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Swine production systems

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Swine production systems

HIGHLIGHTS IN 1975

During 1975 there was a basic change in the orientation of CIAT's Swine Program towards a new philosophy emphasizing training and international cooperation activities. The basis of research activities in the program's experimental farm unit has been the study of the major limiting factors in relation to the efficient utilization of potentially available feedstuffs for swine production in Latin America. Nutritional research on the utilization of cassava, rice meal or polishings and opaque-2 maize in swine feeding systems has received priority. The practical evaluation of these feedstuffs has continued to be oriented towards the development of integrated life-cycle feeding systems. This year experimental data on the use of cassava meal and opaque-2 maize have been completed through one life cycle.

Upon terminating the long-term research on the performance of native pigs, an improved breed (Duroc), and their respective crosses in tropical zones, information has been completed on the performance of two consecutive litters and on the evaluation of the carcass quality of the animals reaching marketing weight. In both litters, the performance of native pigs was lower than that of either improved breeds or crossbred pigs.

In animal health the main objective was the economic evaluation of health problems affecting swine production. In addition, the Animal Health Unit continued to build up basic information on the main diseases affecting swine production in different areas of Latin America in order to establish priorities for future research prior to the development of economic preventive and/or control methods.

The Swine Program has strongly supported close collaboration with national programs in Central and South America, where the potential of swine production is being evaluated. Training activities have been directed mainly at training professionals from CIAT's cooperative programs in Latin America; eight professionals received training in swine production in 1975.

SWINE NUTRITION

better energy/protein balance than the fresh cassava alone.

Cassava

When fresh cassava is fed free choice to growing pigs, its consumption is limited; this is one aspect of swine nutrition that has not been satisfactorily solved. Palatability has been mentioned as one of the possible causes for the low consumption of fresh cassava. In the 1973 Annual Report, mention was made of the marked differences in consumption of fresh sweet and bitter cassava by finishing pigs. Hydrocyanic acid (HCN), present in small quantities (50 to 100 ppm) even in sweet cassava roots, could affect palatability. In recent studies with growing-finishing pigs fed fresh cassava mixed with 15 percent sugar or molasses, it was found that palatability was slightly better than for fresh cassava (Table 1). The intake of protein supplement was less (0.85 vs 1.02 kg/animal/day) when cassava was mixed with sugar. Although there was still an excess in protein intake, the sugar- or molasses-cassava mixtures provided a

In addition to its effect on palatability, the presence of HCN or cyanogenic compounds in cassava rations may have a toxic effect on animal nutrition. Trials with laboratory rats fed bitter cassava meal-based diets (600 mg HCN/kg dry matter) showed that during the gestation period the placental barrier protects the fetuses from high levels of cyanide or its principal detoxification products, thiocyanates (1974 Annual Report). In order to study the possible toxic effect of high levels of cyanide in diets for gestating sows, an experiment was carried out using fresh sweet cassava plus a protein supplement, to which increasing levels of HCN (0, 250 and 500 ppm) were added in the form of potassium cyanide. There were slight metabolic alterations; nevertheless, no adverse effects on fetus viability were observed. Further observations made during the lactation period of these sows did not show the presence of residual effects from these treatments made during gestation that could affect the later

Table 1. Performance of growing-finishing pigs fed a protein supplement free choice and cassava mixed with 15 percent molasses or sugar.

Parameters*	Cassava alone	Cassava + molasses	Cassava + sugar
Daily gain (kg)	0.69	0.72	0.74
Daily feed intake (kg)			
Cassava	2.99	3.37	3.11
Supplement (40% protein)	1.02	0.92	0.85
Total Dry matter	2.03	2.27	2.17
Feed gain	2.97	3.16	2.93
Daily protein intake (kg)	0.54	0.51	0.46
Daily digestible energy intake (kcal)	8,273.10	8,850.50	8,767.30
Percentage of protein intake**	23.45	20.44	18.98

* Mean of 12 pigs per treatment; 91-day trial; av initial weight, 21.9 kg; av final weight, 87.1 kg for the control group

** Based on dry matter

performance of either the sows or their litters.

Because of their high HCN or cyanogenic glucoside content, care must be taken when using bitter cassava varieties because of their possible toxic effect. The preparation of cassava meal reduces the HCN content and thus considerably diminishes the limitations found when using fresh bitter cassava. Nevertheless, pigs fed diets based on meal made from the bitter cassava variety CMC-84 (73.8 percent) had a lower rate of gain (0.50 vs 0.59 kg|day), consumed less feed (1.47 vs 1.67 kg|day), and had a lower rate of feed efficiency (1.32 vs 1.51 feed|gain) than pigs fed diets based on meal prepared from the sweet cassava variety Llanera (73.8 percent). Judging from the analytical results of these meals, lower performance could be partially due to the higher HCN or cyanogenic glucoside content of the bitter cassava meal.

Experimental results obtained thus far suggest that palatability factors and aspects of nonlethal toxicity from residual HCN could be responsible for the lower performance on bitter cassava meal-based diets. In order to detoxify the cyanide

ion, it is necessary to have a dietary source of sulfur that will permit the conversion of cyanides into thiocyanates ($-\text{CN} + \text{S} \rightarrow -\text{SCN}$).

