ANALYSIS OF INNOVATIONS: DAIRY AND EXOTIC CROSSBREEDS FOR BEEF PRODUCTION*

C. R. Shumway and Ernest Bentley

INTRODUCTION

Crossing of breeds traditionally has been viewed skeptically by cattle producers. Although there has been some crossbreeding between traditional beef breeds, little use of dairy-beef crosses in commercial beef herds has been made. Often such calves have been inferior in quality and have yielded a lower return than the standard beef breeds.

Recently, however, considerable research attention has focused on crossbreeds – crossing standard beef breeds, dairy and beef, and standard and exotic (or new) beef breeds. When all three genetic types are crossed, several positive features have been identified: (1) quality is good – few animals grade prime but most finish at satisfactory weights as high good or choice; (2) greater milking capacity of the part-dairy cow increases the potential for rapid gains, thus permitting more beef to be raised per cow, and (3) genetic growth capability of some exotic breeds is greater so such crosses can take advantage of additional milk.

This paper reports an economic analysis of one set of three-way crosses developed to capitalize on these features. Angus-Holstein cows have been crossed with a Charolais bull. Thus, both high milking capacity and strong calf growth potential are blended without the need for an unusually large cow.

However, there are also some disadvantages of such crosses: (1) because calves are larger at birth, more calving problems occur, resulting in a higher death loss and requiring closer management during calving than conventional breeds; (2) replacement heifers must be purchased or a separate activity established to raise them, and dairy-beef heifers sell for a premium, and (3) weaned crossbred calves sell for less per pound because they weigh more.

METHOD ANALYSIS

This analysis has been conducted to determine whether, on balance, that particular crossbreed appears to be a true economic innovation (i.e., having the potential to increase profits enough to stimulate widespread adoption) or merely a passing fad. The crossbreeds are compared with conventional Angus cattle. A linear programming model is used to maximize annual returns to the farm's land, labor, and management. Two sets of farm resources are considered; both contain 200 acres of cleared land, but one has only 25 acres suitable for crop production while the other has 100 acres. Stocking rate, forage and crop system, and calf growth management plan are variable and are optimally determined by the model for each breed. The economic potential of the two herds is analyzed for a wide range of beef prices – 20 to 60 cents per pound for a 500-pound feeder calf. Economic potential in beef production is assessed based upon the premise that recommended production practices are followed in areas not specifically evaluated by this study.

Model restraints include: (1) acreage of land available by type, (2) limits on permissible daily change in cow's weight, (3) a requirement that she weigh the same at the beginning of the next year as at the beginning of year of analysis, (4) limits on the calf's growth curve, (5) a requirement that its birth weight and weaning weight meet prespecified levels, and (6) restraints to assure that total digestible nutrients (TDN) grown and/or purchased in each two-month period are at least as great as the amount consumed by the animals.

C. R. Shumway is an associate professor of agricultural economics, Texas A & M University, and Ernest Bentley is a teaching assistant in economics, North Carolina State University.

*North Carolina State University Agricultural Experiment Station Journal Series No. 4261.

MODEL PARAMETERS

Livestock System

Because the crossbred cow tends to be larger than the Angus, its weight following calving is specified to average 1,050 pounds, while the Angus cow weighs 950 pounds. In actual production, each cow's weight will fluctuate over the year depending upon her age, availability of forage, and amount of milk produced for the calf. In the model simulation, cows are permitted to lose up to 1/4 pound per day or gain up to 1 pound daily in any period, as long as the average weight of the herd is the same following calving the subsequent year as in the year of analysis.

Because of greater calving problems, the proportion of cows assumed to wean calves is estimated to be 2 percent lower for crossbreeds – 90 percent as opposed to 92 percent for Angus calves.

Calving dates for both herds are assumed to center on Jan. 1. The year is then divided into six periods of two months each.

Because some calves are lost at birth, 5 percent of the cows (without live calves) are culled immediately. Another 10 percent (open, injured and old cows) are culled when their calves are weaned.

Model parameters of the calf's birth and weaning weights and the acceptable range of average daily gain are based upon several years of research conducted in North Carolina.

