordskog, Comstock and Winters (1944).
Litter weight at birth	36	36	Cummings, Winters and Stewart (1946).

Character	Heritability per cent		References
	Range	Average	
Litter weight at 56 days	2-21	12	Bernard, Chapman and Grummer (1954); Blunn and Baker (1949); Cummings, Winters and Stewart (1946); Lush and Molln (1942).
Litter weight at 154 days	11	11	Bernard, Chapman and Grummer (1954).
Backfat thickness	12-84	48	Blunn and Baker (1947); Dickerson (1947); Lush (1936); Whatley and Enfield (1957).
Conformation score at 200 lb.	20	20	Stonaker and Lush (1942).
Slaughter weight at 225 lb.	0	0	Dickerson (1947).

Winters et al. (1944) and Winters et al. (1948) produced hybrid vigor in pigs through linecrossing. The results of a study by Warwick and Wiley (1950) indicated that this method gave promise of increasing the general productivity of swine. The crossing of inbred lines from widely unrelated stock has produced more favorable results than crossing lines from related stock (Phillips, 1947), pointing to the importance of genetic diversity in parental animals.

Comparisons have been made of the performance of two-line and three-line crosses. Chambers and Whatley (1951) found that differences in number of pigs per litter and in litter weights at birth, 21, 56 and 180 days were quite large and consistently in favor of the three-line cross litters. Bradford et al. (1958c) showed three-line crosses to be superior in traits affected by productivity of the dam. The superiority of three-line crosses was attributed by England and Winters (1953) to be due to a more diverse genetic make-up.

Sumption et al. (1957) stated that the crossing of breeds was the preferred method of obtaining genetic improvement of economic traits of swine. Crossbreds have generally exceeded the average performance levels of the parental purebreds, in accordance with theoretical expectations (Rice et al., 1957).

It is well to consider at this point the influence of heredity upon pre-natal characters. Any such influence would be important, especially as it affects prenatal viability, since embyro survival rate apparently has a greater influence than ovulation rate in determining litter size at birth (Baker et al., 1958). Dickerson et al. (1946) showed that mortality prior to birth was lower among linecross than among inbred pigs, indicating an expression of heterosis. Likewise, a study by Squiers et al. (1952) indicated that heredity played an important role in influencing ovulation rate and mortality of embyros up to 25 days. Baker et al. (1943) stated, however, that the effect of heredity upon growth before birth was apparently negligible, although conceding a high degree of variability.

At least two recent investigations have demonstrated a lack of advantage for crossbreds in ovulation rate and prenatal growth. Ovulation rates of Chester White and Chester White-Poland China crossbred gilts after flushing were studied by Zimmerman et al. (1957). When compared to the ovulation rate before flushing, the purebred increase in ovulation rate exceeded the increase of the crossbreds. Baker et al. (1958) found that Chester White fetuses were significantly heavier at the 25th day than were Chester White-Poland China crossbred fetuses, and a similar but non-significant trend was found at the 70th day.

Crossbred pigs have been shown to be more vigorous than purebreds, as indicated by their superior ability to survive until weaning age (Winters et al., 1935; Lush et al., 1939; Hutton and Russell, 1939; and Phillips, 1947). In one study, crossbred litters averaged one-third to two pigs larger at weaning (Winters et al., 1935).

Hutton and Russell (1939) found crossbreds to be heavier than purebreds at weaning. This was borne out by Lush et al. (1939) who reported that the advantage was 3-4 pounds per pig, while Winters et al. (1935) showed an advantage of 5-7 pounds per pig and 39-96 pounds per litter. King et al. (1952) presented similar results. Crossbred pigs (sired by inbred boars) exceeded slightly in number of pigs weaned per litter, displayed a definite advantage in pig weight at weaning and 140 days, showed greater average daily gain and reached market weight 18 days earlier than did outbred pigs.

It was noted by Hutton and Russell (1939) that the crossbreds made more rapid gains and were more efficient in feed utilization. This is in agreement with a study by Headley (1940). Winters et al. (1935) found that crossbreds reached 220 pounds 17-22 days earlier than purebreds and did it on 27-36 fewer pounds of grain, while Lush et al. (1939) reported that crossbreds required 25-30 pounds less feed per 100 pounds gain to reach a weight of 225 pounds and gained more in the feed lot.

Crossbreds were shown to be superior to the parental lines in carcass composition by Cummings and Winters (1951). They attributed the superiority not to a higher total yield of the five primal cuts, but to a desirable combination of favored carcass traits of both parents.

A rather controversial interpretation of the results of crossbreeding was presented by Carroll and Roberts (1942). They believed that for crossbreeding to be judged beneficial the performance of the crossbreds should excel the performance of the better of the parental strains of purebreds, and concluded that their data did not support the belief that hybrid vigor could be expected in crossing. However, Whatley et al. (1954), using the data to compare the crossbreds with the average of the purebred parents gave results in favor of crossbreds somewhat comparable to reports of other workers.

Several workers have compared the performance of pigs produced by crossbred dams with the performance of those produced by purebred dams. Winters et al. (1935) noted a superiority of crossbred sows over purebreds for producing market hogs. Sherrit et al. (1954) showed that crossbred gilts produced larger litters at farrowing than purebreds. The pigs from crossbred dams were heavier at weaning and 140 days of age, and gained at a faster rate than purebreds. Litter size was also larger at weaning.

Bradford et al. (1953) found that while litter size at birth and weight of individual pigs were not significantly higher for crossbred than for purebred dams, the increase was substantial and contributed to a significantly higher sow productivity index. Lush et al. (1939) stated that crossbred sows were efficient pig producers when mated either to a purebred boar of one of the parent breeds or to a boar of a third breed.

A rather thorough study of the breeding-of-dam effect was made by Robison (1948). An average of 9.4, 7.9 and 8.0 live pigs were farrowed and 6.9, 6.8 and 7.3 pigs were weaned per litter by gilts approximately a

year of age, when the pigs were purebreds, when the pigs were crossbreds but out of purebred dams and when the pigs were crossbreds and were out of crossbred dams, respectively. All were by purebred sires. At eight weeks of age, the three types of litters named averaged 193.5, 187.5, and 240.7 pounds, respectively. Comparable figures for older sows were averages of 10.6, 9.8 and 9.0 live pigs farrowed, averages of 6.8, 6.8, and 6.4 pigs weaned per litter and averages of 229.8, 259.1 and 246.0 pounds per litter at eight weeks of age, respectively, for the three types of litters.

In the same study it was reported that pigs of a three-breed cross reached an average weight of 220 pounds ten days earlier and required slightly less feed per unit of gain than purebred pigs. Early work at the Minnesota station indicated an overall advantage of 11.7 per cent for three-breed crosses over purebreds (Winters et al., 1935).