In order to assess the efficiency of several sulfur compounds, a trial was carried out with growing pigs fed diets based on bitter cassava meal (70 percent), supplemented with methionine (0.2 percent), sodium thiosulfate (0.79 percent) or elemental sulfur (0.2 percent). Supplementation with methionine gave the best weight gains, with a daily feed intake similar to that of the control (Table 2). The other two sources of sulfur gave slightly lower results as regards weight gains; but the feed conversion for pigs on the diet supplemented with elemental sulfur was similar to those supplemented with methionine. These results confirm previous experiments (1973 Annual Report), in which the addition of methionine improved the quality of the protein in cassava meal-based diets since cassava is most deficient in this amino acid; besides it permits the adequate detoxification of the cyanide or cyanogenic glucoside still present in the meal. The addition of elemental sulfur apparently gives similar results—at least as far as feed conversion is

Table 2. Effect of the addition of sulfur compounds to a bitter cassava meal-based diet on the performance of growing-finishing pigs.

Parameters*	Bitter cassava meal-based diets			
	Control	+ 0.2% methionine	+ 0.79% sodium thiosulfate	+ 0.2% elemental sulfur
Daily gain (kg)	0.67	0.70	0.61	0.65
Daily feed intake (kg)**	1.81	1.77	1.58	1.64
Feed gain**	2.43	2.29	2.32	2.29

* Mean of five pigs per treatment, fed individually; 42-day trial; av initial weight, 19.5 kg; av final weight 47.1 kg

** Based on air-dried feed

concerned—under the conditions of the experiment.

CIAT's Cassava Production Systems Program has conducted a series of experimental trials designed to study cassava storage and its effects on the biochemical and biophysical changes that occur during storage in field clamps or in storage boxes (1974 Annual Report). In cooperation with the Swine Program, a nutritive evaluation was made of the roots stored in field clamps for a minimum of two weeks before being fed to the pigs. The stored roots were

chopped daily and given to the pigs in open feeders. A protein supplement (40 percent crude protein) was available in a separate, automatic feeder. Although the results obtained were from a reduced number of animals during a short experimental period (28 days) and must be confirmed on a large scale, there are certain tendencies that should be considered for future research. There was less consumption of stored cassava than fresh, and less bitter cassava (either fresh or stored) was consumed (Table 3). This limited consumption of cassava was compensated for

Table 3. Effect of field clamp storage on the nutritive value of sweet and bitter cassava for growing pigs.

Parameters*	Experimental variables			
	Sweet cassava (M Col 22)		Bitter cassava (CMC-84)	
	Fresh	Stored	Fresh	Stored
Dry matter content in roots (%)**	40.0	38.7	30.5	31.7
Average daily intake (kg)				
Cassava	1.90	1.68	1.61	1.43
Protein supplement***	0.51	0.91	0.81	0.87
Total dry matter	1.27	1.56	1.30	1.33
Daily gain (kg)	0.57	0.75	0.63	0.66
Feed gain (based on dry matter)	2.23	2.06	2.07	2.03

* Mean of three pigs; 28-day trial

** Dry matter content was calculated daily in samples of chopped cassava during the third week of the trial.

*** The protein supplement contained 40 percent crude protein and 88.2 percent dry matter

by a greater intake of protein supplement so that the total dry matter intake was similar for all groups. The performance of the growing pigs was acceptable in all groups; however, pigs fed stored sweet cassava had the best gains, partly because they consumed more of the protein supplement. The differences in texture and the poorer organoleptic quality of the stored roots apparently affected acceptability. It is necessary to add that as the feed conversion data on the basis of dry matter refer to a short experimental period (only four weeks), they do not reflect the results that could be obtained during the growing-finishing period (weaning to 90 kg liveweight).

Samples of sweet (M Colombia 1148) and bitter cassava (CMC-84) varieties, stored in field clamps or storage boxes for a two-week period, were sliced, oven dried at 65°C, and then ground into meal. In an experiment with laboratory rats, it was found that storage in either system did not affect meal palatability, growth performance, feed intake or efficiency.

Whole grain maize and sorghum

Several experiments were conducted to test the utilization of whole grain maize

and sorghum in order to eliminate the problem and cost of grinding, which is one of the most limiting factors on small farms.

In the first experiment, a mixture was used of 80 percent whole grain maize and 20 percent protein supplement based on either soybean, cottonseed, sesame seed, meat or fish meals (Table 4). The growing pigs responded better when the maize was ground and mixed with the other ingredients (control diet). Intake of whole grain maize was consistently lower, and the animals wasted a lot of food trying to separate the grain from the supplement in order to consume more of the latter.

To eliminate some of the problems encountered, another experiment was carried out, in which the whole grain maize was soaked in water for 24 hours in one of the treatments. In addition, the protein supplement was fed free choice in separate feeders (Table 5). There was a greater consumption of the soaked maize, but there was an excess of protein intake in both cases, especially by the pigs fed the dry grain. Performance improved when the whole grain maize was soaked, but it was not equal to that of ground maize, especially when it was mixed with the other ingredients in the control diet.

Table 4. Effect of whole grain maize-based diets with different protein supplements* on the performance of growing pigs.