On the research farms, Angus calves have averaged 65 pounds at birth with an adjustable 205-day weight of 428 pounds. Projecting the same rate of gain, they would weigh 500 pounds when weaned at 245 days. For purposes of the model, they are assumed to be weaned then. Adjusted average daily gain for two-month periods ranged from 1.5 to 2.1 pounds. The model limits on acceptable average daily gain in each period were set at those levels. Crossbred calves averaged 80 pounds at birth with an adjusted 205-day weight of 610 pounds. In the model, it is assumed that they weigh 660 pounds when weaned at 225 days, 20 days earlier than the Angus calves. Adjusted average daily gain for two-month periods ranged from 2.3 to 2.9 pounds.

Price levels are analyzed in 10-cent increments. North Carolina graded calf sale data indicate that 600- to 700-pound calves sell for approximately 2 cents per pound less than 500-pound calves of the same grade. No substantial differences in grade were noted in comparable research studies of Angus and crossbred herds.

Ownership and nonfeed variable costs and income from cull cow sales are developed in detail in a research report on this study [5].

Cow TDN equations are derived from Neville and McCullough [3] and are estimated to be the same for both breeds. Daily TDN requirements in each period are dependent upon average body weight, change in weight, and milk production:

$$(1)\quad R_i = .0081\,\bar{W}_i + 2.5\,\Delta W_i/T_i + .305\,M_i$$

where R_i is average daily energy requirement in TDN per cow, period i;

$\bar{W}_i$ is average cow weight, period i;

ΔW_i is change in cow weight, period i;

T_i is number of days in period i, and

M_i is average daily milk production in pounds, period i.

In addition, TDN requirements for fetal growth in the last two months of pregnancy are estimated at 30 percent of body maintenance requirements. Calf TDN requirements in excess of that provided by milk come from forage.

TDN requirements for replacement heifers are based upon National Research Council (NRC) energy estimates [2]. Calf TDN requirements are specified as a linear function of beginning and ending weight for each period. They are derived for each breed as linear approximations to the nonlinear NRC equations over the potential weight range for each period. Details on the derivation of these equations are included in the research report [5].

Forage and Crop Options

Corn silage and two cash crops, soybeans and corn for grain, are the major options specified for use of cropland. Although certainly not the only cash crops grown in the Southeast, corn and soybeans are representative of a wide variety of alternative uses where allotments, special soil and climatic conditions, and high capital requirements are not overriding constraints. They also tend to fit more naturally than some crops into an integrated crop-livestock system; they provide home-grown concentrate feeds, and crop residues are available after harvest for gleaning by the animals.

Farm acreage not economically suitable for production of crops is classified as meadowland in this study. It can be used to produce any of four pasture varieties common to the area, including tall fescue, coastal bermuda grass, millet, and rye-rye-grass.

Yields, production costs (exclusive of land, labor, and management) and returns to land, labor and management from cash crops are based upon budgets developed by the North Carolina Agricultural Extension Service [4]. Yields and production costs are representative of what farmers have actually

experienced when employing management practices recommended for central North Carolina. Cash crop prices are representative of the past decade.

The distribution of forage yield by two-month periods is estimated from forage studies conducted in North Carolina [1]. When excess pasture is available in any period, it can be grazed in the next period with an estimated loss of 40 percent of unused TDN. When corn silage is produced, it is stored and can be fed in any period that it is needed.

RESULTS OF COW/CALF ANALYSIS

Cow/Calf Activity Can Increase Farm Income

Beef cattle represent a profitable activity over most of the price range considered. However, when 500-pound feeder calves sell for 20 cents per pound, the cow/calf operation is not competitive with cash crop production. Neither is it an economic supplement to the crop activity if some of the cropland must be used to produce silage instead of a cash crop.

At all prices above 20 cents, each farm's resources are used exclusively for beef production. All available cropland is used to produce corn silage. Pastures are intensively managed to effectively utilize all forage. The number of cows carried at prices of 30-40 cents is dictated by the total amount of feed produced on the farm. Silage is used to supplement pastures in any period that pasture growth is light. In fact, on the farm that has equal amounts of cropland and meadowland, it is profitable to feed substantial quantities of silage in most periods.

To exclude beef cattle from the efficient farm system, corn, which is budgeted at $1.15 per bushel, would have to sell for $1.80 when feeder calf prices are 30 cents per pound and $3.05 when calf prices are 40 cents. Soybeans, which are budgeted at $2.50 per bushel, would have to bring $4.30 and $7.90, respectively. Of course, some combination of beef cattle and crop production may be profitable at lower prices.