From the available information it would seem that some sort of systematic crossing program, such as rotational crossing, would be advantageous for the average breeder (Whatley, 1958). This might take the form of crossing lines developed specifically for crossbreeding or the crossing of breeds chosen for their ability to complement each other in economically important traits (Carmon et al., 1956; and Whatley, 1958). Rotational crossbreeding allows for the retention of crossbred females as parents and thus takes advantage of any hybrid vigor for traits which are more dependent on the genotype of the dam than on the individual's own genotype (England and Winters, 1953; and Carmon et al., 1956). This procedure is a continuous one, consisting of rotating sires of two or more breeds on sows selected from the herd (Robison, 1948; and Whatley, 1958). The findings of Carmon

et al., (1956) indicated that rotational crossing offered greater advantages than the crossing of several breeds or lines followed by random mating.

Robison (1948) showed that pigs of a three-breed backcross reached an average weight of 220.0 pounds 13 days earlier and required 7.9 per cent less feed per unit of gain than purebreds, while pigs of a two-breed backcross reached an average weight of 220.0 pounds only three days earlier and required slightly less feed per unit of gain than did purebreds.

According to Robison (1948) little or no advantage would be expected from the rotation of sires of more than three breeds. Whatley et al. (1954) reported a successful crossing program involving four lines from three breeds and suggested that thorough testing of all possible combinations is necessary to find the one which will give maximum hybrid vigor.

Crosses of lines from different breeds have generally shown considerably more hybrid vigor than that indicated in linecrosses within a breed (Winters et al., 1944; Phillips, 1947; Winters et al., 1948; and Craft, 1953). Gregory and Dickerson (1952) showed that this additional hybrid vigor was manifested in more rapid and more economical gains.

Willham (1944) reported that linecrossbreds were superior in number of pigs per litter at birth, eight weeks and six months of age over the inbred lines and the linecross of the two. However, the linecrosses had the highest average daily gain from weaning to six months of age, as well as the greatest weight at six months of age. Work at the Oklahoma station by Whatley et al. (1954) indicated that linecrossbreds were superior in number of pigs per litter and litter weight at birth, 56 and 154 days as compared to outbreds, crossbreds and linecrosses.

Sierk and Winters (1951b) stated that crosses of inbred lines within the Poland China breed displayed less heterosis than crosses of Minn. No. 1 and Minn. No. 2 or crosses of the Poland China lines and either Minn. No. 1 or Minn. No. 2.

Carcasses of linecrossbreds were found to be superior over outbreds, inbreds or linecrosses by Winters et al. (1948).

CHAPTER III

PROCEDURE

Source of Data

The experimental work described in this study was conducted at Ames Plantation, Grand Junction, Tennessee and includes the first four farrowing seasons of an extended swine breeding project being conducted by the Animal Husbandry-Veterinary Science Department, Agricultural Experiment Station, University of Tennessee, Knoxville, Tennessee.

Data were obtained from the performance of animals of the Hampshire, Duroc, Poland China and Landrace breeds, and various two-, three-, and four-way crosses of those breeds. Data from the backcross performance of Hampshires and Durocs were also obtained. Performance data were obtained for the following traits: litter size at birth, 56 and 154 days; pig weight and litter weight at birth, 56, 154 and 180 days; average daily gain from birth to market weight; and live backfat probe at market weight.

Experimental Animals

The foundation stock, consisting of 50 open gilts and 5 boars, were purchased in the fall of 1955. The breeding groups, the number of animals in each group and the sources of the animals were as follows:

I. Hampshire

1. Twelve gilts from two breeders in Tennessee.
2. Two boars, one from the University of Tennessee herd at Knoxville and one from a breeder in Tennessee.

II. Duroc

1. Ten gilts from a breeder in Tennessee.

2. Six gilts from Iowa State College.

3. One boar from Iowa State College.

III. Poland China

1. Five gilts from Iowa State College.

2. One boar from Iowa State College.

IV. Landrace

1. Ten gilts from Iowa State College.

2. One boar from Iowa State College.

V. Poland x Landrace

1. Seven crossbred gilts from Iowa State College.

Animals obtained from Iowa State College were from the more productive lines developed at that station and in most cases, were slightly inbred.

Breeding was begun shortly after November 1, 1955; thus, the first farrowing season of the project was in the spring of 1956. Subsequent farrowing seasons were in the fall of 1956 and spring and fall of 1957. The farrowing seasons, together with the farrowing dates and number of litters farrowed in each season, were as follows:

Farrowing season	Farrowing date	No. litters
Spring, 1956	3/3 to 4/13	37
Fall, 1956	9/20 to 10/29	38
Spring, 1957	2/25 to 5/24	83
Fall, 1957	10/5 to 12/11	89

As indicated above, the size of the sow herd was approximately doubled for the farrowing seasons of 1957 as compared to 1956. All sow

herd additions and replacements came from within the herd with gilts selected on the basis of certain objective standards. Gilts selected as replacements were from a litter of 8 or more pigs, had a 180-day weight of 200 pounds or more, probed 1.6 inches or less, carried at least 12 teats and were of the desired meat-type. Sows were retained in the herd on the basis of their performance. Some of the original sows were allowed to farrow during all four farrowing seasons, while others were culled after one litter due to poor performance or other factors.

Several boars were selected from the pig crops of the spring and fall, 1957 for use as sires in later farrowing seasons.

Eight boars were purchased during the fall of 1956 and spring of 1957. These boars, in addition to 4 of the 5 original boars, sired pigs which were born during the 1957 farrowing seasons. The breeds and sources of the boars were as follows:

I. Hampshire

1. One boar from a breeder in Tennessee.
2. One boar from the University of Tennessee herd at Knoxville.

II. Duroc

1. One boar from Oklahoma State University.
2. One boar from Iowa State College.
3. Two boars from two breeders in Tennessee

III. Poland China

1. One boar from Iowa State College.

IV. Landrace

1. One boar from Iowa State College

V. Yorkshire

1. One boar from Iowa State College.

Herd Management

The sows were divided into three groups for breeding at two-week intervals. This was necessary since the central farrowing house used to house sows while farrowing could accommodate only 35 sows. The two-week interval allowed time for putting the sows in the farrowing stalls a few days before farrowing, leaving the sows and pigs in the stalls for 7-10 days after farrowing, and steam cleaning and disenfecting the stalls for the next sows.

All sows were pasture bred, each boar being mated to 8-10 sows. Approximate farrowing dates were obtained by the herdsman by checking the sows daily and recording the ones in estrus. Gilts were bred to farrow at 10-14 months of age.

After being brought to the farrowing quarters, sows were thoroughly washed, using soap and a disenfectant, and wormed with piperazine.

Each sow was turned out of the stall twice daily, both before and after parturition, for feed and water. The small amount of pig losses due to crushing by the sow was attributed to the use of farrowing stalls. Farrowing stalls were equipped with electric heat lamps to provide extra heat for the pigs as needed.

Sows and pigs were turned out to pasture when the pigs reached 7-10 days of age.

Once a year sows were vaccinated for erysipelas, cholera and leptospirosis. A brucellosis test was run twice a year. The sows received

wormings twice a year in addition to the worming at farrowing time. They were rung as needed.

Boars were managed somewhat similar to sows. They received the same vaccinations, were tested for brucellosis, and were rung and wormed as needed. During the non-breeding season they were allowed to run together in groups according to age and size. Tusks were kept trimmed.