Treatments**	Daily average		
	Gain (kg)	Feed (kg)	Feed/gain
Ground maize - soybeans	0.72	1.92	2.67
Whole grain corn plus			
Cottonseed - meat - fish	0.55	1.48	2.69
Cottonseed - sesame seed - meat	0.39	1.34	3.43
Cottonseed - sesame seed - meat - soybeans	0.47	1.54	3.28
Sesame seed - soybeans - meat	0.52	1.76	3.38
Cottonseed - soybeans	0.56	1.70	3.03

* These supplements were fed in the form of meal or cake, in different proportions, according to the supplement used.

** Mean of eight pigs per treatment; 49-day trial; av initial weight, 19.9 kg; av final weight, 55.4 kg for the control group

Table 5 Effect of feeding dry and soaked whole grain maize plus a protein supplement* on the performance of growing pigs.

Parameters**	Control (Maize + SBM)	Ground maize	Whole grain maize	
			Soaked***	Dry
Daily gain (kg)	0.82	0.76	0.72	0.68
Daily feed intake (kg)				
Maize	-	2.02	1.66	1.31
Supplement	-	0.43	0.51	0.66
Total	2.42	2.45	2.17	1.97
Feed gain	2.95	3.22	3.01	2.90

* The protein supplement, which contained 40 percent crude protein, was fed free choice in separate feeders.

** Mean of 14 pigs per treatment, 28-day trial; av initial weight, 33.8 kg, av final weight, 56.6 kg

*** Based on air-dried feed

On the other hand, there was not so much difference in pig performance on whole or ground sorghum. Besides, protein consumption and feed waste were lower in the sorghum-based diets (Tables 6 and 7). Gains, as well as feed efficiency, were comparable. There was a slight excess of protein supplement intake by the pigs fed the dry grain; but in the other treatments, the consumption of the supplement was within the normal range for pigs of that age.

Rice meal (bran and | or polishings)

During the last few years, rice production has increased considerably in most Latin American countries; consequently, the availability of its by-products (meal, bran and | or polishings) has grown apace. In many regions, the prices of rice and its by-products compete favorably with the cereal grains (especially maize and sorghum) traditionally used in animal nutrition. However, the utilization of rice

Table 6. Effect of feeding dry and soaked whole grain sorghum on performance of growing pigs.*

Treatments	Daily average		
	Gain (kg)	Feed (kg)	Feed gain
Ground sorghum + protein supplement	0.68	2.03	2.99
Whole grain sorghum + protein supplement			
Dry - fed separately - ad libitum	0.66	1.93	2.93
Dry - mixed - controlled	0.60	1.97	3.28
Dry - mixed - ad libitum	0.61	1.92	3.15
Soaked - fed separately - ad libitum	0.65	1.88	2.90
Soaked - mixed - controlled	0.54	1.82	3.38
Soaked - mixed - ad libitum	0.66	2.24	3.40

* Mean of eight pigs per treatment, 49-day trial; av initial weight, 18.5 kg, av final weight, 50.9 kg for the control group

Table 7. Effect of feeding whole grain sorghum plus a protein supplement* on the performance of growing pigs.

Parameters**	Control (Sorghum + SBM)	Whole grain sorghum		
		Ground sorghum	Soaked***	Dry
Daily gain (kg)	0.66	0.69	0.66	0.66
Daily feed intake (kg)				
Sorghum	-	1.58	1.55	1.37
Supplement	-	0.49	0.48	0.53
Total	2.04	2.07	2.03	1.90
Feed/gain	3.09	3.00	3.07	2.88

* The protein supplement, which contained 40 percent crude protein, was fed free choice in separate feeders.

** Mean of 14 pigs per treatment, 49-day trial; av initial weight, 18.5 kg; av final weight, 51.0 kg.

*** Based on air-dried feed.

does not generally give the results expected since high levels of rice meal in diets adversely affect weight gains and feed efficiency in growing-finishing pigs. Among the possible causes for this limited performance are the level of fiber content (hulls), the availability and balance of amino acids (protein quality), the interaction of minerals, and the effect of prolonged storage (rancidity).

The effect of fiber content had been studied previously (1974 Annual Report). In the earlier experiments the amount of protein in the experimental diets was variable; but in the present experiment, the content of soybean meal (SBM) was

adjusted to obtain isoproteic diets (N x 6.25), thus eliminating the factor of protein quantity as a possible variable. Gains were practically identical for all groups, but pigs fed rice meal with ground hulls added needed to consume a greater quantity of feed daily to obtain the same weight gains (Table 8). The reduction of the digestible energy content of the diets containing rice hulls can be seen even when small percentages were added.

These results and those previously reported (1974 Annual Report) suggest that the quantity of supplementary protein (SBM) in diets with 60 percent rice meal is apparently not a factor of prime impor-

Table 8. Performance of growing pigs fed isoproteic diets based on rice meal containing different levels of hulls.*

Rice meal (%)	60	54	48	42	36
Rice hulls (%)	-	6	12	18	24
Daily gain (kg)	0.64	0.64	0.64	0.64	0.64
Daily feed intake (kg)	1.81	1.87	2.05	1.97	2.05
Feed/gain	2.84	2.91	3.17	3.07	3.35
Digestible energy (kcal/kg DM)	3,504	3,233	2,971	2,849	2,586

* Mean of ten pigs per treatment; av initial weight, 17.1 kg; av final weight, 52.8 kg.