In addition, with effective management, two crops can be produced in the same year on many farms. Double-cropping is more plausible in conjunction with a livestock enterprise than on a specialized crop farm, since a second crop can be harvested for silage before it is mature enough for grain harvest.

Crossbreeds Are More Profitable Than Traditional Breeds

The crossbred cattle yielded a higher return to land, labor, and management than the Angus animals at all price levels that included beef cattle in the optimal system. As beef price increases, the comparative advantage of the crossbred herd increases. At prices above 30 cents, the net income from the crossbred herd is 5-8 percent above the traditional breed. See Table 1.

If a charge is made for labor used, the crossbred option demonstrates a *stronger* comparative advantage. This shift occurs because labor requirements are closely related to cow numbers. Fewer cows are in the optimal-sized crossbred herds than in the Angus herds at all price levels. With labor costs considered, net returns from the crossbred herd range from 8-30 percent above the Angus herd.

For this analysis, it is anticipated that crossbred calves sell for 2 cents per pound less than the smaller Angus calves of comparable grade. If this expectation is valid, the crossbred option becomes relatively more profitable than the Angus herd at higher price levels. However, if the price differential were 6 percent instead of 2 cents per pound, the producer would be essentially indifferent between the two options at all price levels.[1] If the crossbred calves sell for more than a 6 percent discount, the Angus option would yield a higher return to land, labor, and management.

Optimal Stocking Rate, Forage/Crop Selection, and Labor Requirements Depend Upon Price and Farm Resources

With an extended price outlook of 20 cents per pound for 500-pound feeder calves, all cropland should be used to produce soybeans. The beef enterprise adds nothing to net farm income. With specialization in beef cattle profitable at all higher price levels, the farm with 100 acres of cropland (Farm A) can support up to 210 crossbred or 257 Angus cows without purchase of additional feed.[2] The other (Farm B) can support 157 crossbred or 196 Angus cows. These stocking rates are optimal when price is between 30-40 cents. If a higher price is expected to prevail for relatively long periods, it may be profitable to purchase additional feed and increase the number of cows above these levels.

On Farm A, meadowland is optimally planted entirely to coastal bermuda grass at a price of 30 cents or above. On Farm B, meadowland should be

[1] If the opportunity cost of labor were near zero.

[2] Except for protein supplement fed with corn silage.

Table 1. RETURN TO LAND, LABOR, AND MANAGEMENT FROM OPTIMUM FARM PLANS

Farm resources	Breeding system	With 500 - lb. feeder calf price per lb. at: 20¢	30¢	40¢	50¢	60¢
Farm A (100 acres crop, 100 acres meadow)	Cross	$4,155	$10,519	$23,102	$35,685	$48,268
	Angus	4,155	10,019	21,559	33,100	44,548
Farm B (25 acres crop 175 acres meadow)	Cross	1,039	8,401	17,917	27,363	36,882
	Angus	1,039	8,221	17,043	25,864	34,685
Cash crops grown		soybeans	none	none	none	none

planted to bermuda grass and fescue in a ratio of approximately 3:4 for crossbreeds and for 1:1 for the Angus herd.

With a specialized beef operation on either farm, one full-time person can handle most labor requirements during the year. Some additional help would be needed during breeding and calving seasons. A part-time operator could supply most of the labor needed for cash crop production on either farm.

Land Values Vary with Beef Price

In order to determine the amount a farmer could afford to pay to rent additional land, labor first is charged at a cost of $2 per hour. It is further assumed that the beef enterprise requires a fixed quantity of managerial input; therefore, no charge is made for additional management resources if the herd is expanded. Rental rates for good cropland are approximately twice that of land suitable only for pasture or trees.

At rather typical rental rates of $30 for cropland and $15 for meadowland, the farmer would find it profitable to rent additional land at all beef price levels. Of course, at the lowest price he would only rent cropland to produce cash crops. Table 2 reports the maximum rent the farmer could pay for additional land at alternative beef prices. Rents listed are for cropland calculated under the assumption that meadowland rents for half as much. They vary by farm and breed, tending to be higher for crossbreeds and for the farm with the smaller endowment of cropland. On an average, the break-even rent for cropland increases 6 1/2 times when beef price increases from 30-60 cents per pound.