Pigs were ear notched at birth using the U. S. D. A. system. This system gives a numerical value to each notch, with the left ear indicating the litter number and the right ear indicating the individual pig number within the litter. The needle teeth of the pigs were cut and the gums treated with tincture of iodine. Iodine was also applied to the freshly cut notches and to the umbilical cords. Pigs were weighed to the nearest 0.1 pound and injected with 3 cc. of erysipelas serum.

At 3-5 days of age the pigs were injected with an iorn compound for the prevention of anemia, and at 7-10 days of age pigs and dams were moved to pasture lots.

The first selection of boars was made at four weeks of age. Boars which did not show promise at this age were castrated. All pigs were vaccinated with EVA and mixed bacterin.

Litters were weaned and weighed at approximately eight weeks of age. A second selection for boars was made at this time. All pigs were rung and vaccinated for cholera. A teat count was made on both boars and gilts. The weaned pigs were sorted into groups according to size and weight. Pigs were wormed with piperazine two weeks after weaning and again at four week intervals depending on the level of infestation.

The pigs were weighed again at approximately 154 days of age and divided into the following weight groups: 200 pounds and over, 185-200 pounds, 165-185 pounds and 165 pounds and under.

At approximately 180 days of age, the pigs were weighed and those weighing around 220 pounds were marketed or sold as breeding stock. A live-animal backfat probe was taken at the 7th rib, 3 inches off center of the back, using a knife and a steel ruler (probe).

Feeds and Rations

All animals were fed rations containing corn which was grown on Ames Plantation. Some of the corn was fed as ground ear corn while some was fed as whole ear corn, depending upon the animals receiving the ration. Protein supplements were purchased. Varying amounts and proportions of tankage, soybean oil meal and alfalfa leaf meal were fed, depending upon the quality and amount of pasture available and upon the condition and age of the animals.

Sows were fed one of two supplement mixtures: (a) on "good" pasture, a mixture of 100 pounds tankage and 100 pounds of soybean oil meal; (b) on "poor" pasture, a mixture of 100 pounds tankage, 100 pounds of soybean oil meal and 100 pounds of alfalfa leaf meal. Ten pounds of dicalcium phosphate and 2 pounds of salt were added per 100 pounds of either mixture.

From the time litters were weaned until rebreeding, sows were hand fed a daily ration of 2-5 pounds of ground ear corn and ½-1 pound of supplement (a) or (b), the amount depending on the age and condition of the sows and the quality of the pasture.

At breeding time the sows were flushed by increasing the amount of ground ear corn by about 2 pounds and the supplement by ½-1 pound. This level of feeding was continued through the first month of pregnancy. After that the concentrate level was reduced to prevent the sows from becoming overly fat.

Three to four weeks before farrowing the supplement was raised to 1½-2 pounds daily and the amount of ground ear corn increased. After farrowing, sows were started on a small amount of ground ear corn plus supplement(b). At the time the sows went on pasture with their pigs, their ration was increased to a full feed level and were self fed ear corn and supplement until pigs were weaned. After weaning of pigs no feed was given the first day or two if the pasture was good. A limited amount of feed was fed during the rest of the drying-up period.

Boars were fed according to their condition. They received the same rations as the sows but were kept in a thrifty condition at all times and not allowed to become fat.

Pigs were self fed ear corn and supplement free choice from weaning until reaching market weight. They were fed one of two supplements depending upon the quality and amount of pasture available and the age of the pigs. On "good" pasture, pigs up to four months of age were self fed a supplement mixture consisting of 100 pounds of tankage and 100 pounds of soybean oil meal. From four months to market weight, an additional 100 pounds of soybean oil meal was added to the mixture. On "poor" pasture, pigs up to four months of age were self fed a supplement mixture of 150 pounds of tankage, 150 pounds of soybean oil meal and 50 pounds of alfalfa

meal. For pigs from four months to market weight, the tankage was decreased by 50 pounds and the soybean oil meal increased by 50 pounds. Ten pounds of dicalcium phosphate and 2 pounds of salt were added per 100 pounds of either supplement. An antibiotic was added at the rate of 4 grams of activity per 100 pounds of supplement mixture.

Permanent pastures of alfalfa, Ladino clover and orchardgrass were provided for spring litters. Temporary pastures of oats and crimson clover were provided for fall litters. Pastures were grazed at the rate of approximately 20 pigs per acre.

Methods and Analysis

Individual pig weights of both straightbred and crossbred pigs were adjusted to three standard ages to permit comparisons between individuals, between litters and between breeding groups.

A standard 56-day weight (weaning weight) was obtained for each pig by subtracting the birth weight from the actual weight at weaning, dividing the remainder by the weaning age to calculate the average daily gain, multiplying the average daily gain by 56 and adding the product back to the birth weight.

A standard 154-day weight was obtained by subtracting the actual weaning weight from the actual weight at approximately 154-days, dividing the remainder by the days from weaning to the weigh date to get the average daily gain for the period, multiplying the average daily gain by the number of days between the weigh date and 154 days and adding the product to the actual weight if the pig was less than 154 days old and subtracting it if the pig was older than 154 days. The same procedure was used to obtain the 180-day weight.

Pigs in this study reached market weight at about 180 days. Pigs which reached 200 pounds or more by 154 days were marketed at that time and the same average daily gain used to calculate both 154 and 180-day weights.

Backfat thickness was adjusted to a standard weight of 200 pounds through the use of an adjustment table devised by H. W. Bean, University of Illinois.

All pigs farrowed, whether farrowed alive or born dead, were included in litter size at birth. The dead pigs in each litter were not weighed but were assigned the average live-pig weight for the litter and included as a part of total litter birth weight.

Comparisons between the performance of straightbreds and crossbreds were limited to those within season and age of dam. Differences between the average performance of crossbred and straightbred for each age of dam group within season were weighted according to $\frac{N_1 N_2}{N_1+N_2}$ where N_1 and N_2 were the number of crossbred and straightbred litters, respectively.

Tests of significance as described by Snedecor (1956) were employed to test the significance of the difference between straightbred and crossbred groups.

The "t" test was used to test the significance of the differences between straightbred and crossbred groups for the following six traits: litter size at birth, litter size at 154 days, pig weight at 180 days, litter weight at 180 days, average daily gain from birth to weaning and adjusted backfat thickness. An average of the performance of the parental breeds involved in a cross was used as a base to compare the straightbreds

with the crossbreds. For example, the average of the performance of the Hampshire, Poland China and Landrace breeds was used for comparison with the performance of the Hx(PxL) cross.

The significances of individual pig and litter weight were tested at 180 days rather than at 56 or 154 days in order to get a better indication of what might be expected as to performance at the time pigs were marketed. While performance at birth, 56 or 154 days influences 180-day performance, the producer is most concerned with the total pounds of live pork which can be marketed as well as feed efficiency and the length of time required to grow and finish the hogs.

The multiple range test as outlined by Duncan (1955) was used to test the significance of differences among various items of performance for the four breeds.