Table 9. Performance of growing-finishing pigs fed rice meal-based diets with different protein supplements.

Dietary treatments	Daily average		
	Gain (kg)	Feed intake (kg)	Feed gain
Control: maize + soybean meal	0.70	2.29	3.11
Rice meal (60%) plus			
Soybean meal	0.57	1.89	3.16
Fish meal	0.67	2.11	3.03
Meat meal	0.60	1.93	3.08
Fish meal + cottonseed meal	0.61	2.04	3.19

* Mean of ten pigs per treatment, av initial weight, 18.5 kg; av final weight, 91.8 kg for the control group

tance in the depression in performance observed in growing pigs. In recent experiments, the combination of rice meal with protein sources other than soybean meal were studied in growing-finishing pigs in order to assess the possible effect of the supplementary protein quality. In spite of the fact that performance with the protein sources other than SBM was better, it was not equal to the control diet of common maize plus SBM (Table 9). Diets supplemented with animal protein were consumed at levels that were comparable to the control diet and feed efficiency was similar. These data suggest that protein quality may be one of the

limiting factors in the efficient use of rice meal. On the other hand, it has been found in rice meal-based diets (except for studies on the effect of adding hulls) that the consumption of feed is consistently lower than for the control.

In order to study further the possible effect of protein quality, an experiment was carried out with growing pigs fed a basal diet composed of 60 percent rice meal and SBM, supplemented with the amino acids lysine and methionine (Table 10). Lysine supplementation produced an adverse effect, whereas the addition of methionine produced gains similar to those

Table 10. Effect of lysine and methionine supplementation on the utilization of rice-based diets for growing pigs.*

Treatment**	Daily average		
	Gain (kg)	Feed intake (kg)	Feed gain
Control: maize + soybean meal	0.65	1.82	2.81
60% rice meal + soybean meal +			
0.15% lysine	0.58	1.66	2.86
0.15% methionine	0.63	1.71	2.72
0.15% lysine + 0.15% methionine	0.61	1.76	2.89
60% rice meal + fish meal	0.62	1.61	2.61

* Mean of six animals per treatment, 49-day trial; av initial weight, 17.7 kg, av final weight, 49.2 kg for the control group

** Isoproteic diets calculated to supply 16 percent crude protein

of the control animals and to those animals fed the rice meal-based diet supplemented with fish meal. Feed efficiency with methionine or with fish meal as a source of protein was better than that of the control and of the other treatments. This suggests that with rice meal-based diets, greater emphasis should be placed on the quality of the supplementary protein than on the total quantity of protein supplied.

Another factor to be considered is the quantity and quality of phosphorus in rice meal and its possible effect on the calcium|phosphorus relationship in the diets. In rice meal, as in the majority of products of plant origin, most of the phosphorus is found in the form of phytic phosphorous which is, in the majority of cases, unavailable to monogastric animals. Diets with high levels of phytic phosphorous tend to interact with other mineral elements, especially zinc, producing insoluble zinc phytates, thereby reducing the availability of this minor element. Nevertheless, in a factorial experiment designed to study different ratios of total Ca|total P and their interactions with two levels of zinc (50 and 100 ppm) in the form of zinc oxide, no improvements in growth gains were observed. In comparison to the control group, feed intake on the rice-based diets did not increase.

The experimental results obtained to date suggest that the nutritive quality of rice meal depends to a great extent on its crude fiber content, which increases with the addition of hulls. Good-quality rice meals (i.e., low crude fiber content) can be used at relatively high levels (40 to 60 percent) as a principal source of energy in diets if good-quality protein sources are used. Further studies need to be done to clear up certain aspects of interaction between amino acids in order to find a practical solution to this problem, especially in regard to the supplementation of methionine, which is apparently the limiting amino acid. The reduced intake of rice meal-based diets suggests that certain

physical aspects such as consistency, density and palatability should be considered to obtain the efficient utilization of rice by-products in swine feeding.

Opaque-2 maize

Most of the studies conducted previously with opaque-2 maize have concentrated on evaluating this product during the growing-finishing phases (1972 and 1973 Annual Reports). Nevertheless, its nutritive value had not been determined for the lactation period when the protein needs are most critical because of the additional requirements for milk production.

In a series of studies with pigs and rats, it was found that when opaque-2 maize was used as the only energy source, it was not sufficient for pig performance during lactation. In lactating sows, the negative effect was mainly reflected in weight losses (Table 11), whereas in rats the mother, as well as her offspring, was affected.

In these experiments five treatments were used with different combinations of opaque-2 maize and three protein levels. In two of these treatments, the diet was changed at 28 days in order to evaluate different feeding systems during the first half of the lactation period (56 days) because of the difference in milk production during these two phases. As can be seen in Table 11, there was a clear nutritional advantage for sows that consumed opaque-2 maize (9.5 percent protein) during the first phase and opaque-2 maize plus soybean meal (13 percent protein) until weaning. Performance in terms of weight gain for the sow and performance for the litters were equal or better than the other opaque-2 maize treatments in spite of the fact that total protein consumption during lactation was less, except for the group that consumed only opaque-2 maize during the whole period.