When feeder calf price is at least 30 cents, the marginal value of cropland to Farm A (containing equal endowments of each) is approximately 35 percent greater than the marginal value of meadowland. To Farm B (containing seven times as much meadowland as cropland) it is approximately 130 percent greater. Hence, if the rental rate structure is 2:1 (as assumed in Table 2), it would be most profitable to combine total land resources in some ratio between these two extremes.

Rental rates impact directly on land value. Presuming that land derives its market value from the stream of income it can produce, then its market value should be directly influenced by such break-even rents which are dependent upon product prices (in this case feeder calves, soybeans, and corn). The impact of product price on land value depends upon the discount rate, how long that price level is expected to remain, and what the prospects are for alternative prices. Assuming a discount rate of 10

Table 2. MAXIMUM RENT SCHEDULE, CROPLAND[a]

Breeding system	With 500-lb. feeder calf price per lb. at: 20¢	30¢	40¢	50¢	60¢
	($/acre)				
Farm A[b]					
Crossbreeds	35	43	127	211	295
Angus	35	33	110	187	263
Farm B[c]					
Crossbreeds	35	52	136	220	305
Angus	35	47	125	204	282
Average	35	44	125	206	286

[a]Calculations are based on assumption that cropland rent is twice meadowland rent.

[b]Land resources: 100 acres cropland, 100 acres meadowland.

[c]Land resources: 25 acres cropland, 175 acres meadowland.

percent and permanency of the price selected, the value of cropland would be $350 per acre at a feeder price of 20 cents or $2,860 at 60 cents. If beef prices are expected to average 30 cents over the long term, cropland value would approach $440 per acre.

COMMENTS ON FINISHING OPERATION

Although the focus of this analysis has been on the cow/calf enterprise, a simple partial budgeting evaluation of the finishing activity also was made. Based on feeding trials in North Carolina and NRC nutrient estimates, finishing of crossbred calves appears to have a slight comparative advantage. Much of this advantage is due to a more rapid rate of gain, thus permitting a faster turnover of animals through the feedlot. Even in North Carolina, where few calves are carried to slaughter, it could have been profitable to fatten crossbred calves in seven of the last nine years.

SUMMARY

At feeder calf prices of at least 30 cents per pound, beef production is competitive with corn and soybeans on farms having considerable amounts of marginal land. In addition, crossbreeds are more profitable than traditional breeds. This is true for both cow/calf and finishing activities. Returns to land and management tend to be at least 8 percent higher for crossbreeds, which suggest that crossbreeding is an economic innovation and likely will become more widespread in the future. However, the magnitude of its comparative advantage is not so great that beef producers are likely to accept potentially higher risks by turning exclusively to crossbreeds in the near future.

Optimal stocking rates, forage/crop selection, labor requirements, and land value depend upon beef price and farm resources. The optimal stocking rate ranges from zero when feeder price is 20 cents to about a cow per acre at a price of 40 cents. Stocking rate is very sensitive to price between 20-30 cents and quite stable above. The highest carrying capacity is obtained with corn silage and coastal bermuda on one farm and these plus fescue on the other. A part-time operator could provide all the labor needed when crops exclusively are grown, and a full-time operator could supply most labor needed for intensive beef production. The value of land for beef production varies much more widely than beef prices, emphasizing the importance of residual earnings in establishing land prices. The combination of crop and meadowland on the farm also greatly affects the ratio of imputed values for these land resources.

REFERENCES

[1] Department of Animal Science, Crop Science and Soil Science, N.C. State University. "Technical Guide on Seasonal Production of Forages." Section III-C, Jan. 1968.

[2] National Research Council. *Nutrient Requirements of Beef Cattle.* 4th revised edition. 1970.

[3] Neville, W. E., and M. E. McCullough. "Calculated Energy Requirements of Lactating and Non-Lactating Hereford Cows." *Journal of Animal Science.* Vol. 25, No. 5, pp. 823-829, Nov. 1969.

[4] Neuman, D. F.; R. C. Wells, and S. H. Dobson. *Planning for Profit – Forage Crops.* N.C. Agr. Ext. Serv. Circular 523, Feb. 1971.

[5] Shumway, C. R.; Ernest Bentley, and E. R. Barrick. "Economic Analysis of a Beef Production Innovation: Dairy-Beef Crossbreeding." Submitted for publication.