CHAPTER IV

RESULTS AND DISCUSSION

Complete data for the four farrowing seasons are shown in Appendix Tables I, II, III, and IV for the performance of all straightbred and crossbred groups included in this study. The data are summarized by age of dam groups within seasons and indicate the actual performance of the breeding groups without adjustements other than that made for weight-for-age and backfat thickness.

Comparisons shown in Appendix Tables V and VI involved only crossbreds with breeds used in the crosses. Some breeding groups were not used in comparisons since comparable straightbred or crossbred litters were not farrowed in the same season, or were from different aged sows.

The weighted average performance of crossbreds and straightbreds on a within season and age of dam basis is presented in Appendix Table V. Within season and age of dam weighted mean differences between crossbreds and straightbreds for the various traits and percentage advantage of crossbreds are presented in Appendix Table VI.

The largest number of crosses included in this study involved the Hampshire and Duroc breeds. Significant differences ($P < .05$) were found for litter size at birth, litter size at 154 days, litter weight at 180 days and average daily gain between the straightbreds and the HxD cross in favor of the crossbreds. Hampshire and Duroc crossbred litters gained about 8 per cent faster from birth to market weight and were about 28 per cent heavier at 180 days than straightbred litters. Crossbred litters

were 21.3 and 20.0 per cent larger at birth and 154 days, respectively. Although the performance of the reciprocal cross, DxH, and the backcrosses, Hx(HxD) and Dx(HxD) exceeded the average performance of the straightbreds in almost all traits, differences were not statistically significant. Differences of 2.1 pigs per litter were observed between straightbreds and both backcrosses at 154 days ($P < .10$). This represented an advantage of about 27.0 to 28.0 per cent for the crossbred sows. The difference in litter weight at 180 days between the straightbreds and both the Dx(HxD) and Hx(HxD) backcrosses approached significance ($P < .10$). Individual weights of the backcross pigs were only about 4.0 per cent greater than weights of straightbred pigs but the total litter weights for the Dx(HxD) and Hx(HxD) crosses were about 26.0 to 30.0 per cent greater than straightbred litter weights. Work by Winters et al. (1936), Lush et al. (1939) also indicated that crossbred sows were efficient pig producers when mated to a purebred boar of one of the parent breeds. However, little advantage was noted by Robison (1948) for pigs of a two-breed backcross.

A comparison was available for a single cross of the Hampshire and Landrace breeds in one season (Appendix Table V). Although a considerably heavier litter weight was obtained for the crossbred pigs at 180 days, the differences ($P < .05$) were observed for litter size at 154 days, pig weight at 180 days and average daily gain. These advantages were generally similar to those in reports by Winters et al. (1935), Hutton and Russell (1939) and Lush et al. (1939).

The performance of two three-way crosses, Lx(HxD) and Hx(PxL) was compared with the average performance of the breeds used in the crosses.

Significant differences ($P < .05$) were found between the Lx(HxD) cross and the straightbreds for pig weight at 180 days and average daily gain. The advantage in total litter weight at 180 days for the crossbred litters was 314 pounds or 21.4 per cent when compared with the straightbred litters. The Hx(PxL) litters were significantly larger at 154 days. Significant differences were also obtained for pig weight at 180 days ($P < .05$), total litter weight at 180 days ($P < .01$) and average daily gain ($P < .01$) in favor of the crossbred Hx(PxL) pigs. The differences in litter weight at 180 days (1026 pounds) and average daily gain (0.19 pound) were the highest observed between any crossbred and straightbred groups in the study. These results are in general agreement with early work at the Minnesota station which indicated an overall advantage of 11.7 per cent for three-breed crosses over purebreds (Winters et al., 1935). Robison (1948) also noted a superiority of a three-breed cross over purebreds.

The general performance of two crossbred groups, Hx(HxPxL) and Lx(HxPxL), was considerably below that of the three-breed cross, Hx(PxL). When compared with the straightbreds the Hx(HxPxL) cross had significantly more ($P < .05$) pigs per litter at 154 days and the difference in litter weight at 180 days approached significance ($P < .10$). The differences between the Lx(HxPxL) cross and the straightbreds were in favor of the crossbreds in all traits except pig birth weight, but none of the differences were statistically significant. Litter weights at 180 days were 17.7 and 44.5 per cent ($P < .10$) heavier for the Lx(HxPxL) and Hx(HxPxL) groups, respectively, as compared with the straightbred groups. Robison (1948) that pigs of a three-breed backcross reached an average weight of 220

pounds 13 days earlier and required 7.9 per cent less feed per unit of gain than purebreds.

Differences between the average for the four-breed cross, Dx(HxPxL) and the average of the parental breeds were highly significant ($P < .01$) for pig weight at 180 days, average daily gain and litter weight at 180 days. The four-breed cross pigs and litters were 31.4 per cent and 35.1 per cent heavier, respectively, than straightbred pigs and litters at 180 days.

The use of the Landrace breed in crosses was very effective in reducing the backfat thickness in crossbred pigs. In five out of six crosses which included Landrace breeding there was an advantage for the crosses in having a lower backfat thickness. The exception was a two-way cross, LxH.

In general, crossbred litters were slightly larger at birth and consistently had a larger litter size at market weight than purebreds litters. Pig and litter weights at 56, 154 and 180 days was heavier in all cases for crossbreds than for purebreds. The litters with the most pigs farrowed generally had the lowest average individual pig weights at birth. The crossbred pigs also exceeded the purebreds in average daily gain from birth to weaning.

The average performance of the straightbred Duroc, Hampshire, Poland China and Landrace over all seasons is given in Appendix Table VII. Pigs of the Duroc breed consistently had the highest average performance of any of the straightbreds for all traits studied. However, differences between the Duroc and Hampshire breeds were small and none were statistically significant.

The average performance of the Durocs exceeded that of both the Landrace and Polands in all characters studied except backfat thickness and all differences were significant. The backfat thickness of the Landrace and Poland pigs was more desirable than that of the Duroc pigs and the difference between Landrace and Duroc pigs was significant ($P < .05$).

The average performance of the Hampshires was significantly greater than the average performance of the Landrace for all traits. However, the backfat thickness of the Landrace was more desirable. Differences between the Hampshires and Polands were in favor of the Hampshires and were significant except for litter size at birth and adjusted backfat thickness. Likewise, Polands had significantly greater performance in all traits when compared with the Landrace except for litter size at birth and adjusted backfat thickness.

Pigs of the Landrace breed had a more desirable backfat thickness (less) than other straightbred groups but relatively smaller litter size, pig weight, litter weight and daily gain.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was undertaken to compare certain performance traits of hogs produced by two breeding systems, straightbreeding and crossbreeding, and to compare the relative performance of straightbreds and of various crosses.

A total of 133 straightbred Hampshire, Duroc, Poland China and Landrace litters and 114 two-, three- and four-breed cross litters involving these breeds were farrowed over four seasons during a two-year period, 1956 and 1957. Analyses for comparisons between various straightbred and crossbred groups were restricted to data from groups of pigs farrowed in the same season and from dams of the same age. Intra-age of dam and season weighted average differences were obtained between the average performance of the parental breeds and the average performance of the crossbreds.