Table 11. Performance of lactating sows fed different combinations of opaque-2 maize and protein.

Parameter	Treatments*				
	Control (16%)	Op-2 (9.5%)	Op-2 + SBM (13%)	Op-2 + → Op-2 SBM (13% → 9.5%)	Op-2 → Op-2 + SBM (9.5% → 13%)
Lactating sows**					
Wt changes (kg)	0.15	-22.85	-7.39	-17.04	-7.32
Daily feed intake (kg)	5.10	4.76	5.37	4.88	5.58
Farrowing data					
No. pigs/litter	10.57	10.0	11.0	8.57	9.71
Individual wt (kg)	1.14	1.15	1.28	1.33	1.24
Litter wt (kg)	12.08	11.20	13.82	11.45	11.94
Weaning data					
No. pigs/litter	8.86	8.29	9.43	8.00	8.57
Individual wt (kg)	16.03	15.62	16.01	17.62	17.44
Litter wt (kg)	141.96	129.32	151.00	140.04	149.21

* In the first three treatments, the diet was given throughout the lactation period, whereas in the last two, there was a change after 28 days. Figures in parentheses indicate the level of protein used.

** There were seven sows per treatment, 56-day lactation period.

Cassava meal and opaque-2 maize in life-cycle swine feeding

The evaluation of these feeds in integrated life-cycle swine feeding was continued this year. Descriptions of the sequence of the experimental diets for each of the different periods of the life cycle of the pig, as well as results for the growing-finishing periods, were presented in the 1974 Annual Report. During this year the complete cycle, which also includes pregestation, gestation and lactation, was completed.

The results of these first litters obtained from this experiment are given in Table 12. The larger number of births corresponded to the group fed cassava meal; however, this can be attributed to aspects of management or individual variations in animals rather than to the experimental treatments. Some gilts were eliminated in the final selection of the breeding stock before the mating period; others had

delayed estrus and were therefore not considered along with the others. For this reason, there is a difference in the number of gilts in the table.

The number of pigs per litter was similar for all groups although gilts on cassava meal diets tended to have smaller litters. In addition, the weights of these pigs at birth were consistently lower than for the other groups. The average number of pigs at weaning was significantly lower in the cassava meal group, so the slight differences observed at birth were more significant at weaning. Although the average weights per pig at weaning were not appreciably different for the three groups, the interaction of weight and number of pigs per litter, expressed as total weight per litter at weaning, was considerably lower for the cassava meal group, especially when compared to the control group (103.6 and 145.4 kg, respectively). The performance of litters from the opaque-2 maize group was intermediate.

Table 12. Reproductive performance of gilts fed diets based on cassava meal, opaque-2 maize, or common maize during one life cycle.*

Parameter	Experimental variable		
	Common maize	Opaque-2 maize	Cassava meal
No. of gilts	10	12	14
Farrowing data			
No pigs/litter	10.0	9.0	8.4
Individual pig wt (kg)	1.09	1.10	0.97
Weaning data			
No. pigs/litter	9.4	7.5	6.6
Individual pig wt (kg)	15.87	15.42	15.70
Litter wt (kg)	145.4	111.1	103.6

* Life-cycle swine nutrition: performance of Yorkshire gilts fed the experimental diets during the growing, finishing, pregestation, gestation and lactation periods.

Total feed intake per gilt during the life cycle, including the starter diet for the suckling pigs, was similar (approximately 1 ton/animal) for all groups. (Table 13). The most noticeable differences correspond to the supplementary protein needs, in this case, soybean meal. Because of the high-quality protein of opaque-2 maize, animals fed these diets required only 36 percent of the quantity of SBM (53.7 vs 149.1 kg)

needed by the animals fed the common maize-based diets. On the other hand, the reduced quantity of crude protein present in cassava meal and its poor quality led to the high SBM requirements (269.0 kg), as compared to 149.1 and 53.7 kg for the common maize and opaque-2 maize-based diets, respectively. Therefore, in order to balance the experimental diet based on cassava meal, animals needed 80 percent

Table 13. Intake data for gilts fed diets based on cassava meal, opaque-2 maize, or common maize during one life cycle.*

Parameter	Experimental variable		
	Common maize	Opaque-2 maize	Cassava meal
Total intake (kg)			
Diet	1,001.4	977.9	1,079.6
Maizes	796.4	870.2	-
Cassava meal	-	-	754.1
Soybean meal	149.1	53.7	269.0
Proportional intake of SBM (%)	100.0	36.0	180.4

* Figures indicate total intake of diet and basic ingredients consumed by a gilt during the growing, finishing, pregestation, gestation and lactation periods, including the diet for the litter.

Table 14. Performance of the second litter of Zungo (Z) and Duroc (D) sows.

Parameter	Z x Z*	D x Z	Z x D	D x D
No. of litters	7	4	3	4
Farrowing data				
No. of pigs/litter	8.6	9.0	9.0	9.0
Individual pig wt (kg)	0.96	1.08	1.22	1.31
Litter wt (kg)	8.2	9.8	11.0	11.8
Weaning data (56 days)				
No. of pigs/litter	5.9	6.8	6.0	5.5
Individual pig wt (kg)	10.53	13.10	13.56	13.15
Litter wt (kg)	61.7	88.4	81.3	72.3

* Parent designation: boar x sow

more SBM than the control group. The lower performances in the cassava meal group can be partially explained by the effect of the protein quality, possibly due to the methionine deficiency in both the cassava and the SBM.

Experimental observations confirm the theoretical estimates of protein saving or protein supplementation derived from the use of high-lysine maize, such as opaque-2. On the other hand, when cassava meal is used, there is a need for greater nutritional and economic considerations in order to obtain results as satisfactory as those of the control diet.

The performance of native and improved swine in tropical zones

Studies measuring the performance of native and improved swine (Duroc) and

their respective crosses were continued in collaboration with the Instituto Colombiano Agropecuario (ICA) at the Turipaná Experimental Station in Montería. Part of this research constituted doctoral thesis work of a research associate from the Technical University in Berlin. A brief description of the techniques and experimental design used is given in the 1974 Annual Report.

Table 14 gives the results obtained with the second litters from the foundation breeding stock used in the experiment. The number of pigs in the second litter of the Zungo sows was similar to that of the Durocs, although their average weight (as was also true of both their first litters) was slightly less. The total number of weaned pigs in the second litter was slightly lower than for the first litter; nevertheless, their

Table 15. Performance of Zungo, Duroc and crossbred pigs during the growing-finishing periods.*

Parameter	Z x Z**	D x Z	Z x D	D x D
Duration (days)	182	131	128	126
No. of animals	16	19	14	12
Daily gain (kg)	0.44	0.61	0.61	0.63
Daily feed intake (kg)	1.93	2.42	2.38	2.44
Feed/gain	4.38	3.99	3.92	3.90

* Period from weaning to approximately 90 kg liveweight

** Parent designation: boar x sow

weights were higher. As can be seen, the performance at weaning of the D x Z offspring was similar to that of purebred Durocs or Z x D crosses.

Performance indices of the offspring during the growing-finishing periods indicate that Zungo pigs grow more slowly, consume less feed and have a lower feed efficiency than pure Durocs or crossbreds (Table 15).

These data suggest that under intensive management conditions, native pigs should be submitted to a rigorous genetic selection plan to bring their level of performance up to that of the improved breeds. The simple cross considerably improved the performance of native swine under the experimental conditions used.

At the end of the growing-finishing period, the pigs were slaughtered to study their carcass quality. The results were quite similar for both the first and second litters; Table 16 gives data for the latter. Carcasses from Zungo pigs had more backfat, a greater quantity of total fat and a lower percentage of lean parts than the pure Durocs. The carcasses of the crossbred animals showed intermediate characteristics. Although the demand for animal fat, especially that of pork, still seems to be important in many Latin American countries, there is a growing tendency towards greater consumption of fats and oils of plant origin. This would

mean that greater emphasis should be placed on the selection of native pigs that would produce more meat and less fat.

ANIMAL HEALTH

The major objective this year was animal disease economics; that is, the measurement of economic impact and the cost-benefit ratio of control. Secondly, work was carried out to identify areas where further investigation or research was required before economic methods of prevention or control could be devised. These activities were based on the knowledge accumulated on the spectrum of swine diseases in the Latin American tropics, enumerated in previous reports.

Disease impact at the farm level

The collection of data on foot-and-mouth disease has continued. In addition, information was gathered on brucellosis, leptospirosis, transmissible gastroenteritis and swine dysentery; however, the economic analyses of these data have not been completed.

Foot-and-mouth disease

In the absence of an adequate vaccine, swine producers normally attempt to control foot-and-mouth disease outbreaks through sanitary methods and treatment of clinical cases. There was an opportunity to

Table 16. Carcass characteristics of Zungo, Duroc and crossbred pigs (second litter).

Parameter	Z x Z*	D x Z	Z x D	D x D
Liveweight (kg)	90.1	91.5	91.1	91.8
Carcass yield (%)	83.0	82.8	84.2	82.6
Backfat thickness (cm)	5.2	4.7	4.6	4.1
Total fat (%)	32.3	30.4	28.5	26.0
Ham (%)	26.1	27.4	27.0	29.4
Lean parts (%)	33.6	37.0	37.3	41.8
Carcass length (cm)	88.4	91.3	92.8	90.2

* Parent designation boar x sow

make an evaluation of the sick and in-contact animals slaughtered as a complementary control to sanitary measures. The control of the outbreak (Type A virus) was striking. Of 709 animals, seven were found with lesions; there were 14 contacts. All 21 animals were slaughtered. The value of these animals was US\$3,900 whereas the value of all animals on the farm at the time of the outbreak was US\$36,000. The quarantine was lifted one month after the first case was detected, and the farm resumed normal operations.