Crossbred sows farrowed slightly larger litters than straightbred sows but differences in most comparisons were not statistically significant. However, the differences in litter size between crossbreds and straightbreds were much larger at 56 and 154 days and in many comparisons the differences were statistically significant or approached significance. The differences in litter size between crossbreds and straightbreds for the various comparisons varied from 0.6 to 3.6 pigs with an average difference of about 1½ pigs per litter (20 to 25 per cent) in favor of the crossbreds. This advantage in litter size at 154 days could be attributed primarily to the increased viability of crossbred pigs rather than to the increase in number farrowed in crossbred litters.

Crossbred pigs gained faster from birth to market weight than straightbreds, although not all differences were statistically significant. Crossbred pigs were about 8 to 10 per cent heavier at 180 days.

Total litter weights of crossbred litters were consistently heavier at 56, 154 and 180 days for all comparisons between straightbred and crossbred groups. Differences between total litter weights were in favor of the crossbreds in all comparisons and ranged from 198 to 1026 pounds with an average difference of 400 to 450 pounds (30 to 35 per cent). Increased number of pigs per litter due to greater viability of crossbred pigs and greater productivity of crossbred dams, was in most cases, sufficient to account for a large percentage of the increase in total litter weight of the crossbreds as compared with the straightbreds. Although crossbred pigs gained faster than straightbred pigs, hybrid vigor was expressed to a greater extent in the increased viability of the pigs than in the increased growth rate of pigs.

Pigs of the Duroc breed consistently had the highest average performance of any of the straightbreds for all traits studied. However, differences between the Duroc and Hampshire breeds were small and none were statistically significant.

The average performance of the Durocs exceeded that of both the Landrace and Polands in all characters studied except backfat thickness and all differences were significant. The backfat thickness of the Landrace and Poland pigs was more desirable than that of the Duroc pigs and the difference between Landrace and Duroc pigs was significant.

The average performance of the Hampshires was significantly greater than the average performance of the Landrace for all traits. However, the

backfat thickness of the Landrace was more desirable. Differences between the Hampshires and Polands were in favor of the Hampshires and were significant except for litter size at birth and adjusted backfat thickness. Likewise, Polands had significantly greater performance in all traits when compared with the Landrace except for litter size at birth and adjusted backfat thickness.

Pigs of the Landrace breed had a more desirable backfat thickness (less) than other straightbred groups but relatively smaller litter size, pig weight, litter weight and daily gain.

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APPENDIX

TABLE I

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, SPRING 1956[a]

	Breeding of pigs					
	Hampshire	Duroc	Poland	Landrace	HxD	Hx(PxL)
No. of litters	8	9	5	7	4	4
No. of pigs per litter						
Birth	8.4	8.6	7.8	7.3	10.2	10.5
56 days	7.0	7.4	7.6	5.6	9.2	10.0
154 days	6.8	7.3	7.4	5.0	9.0	10.0
Av. pig weight, lb.						
Birth	3.2	2.7	2.9	2.9	2.6	2.8
56 days	38.3	36.2	36.5	29.9	41.4	36.3
154 days	158.2	161.6	164.1	136.2	185.0	178.8
180 days	193.6	207.7	208.4	167.6	226.4	224.1
Av. litter weight, lb.						
Birth	26.5	23.2	22.8	21.0	27.2	29.4
56 days	268.1	269.9	277.2	166.8	383.2	362.6
154 days	1067.8	1185.0	1214.4	681.3	1664.8	1788.5
180 days	1316.5	1516.2	1542.2	838.0	2037.6	2241.0
Av. daily gain, birth to market, lb.	1.10	1.16	1.14	0.96	1.25	1.22
Adjusted backfat (200 lb.) in.	1.61	1.75	1.33	1.32	1.52	1.39

[a]All pigs out of one-year-old dams.

TABLE II

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, FALL 1956[a]

	Breeding of pigs				
	Hampshire	Duroc	Landrace	HxD	Hx(PxL)
No. of litters	11	10	6	4	7
No. of pigs per litter					
Birth	10.4	9.5	5.7	11.2	10.3
56 days	9.2	7.2	3.5	9.8	8.7
154 days	9.2	7.0	3.2	9.8	8.7
Av. pig weight, lb.					
Birth	3.0	3.1	3.4	2.9	3.2
56 days	35.6	33.1	30.7	38.0	44.8
154 days	167.6	163.3	152.0	180.1	194.8
180 days	207.2	210.8	180.7	223.0	201.1
Av. litter weight, lb.					
Birth	31.8	29.5	19.3	32.2	32.4
56 days	326.6	238.2	107.3	370.0	390.8
154 days	1538.8	1143.4	481.2	1755.7	1697.8
180 days	1906.2	1475.6	578.2	2185.4	1749.6
Av. daily gain, birth to market, lb.	1.13	1.16	0.98	1.23	1.31
Adjusted backfat (200 lb.) in.	1.78	1.79	1.38	1.61	1.47

[a]All pigs out of 1½-year-old dams.

TABLE III

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, SPRING 1957

	Breeding of pigs and age of dam							
	Hampshire		Duroc		Poland	Landrace	HxD	
	1 yr.	2 yr.	1 yr.	2 yr.	1 yr.	1 yr.	1 yr.	2 yr.
No. of litters	7	7	8	7	6	5	4	1
No. of pigs per litter								
Birth	7.6	10.8	9.8	11.7	8.3	9.2	10.8	16.0
56 days	6.4	8.6	8.8	7.6	7.2	7.0	9.0	10.0
154 days	6.4	8.4	8.5	7.6	6.8	6.8	9.0	10.0
Av. pig weight, lb.								
Birth	3.2	3.5	2.9	2.9	3.2	3.4	2.7	2.2
56 days	33.2	39.1	32.4	32.8	32.4	35.9	38.0	31.3
154 days	166.3	168.5	165.1	161.4	164.0	157.2	188.2	180.9
180 days	204.8	211.8	204.3	199.7	197.0	193.3	228.8	223.2
Av. litter weight, lb.								
Birth	24.6	38.2	28.6	33.9	26.6	31.7	29.5	25.9
56 days	213.1	334.8	283.2	262.6	231.9	251.3	341.6	313.4
154 days	1069.1	1420.0	1403.3	1221.9	1120.4	1068.6	1694.3	1808.8
180 days	1310.7	1779.1	1736.6	1517.7	1339.6	1314.4	2059.2	2232.1
Av. daily gain, birth to market, lb.	1.12	1.16	1.14	1.12	1.08	1.07	1.28	1.23
Adjusted backfat (200 lb.) in.	1.53	1.49	1.63	1.61	1.51	1.27	1.54	1.63

TABLE III

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, SPRING 1957 (continued)