Brucellosis

Sufficient information is now available for analyzing brucellosis, another disease that can seriously affect the profitability of swine production, as well as being transmissible to man. The control method being evaluated consists primarily in isolating infected animals, which are then eliminated from the farm. Possible contacts and animals giving weak serological titers were submitted to two more tests two months apart, in addition to other complementary techniques. Data for economic analysis include morbidity, mortality, pregnancy and birth rates; sales of animals, costs of bleeding the animals, testing and elimination. It was found that progenies from brucellosis-positive sows could be utilized as replacement breeding stock; this is a very important economic development for swine producers.

Having established an improved methodology for the control and eradication of this disease, it is necessary to establish the cost-benefit ratio in relation to the different types of swine operations. Given this kind of analysis, a national government can design area or country-wide eradication policies.

Disease investigation and research

Leptospirosis

This is another disease known to cause important production losses, as well as being a zoonosis. Evidence of infection was found on most farms visited in the Valle del Cauca, but epidemiological studies were necessary to determine optimal control methods. *L. pomona* is known to be the most important of these pathogens for swine; the three isolations made to date from aborted pig fetuses have been of this serotype.

The rodent population was examined on four infected farms. Cultures were made from the kidneys of 111 brown rats (*Rattus norvegicus*) (Table 17). To date, eight isolations representing seven strains of *L. icterohaemorrhagiae* and one of *L. pomona* have been obtained.* The latter report is significant as few reports exist of

* Typing was confirmed at the Centro Panamericano de Zoonosis (CEPANZO), Buenos Aires, Argentina

Table 17. Isolation of two types of *Leptospira* from kidneys of *Rattus norvegicus* trapped on infected pig farms.

Farm	No. of kidneys cultivated*	No. isolations	Types of <i>Leptospira</i>
A	8	1	<i>L. pomona</i>
B	27	0	—
C	30	2	<i>L. icterohaemorrhagiae</i>
D	46	5	<i>L. icterohaemorrhagiae</i>
Totals	111	8	

* Media used: Fletcher, Korthof and Ellinghausen

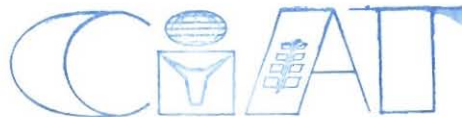


Table 18. Kidney histological lesions indicative of leptospirosis found in *Rattus norvegicus* trapped on infected pig farms.

Farm	No. of animals examined	No. with lesions	% with lesions
A	8	0	0
B	27	11	40.7
C	30	13	43.3
D	<u>46</u>	<u>30</u>	<u>60.5</u>
Totals	111	54	48.6

rats acting as carriers of this serotype. Histological examinations of all the kidneys collected showed that 48 percent of them had lesions compatible with subacute or chronic leptospirosis (Table 18). These are strong indications of the rat's role in the epidemiology of the disease. The results are even more important in relation to human health as *L. icterohaemorrhagiae* and *L. pomona* are the two serotypes most commonly found infecting man.

The importance of *L. icterohaemorrhagiae* infections in pigs was checked by experimental infections with isolates from rats. There was no mortality; but in all cases, interstitial nephritis was found in the autopsies.

Eradication by slaughter is not feasible because of the high prevalence of infection on the farms. Methods of control and eradication using antibiotics and rodent control are being studied on individual farms, particularly in areas where there are leptospiral abortions.

Porcine enteroviruses

Serum samples sent to the Plum Island Animal Disease Center in 1974 gave strongly positive reactions to this group of viruses. When this evidence was considered together with the clinical and histological findings in a herd of pigs where cases of a central nervous system disorder were

occurring, there was a strong likelihood that it was Teschen disease. Final confirmation depended on the isolation and characterization of the virus. This has been done and sent to Plum Island. There is very little information available in Latin America concerning this group of viruses: whereas in countries with highly developed swine industries, the enteroviruses have an important economic impact.

Swine dysentery

After identifying swine dysentery due to *Treponema hyodysenteriae* for the first time in Latin America, information on diagnostic and control methods was distributed to veterinarians working in both public and private institutions. The disease is probably widespread on commercial pig farms. New outbreaks were rapidly controlled using broad spectrum antibiotics.

A trial was carried out to determine the relative importance and interrelationship between *Treponema* and two other causal agents of dysentery, *Vibrio coli* and *Balantidium coli*.

INTERNATIONAL COOPERATION AND TRAINING

In 1975 contacts were extended with some national institutions that develop training, research and swine production programs in Latin America. Visits were made to those institutions and professionals developing national swine production programs. Their projects were studied as a basis for evaluating priorities in future training and technical cooperation programs. Maps of Central and South America, locating these institutions, are presented in Figures 1 and 2. The type of cooperation has been classified into three categories in accordance with the following criteria:



Figure 1. Swine production projects in Central America.

1. **CIAT|national institutions cooperative programs.** This category includes those sites where CIAT has participated most directly on the basis of agreements and priorities established by the IDRC|CIAT Project. In these cases there has been greater collaboration in technical assistance, in the training of professionals, and in the financing of some installations for the swine unit. CIAT has participated in these projects from the beginning, including the selection of the site, planning and supervision of the infrastructure and the projection of immediate activities. On the basis of these agreements, the cooperative projects should place emphasis on the training of professionals and swine producers, the transfer of technology, the development of swine production at a regional and national level, and the conducting of applied research oriented to solve local problems.