	Breeding of pigs and age of dam				
	DxH 2 yr.	DxP 1 yr.	DxL 2 yr.	YxH 1 yr.	Dx(PxL) 2 yr.
No. of litters	1	3	2	4	4
No. of pigs per litter					
Birth	9.0	8.3	10.5	9.5	12.5
56 days	6.0	7.0	8.0	8.0	11.2
154 days	6.0	7.0	8.0	8.0	11.0
Av. pig weight, lb.					
Birth	3.4	3.9	3.8	2.7	3.8
56 days	57.2	37.2	38.2	28.9	45.9
154 days	203.0	170.1	169.0	167.1	202.4
180 days	232.4	218.8	216.3	203.1	239.2
Av. litter weight, lb.					
Birth	30.2	32.3	40.2	25.8	46.9
56 days	343.4	260.2	305.4	231.4	516.3
154 days	1218.3	1190.5	1351.8	1337.0	2226.2
180 days	1394.4	1532.0	1730.4	1624.9	2630.9
Av. daily gain, birth to market, lb.	1.28	1.19	1.17	1.10	1.32
Adjusted backfat (200 lb.) in.	1.52	1.44	1.40	1.66	1.27

TABLE III

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, SPRING 1957 (continued)

	Breeding of pigs and age of dam				
	Dx(HxD) 1 yr.	Lx(HxD) 1 yr.	Yx(HxD) 1 yr.	Dx(HxPxL) 1 yr.	Lx(HxPxL) 1 yr.
No. of litters	3	3	5	7	6
No. of pigs per litter					
Birth	12.0	12.0	10.2	9.4	8.8
56 days	10.0	10.3	8.8	8.1	7.3
154 days	10.0	10.3	8.6	7.8	7.3
Av. pig weight, lb.					
Birth	2.7	3.0	3.0	3.0	3.0
56 days	35.6	40.4	32.2	37.2	38.6
154 days	173.2	183.0	172.7	183.5	176.4
180 days	208.5	222.5	214.1	223.6	214.4
Av. litter weight, lb.					
Birth	32.1	35.7	30.5	28.2	25.1
56 days	355.6	418.0	283.3	302.9	283.3
154 days	1732.2	1891.3	1485.6	1442.2	1293.4
180 days	2085.0	2291.8	1841.2	1744.1	1565.1
Av. daily gain, birth to market, lb.	1.12	1.21	1.16	1.22	1.16
Adjusted backfat (200 lb.) in.	1.49	1.37	1.52	1.36	1.35

TABLE IV

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, FALL 1957

	Breeding of pigs and age of dam						
	Hampshire			Duroc			Poland
	1 yr.	1½ yr.	2 yr.	1 yr.	1½ yr.	2 yr.	1½ yr.
No. of litters	1	3	4	3	7	3	9
No. of pigs per litter							
Birth	9.0	9.3	10.0	10.7	11.6	10.7	8.7
56 days	8.0	8.0	7.5	9.0	9.7	7.7	6.3
154 days	6.0	7.0	7.5	8.7	9.4	7.3	5.8
Av. pig weight, lb.							
Birth	3.2	3.8	3.6	2.8	3.0	3.2	3.2
56 days	22.6	35.4	37.0	32.0	35.8	35.1	30.9
154 days	136.0	165.1	161.0	163.5	163.3	193.8	152.6
180 days	172.3	206.8	202.9	202.3	215.2	239.3	191.4
Av. litter weight, lb.							
Birth	29.2	35.3	36.2	29.4	34.3	33.7	27.4
56 days	181.1	283.3	277.4	288.4	347.9	269.2	195.7
154 days	815.8	1155.5	1207.8	1417.3	1540.1	1421.0	882.0
180 days	1033.8	1447.6	1521.8	1760.0	2022.9	1746.9	1110.1
Av. daily gain, birth to market, lb.	0.98	1.10	1.12	1.11	1.16	1.28	1.05
Adjusted backfat (200 lb.) in.	1.34	1.52	1.41	1.58	1.56	1.45	1.74

TABLE IV

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, FALL 1957 (continued)

	Breeding of pigs and age of dam						
	Landrace		HxD		DxH		
	1 yr.	1½ yr.	1 yr.	2 yr.	1 yr.	1½ yr.	2 yr.
No. of litters	2	5	4	1	7	1	2
No. of pigs per litter							
Birth	8.0	10.6	10.8	16.0	8.1	14.0	11.5
56 days	6.0	7.2	7.5	9.0	7.6	10.0	10.5
154 days	5.5	6.6	7.0	9.0	7.3	10.0	10.5
Av. pig weight, lb.							
Birth	3.0	3.4	2.7	2.2	2.9	3.2	3.3
56 days	24.0	30.3	29.5	25.3	29.5	35.0	39.5
154 days	122.5	134.0	152.6	143.9	152.3	157.0	183.4
180 days	150.3	161.0	194.9	189.2	193.5	197.0	226.6
Av. litter weight, lb.							
Birth	24.1	35.7	28.8	35.0	23.7	44.7	38.2
56 days	144.2	218.1	221.2	227.4	223.1	350.5	414.7
154 days	673.7	884.3	1068.0	1294.9	1109.7	1570.2	1925.4
180 days	826.6	1062.6	1364.3	1702.8	1412.6	1970.0	2379.3
Av. daily gain, birth to market, lb.	0.93	0.89	1.04	1.09	1.05	1.09	1.22
Adjusted backfat (200 lb.), in.	1.21	1.25	1.52	1.75	1.54	1.61	1.57

TABLE IV

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, FALL 1957 (continued)

	Breeding of pigs and age of dam							
	LxD			LxH		Dx(HxD)	Hx(HxD)	
	1 yr.	1½ yr.	2 yr.	1 yr.	1½ yr.	1 yr.	1 yr.	1½ yr.
No. of litters	1	2	1	2	1	2	3	2
No. of pigs per litter								
Birth	10.0	5.5	11.0	9.5	12.0	8.5	9.0	12.5
56 days	10.0	4.0	10.0	7.0	9.0	8.5	8.3	12.0
154 days	10.0	4.0	10.0	7.0	9.0	8.5	8.3	11.5
Av. pig weight, lb.								
Birth	2.6	3.7	3.1	2.9	3.5	2.5	2.6	3.3
56 days	36.7	38.1	44.1	31.8	40.6	32.4	31.9	33.4
154 days	169.6	180.6	196.7	164.9	185.4	163.6	168.1	162.5
180 days	207.4	226.2	237.7	207.2	228.4	204.8	209.0	204.1
Av. litter weight, lb.								
Birth	26.5	20.3	34.2	27.6	41.9	21.3	23.7	40.8
56 days	367.0	152.3	440.9	222.4	365.6	275.2	265.5	400.8
154 days	1696.2	722.6	1967.3	1154.4	1669.0	1390.6	1401.2	1868.4
180 days	2074.0	904.8	2377.0	1450.4	2055.6	1740.8	1734.7	2347.2
Av. daily gain, birth to market, lb.	1.14	1.27	1.26	1.13	1.23	1.11	1.13	1.11
Adjusted backfat (200 lb.), in.	1.48	1.52	1.45	1.38	1.46	1.60	1.62	1.66

TABLE IV

PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, FALL 1957 (continued)

	Breeding of pigs and age of dam					
	Yx(HxD)	Lx(HxD)	Yx(HxPxL)	Dx(HxPxL)	Hx(HxPxL)	
	1½ yr.	1½ yr.	1 yr.	1½ yr.	1 yr.	1½ yr.
No. of litters	4	2	6	3	3	4
No. of pigs per litter						
Birth	12.8	5.5	11.0	11.3	8.3	10.8
56 days	11.0	5.0	9.3	10.0	5.0	9.0
154 days	11.0	4.5	8.8	9.3	5.0	8.8
Av. pig weight, lb.						
Birth	3.3	4.6	3.0	3.2	3.2	3.2
56 days	35.6	43.3	32.3	43.6	25.6	34.1
154 days	169.9	189.5	158.4	191.3	138.1	160.9
180 days	216.3	227.0	196.0	240.8	175.4	198.9
Av. litter weight, lb.						
Birth	41.7	25.3	32.6	36.3	26.9	34.5
56 days	392.0	216.6	301.9	435.7	127.8	307.1
154 days	1869.0	852.7	1398.8	1785.5	690.6	1407.8
180 days	2379.4	1021.5	1731.8	2239.4	877.0	1750.3
Av. daily gain, birth to market, lb.	1.17	1.22	1.08	1.29	1.03	1.08
Adjusted backfat (200 lb.), in.	1.56	1.24	1.50	1.46	1.50	1.41

TABLE V

INTRA-SEASON AND AGE OF DAM WEIGHTED AVERAGE PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, SPRING AND FALL, 1956 AND 1957

	Breeding of pigs							
	SB[a]	HxD	SB[a]	DxH	SB[a]	Hx(HxD)	SB[a]	Dx(HxD)
No. of litters	78	18	35	11	14	5	19	5
No. of seasons	4	4	2	2	1	1	2	2
No. of age of dam groups	6	6	4	4	2	2	2	2
No. of pigs per litter								
Farrowed	9.4	11.4	10.3	10.0	10.1	10.7	9.1	10.8
56 days	7.8	9.1	8.2	8.5	8.6	10.1	7.9	9.5
154 days	7.5	9.0	7.6	8.4	7.8	9.9	7.4	9.5
Av. pig weight, lb.								
Birth	3.0	2.6	3.2	3.1	3.2	2.9	3.0	2.6
56 days	33.9	36.3	32.2	37.3	31.4	32.6	30.9	34.5
154 days	162.6	176.8	161.6	169.1	156.9	165.3	160.2	169.9
180 days	203.7	218.8	203.5	208.8	199.0	206.6	198.6	207.2
Av. litter weight, lb.								
Birth	28.7	29.6	32.7	31.7	32.0	32.1	27.5	28.3
56 days	264.7	331.5	267.3	311.8	274.7	332.3	243.5	327.7
154 days	1229.0	1592.0	1236.0	1412.0	1231.0	1632.0	1195.0	1614.0
180 days	1536.0	1972.0	1550.0	1749.0	1564.0	2037.0	1566.0	1966.0
Av. daily gain, birth to market, lb.	1.12	1.21	1.11	1.14	1.08	1.12	1.10	1.12
Adjusted backfat (200 lb.), in.	1.62	1.57	1.48	1.55	1.50	1.64	1.54	1.53

[a]SB = straightbreds - average of the performance of the breeds represented in crossbreds.

TABLE V

INTRA-SEASON AND AGE OF DAM WEIGHTED AVERAGE PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, SPRING AND FALL, 1956 AND 1957 (continued)

	Breeding of pigs					
	SB[a]	LxH	SB[a]	Lx(HxD)	SB[a]	Hx(PxL)
No. of litters	10	3	35	5	20	4
No. of seasons	1	1	2	2	1	1
No. of age of dam groups	2	2	2	2	1	1
No. of pigs per litter						
Farrowed	9.1	10.6	9.5	9.4	7.8	10.5
56 days	7.2	7.8	7.8	8.2	6.7	10.0
154 days	6.2	7.8	7.4	8.0	6.4	10.0
Av. pig weight, lb.						
Birth	3.3	3.2	3.3	3.6	3.0	2.8
56 days	27.3	35.5	33.8	41.6	34.9	36.3
154 days	137.9	173.6	159.4	185.6	152.8	178.8
180 days	170.9	216.2	198.2	224.3	189.9	224.1
Av. litter weight, lb.						
Birth	30.4	33.7	31.0	31.5	23.4	29.4
56 days	200.1	283.4	262.8	336.9	237.4	362.6
154 days	862.0	1374.0	1186.0	1473.0	988.0	1788.0
180 days	1069.0	1708.0	1466.0	1780.0	1215.0	2241.0
Av. daily gain, birth to market, lb.	0.98	1.17	1.08	1.21	1.03	1.22
Adjusted backfat (200 lb.), in.	1.32	1.41	1.46	1.32	1.42	1.39

[a]SB = straightbreds - average of the performance of the breeds represented in crossbreds.

TABLE V

INTRA-SEASON AND AGE OF DAM WEIGHTED AVERAGE PERFORMANCE OF STRAIGHTBREDS AND CROSSBREDS, AMES PLANTATION, SPRING AND FALL, 1956 AND 1957 (continued)

	Breeding of pigs					
	SB[a]	Hx(HxPxL)	SB[a]	Lx(HxPxL)	SB[a]	Dx(HxPxL)
No. of litters	17	4	18	6	50	10
No. of seasons	1	1	1	1	2	2
No. of age of dam groups	1	1	1	1	2	2
No. of pigs per litter						
Farrowed	9.5	10.8	8.4	8.8	9.1	10.0
56 days	7.2	9.0	6.9	7.3	7.5	8.7
154 days	6.5	8.8	6.7	7.3	7.1	8.3
Av. pig weight, lb.						
Birth	3.5	3.2	3.3	3.0	3.3	3.1
56 days	32.2	34.1	33.8	38.6	33.4	39.3
154 days	150.6	160.9	162.5	176.4	160.1	186.0
180 days	186.4	198.9	198.4	214.4	197.8	229.2
Av. litter weight, lb.						
Birth	32.8	34.5	26.5	25.1	29.6	30.8
56 days	232.4	307.1	232.1	283.3	250.2	346.2
154 days	974.0	1408.0	1086.0	1293.0	1149.0	1554.0
180 days	1212.0	1750.0	1329.0	1565.0	1410.0	1906.0
Av. daily gain, birth to market, lb.	1.01	1.08	1.09	1.16	1.08	1.24
Adjusted backfat (200 lb.), in.	1.50	1.41	1.44	1.35	1.49	1.39

[a]SB = straightbreds - average of the performance of the breeds represented in crossbreds.

TABLE VI

INTRA-SEASON AND AGE OF DAM WEIGHTED AVERAGE DIFFERENCES BETWEEN CROSSBREDS AND STRAIGHTBREDS AND PERCENTAGE ADVANTAGE OF CROSSBREDS, AMES PLANTATION, SPRING AND FALL, 1956 AND 1957

	Breeding of pigs							
	HxD		DxH		Hx(HxD)		Dx(HxD)	
	Diff.[a]	Per cent adv.	Diff.[a]	Per cent adv.	Diff.[a]	Per cent adv.	Diff.[a]	Per cent adv.
No. of seasons	4	4	2	2	1	1	2	2
No. of age of dam groups	6	6	4	4	2	2	2	2
No. of pigs per litter								
Farrowed	2.0**	21.3	-0.3	-2.9	0.6	5.9	1.7	18.7
56 days	1.3	16.7	0.3	3.6	1.5	17.4	1.6	20.2
154 days	1.5*	20.0	0.8	10.5	2.1	26.9	2.1	28.4
Av. pig weight, lb.								
Birth	-0.4	-13.3	-0.1	-3.1	-0.3	-9.4	-0.4	-13.3
56 days	2.4	7.1	5.1	15.8	1.2	3.8	3.6	11.6
154 days	14.2	8.7	7.5	4.6	8.4	5.4	9.7	6.0
180 days	15.1	7.4	5.3	2.6	7.6	3.8	8.6	4.3
Av. litter weight, lb.								
Birth	0.9	3.1	-0.1	-3.0	0.1	0.3	0.8	2.9
56 days	66.8	25.2	44.5	16.6	57.6	21.0	84.2	34.6
154 days	363.0	29.5	176.0	14.2	401.0	32.6	419.0	35.1
180 days	435.0**	28.3	198.0	12.8	473.0	30.3	399.0	25.5
Av. daily gain, birth to market, lb.	0.09**	8.0	0.03	2.7	0.04	3.7	0.02	1.8
Adjusted backfat (200 lb.), in.	-0.05	-3.1	0.07	4.7	0.14	9.3	-0.01	-0.6

[a]Diff. = average of crossbreds minus average of straightbreds.
*Difference significant at the 5 per cent level.
**Difference significant at the 1 per cent level.

TABLE VI

INTRA-SEASON AND AGE OF DAM WEIGHTED AVERAGE DIFFERENCES BETWEEN CROSSBREDS AND STRAIGHTBREDS AND PERCENTAGE ADVANTAGE OF CROSSBREDS, AMES PLANTATION, SPRING AND FALL, 1956 AND 1957 (continued)

	Breeding of pigs					
	LxH		Lx(HxD)		Hx(PxL)	
	Diff.[a]	Per cent adv.	Diff.[a]	Per cent adv.	Diff.[a]	Per cent adv.
No. of seasons	1	1	2	2	1	1
No. of age of dam groups	1	1	2	2	1	1
No. pigs per litter						
Farrowed	1.5	16.5	-0.1	-1.0	2.7	34.6
56 days	0.6	8.3	0.4	5.1	3.3	49.2
154 days	1.6*	25.8	0.6	8.1	3.6*	56.2
Av. pig weight, lb.						
Birth	-0.1	-3.0	0.3	9.0	-0.2	-6.7
56 days	8.2	30.0	7.8	23.1	1.4	4.0
154 days	35.7	25.9	26.3	16.4	26.0	17.0
180 days	45.3*	26.5	26.1*	13.2	34.2*	18.0
Av. litter weight, lb.						
Birth	3.3	10.8	0.5	1.6	6.0	25.6
56 days	83.3	41.6	74.0	28.2	125.2	52.7
154 days	512.0	59.4	287.0	24.2	801.0	81.0
180 days	640.0	59.8	314.0	21.4	1026.0**	84.4
Av. daily gain, birth to market, lb.	0.19*	19.4	0.13*	12.0	0.19**	18.4
Adjusted backfat (200 lb.), in.	0.09	6.8	-0.15	-9.6	-0.03	-2.1

[a]Diff. = average of crossbreds minus average of straightbreds.
*Difference significant at the 5 per cent level.
**Difference significant at the 1 per cent level.

TABLE VI

INTRA-SEASON AND AGE OF DAM WEIGHTED AVERAGE DIFFERENCES BETWEEN CROSSBREDS AND STRAIGHTBREDS AND PERCENTAGE ADVANTAGE OF CROSSBREDS, AMES PLANTATION, SPRING AND FALL, 1956 AND 1957 (continued)

	Breeding of pigs					
	Hx(HxPxL)		Lx(HxPxL)		Dx(HxPxL)	
	Diff.[a]	Per cent adv.	Diff.[a]	Per cent adv.	Diff.[a]	Per cent adv.
No. of seasons	1	1	1	1	2	2
No. of age of dam groups	1	1	1	1	2	2
No. pigs per litter						
Farrowed	1.3	13.7	0.4	4.8	0.9	9.9
56 days	1.8	25.0	0.4	5.8	1.2	16.0
154 days	2.3*	35.4	0.6	9.0	1.2	16.9
Av. pig weight, lb.						
Birth	-0.3	-8.6	-0.3	-9.1	-0.2	-6.1
56 days	1.9	5.9	4.8	14.2	5.9	17.7
154 days	10.3	6.8	13.9	8.6	25.9	16.2
180 days	12.5	6.7	16.0	8.1	31.4**	15.9
Av. litter weight, lb.						
Birth	1.7	5.2	-1.4	-5.3	1.2	4.0
56 days	74.7	32.1	51.2	22.0	96.0	38.4
154 days	434.0	44.6	207.0	19.1	405.0	35.2
180 days	539.0	44.5	236.0	17.7	495.0**	35.1
Av. daily gain, birth to market, lb.	0.07	6.9	0.07	6.4	0.16**	14.8
Adjusted backfat (200 lb.), in.	-0.09	-6.0	-0.09	-6.2	-0.10	-6.7

[a]Diff. = average of crossbreds minus average of straightbreds.
*Difference significant at the 5 per cent level.
**Difference significant at the 1 per cent level.

TABLE VII

AVERAGE PERFORMANCE OF STRAIGHTBREDS, AMES PLANTATION
SPRING AND FALL, 1956 AND 1957

	Breed			
	Landrace	Poland	Hampshire	Duroc
No. of litters	25	20	41	47
No. pigs per litter				
Birth	8.0	8.4	9.5	10.2
56 days	5.7	6.9	7.9	8.1
154 days	5.3	6.5	7.7	7.9
Av. pig weight, lb.				
Birth	3.2	3.1	3.3	2.9
56 days	31.1	32.9	36.2	34.5
154 days	149.8	159.5	164.6	167.6
180 days	173.0	195.0	204.3	209.3
Av. litter weight, lb.				
Birth	25.9	26.0	31.3	29.4
56 days	177.9	227.0	285.7	279.2
154 days	790.7	1036.6	1268.4	1322.8
180 days	913.6	1267.8	1574.4	1652.5
Av. daily gain, birth to market, lb.	0.98	1.09	1.13	1.16
Adjusted backfat (200 lb.), in.	1.29	1.53	1.62	1.65

[a]Significance of differences between averages tested through use of Duncan's multiple range test. Averages underscored by the same line are not significantly different. Averages not underscored by the same line are significantly different.