2. **Technical assistance for national programs that are already established.** This category includes those national programs where CIAT has provided indirect cooperation sporadically, especially in the areas of research, training and technical assistance. Each of these projects has been visited several times during the year as a starting point for greater international cooperation in the future.

3. **Other programs where there are possibilities of future cooperative projects.** This covers national or regional projects visited and evaluated by CIAT staff, where there has been only an exchange of information. CIAT cooperation, especially in training and technical assistance, can be increased in many of these sites in the future.

The principal activities related to international cooperation and training



Figure 2 Swine production projects in South America.

programs in swine production are given by country.

Bolivia

The construction of a swine unit for the cooperative Universidad Gabriel René Moreno|Proyecto Heifer|CIAT program in Santa Cruz (16)* was finished during the

* The number in parentheses refers to the one used to locate the sites in Figures 1 and 2.

present year, with the technical and financial cooperation of the IDRC|CIAT Project. Facilities include buildings for lactating sows, growing-finishing pigs, postweaning corrals, and office and warehouse facilities. The equipment and the foundation breeding stock arrived by midyear, and the unit is presently functioning. The production of breeding stock for promoting development projects and for carrying out local research activities

will be initiated during the first months of 1976. A coordinating committee, made up of representatives from the aforementioned cooperating entities, was created with the purpose of formulating a work plan and providing technical assistance for those professionals doing research, teaching and extension work. These professionals participated in training activities of the Swine Program at CIAT.

Other contacts have been established with the Comité de Obras Públicas in Santa Cruz and Chuquisaca (17), in an attempt to integrate activities such as the production of breeding stock, swine development and transfer of technology to swine producers through the Cooperative Project. A preselection of possible candidates for the 1976 training course at CIAT was made of professionals from both institutions.

Costa Rica

Construction of the buildings that will house the swine unit forming part of the cooperative Universidad de Costa Rica, UCR |CIAT program in Atenas (7) has not yet begun. Through the IDRC|CIAT Project, technical and financial assistance was given in 1975 to begin activities for promoting the development of swine production. The site, plans and budget for construction are ready; only a few legal requisites need to be fulfilled before the university will permit construction to begin.

As part of this program, a CIAT swine specialist went to Costa Rica for six months as an instructor of the swine production course at the UCR Departamento de Zootecnia. Several research projects were begun on local nutritional problems as topics for graduate degree theses. Other complementary activities carried out by this professional included several conferences for swine producers and the organization of a Central American swine production course programmed for 1976.

In 1975 two Costa Ricans participated in CIAT's training program. One of them is on the staff at UCR and the other at the Ministerio de Agricultura y Ganadería in Guápiles (8). Foundations have been laid for a more effective integration between these two entities in the promotion and development of swine production in Costa Rica. A preselection was made of two technicians from the ministry for attending CIAT's 1976 training program.

Peru

Cooperation with this country has continued, mainly through the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) in Pucallpa (15). The construction of facilities for a swine production unit housing 20 to 30 breeding sows was begun and should be finished at the beginning of 1976.

The professional in charge of IVITA's cooperative swine program participated in the training program at CIAT. At the same time, he received technical assistance for the initial phase of the project (building the installations for the animals, training programs, immediate plans for local experiments, etc.).

Contacts have also been made with other institutions, especially the Sociedad Agrícola de Interés Social (SAIS) and the Ministerio de Alimentación, with the purpose of selecting candidates for future CIAT training programs.

Colombia and Ecuador

Most of the cooperative work in these countries has been carried out through ICA in Colombia (11, 12) and the Instituto Nacional de Investigaciones Agropecuarias (INIAP) in Santo Domingo and Quito, Ecuador (13, 14). The activities developed this year were related to specific research projects and the training of professionals.

Cooperative ICA|CIAT work on the evaluation of the native breed (Zungo) has continued; results are presented in the section of this report on the performance of native and improved swine in tropical zones. Two Ecuadorians were trained at CIAT during 1975. One of them returned to INIAP after one year. A research associate returned after finishing his thesis work at CIAT on the utilization of opaque-2 maize in diets for lactating sows.

Other countries

The most important activities developed in other countries are related to training programs for professionals belonging to national institutions and technical assistance for swine programs through periodic consultations and visits. This group includes the Instituto de Ciencia y

Tecnología Agrícolas (ICTA) and the Instituto Técnico Agrícola (ITA) in Guatemala (1, 2); the Banco Nacional de Fomento in Honduras (3); the Centro de Desarrollo Agropecuario (CEDA) of the Ministerio de Agricultura y Ganadería in Sonsonate and San Salvador, Salvador (4, 5); the Banco Nacional (6) and the Ministerio de Agricultura y Ganadería in Nicaragua; the Universidad de Panamá (10) and the Ministerio de Desarrollo Agropecuario in Veraguas, Panama (9); and the Ministerio de Agricultura y Ganadería in Asunción, Paraguay (18).

Two professionals from Nicaragua and one from Panama participated in CIAT's training programs. Also during 1975, two research fellows returned to Nigeria after finishing work for their doctoral theses as part of the IDRC|CIAT|University of Ibadan Project.

PUBLICATIONS*

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- CLAWSON, A.J., MANER, J.H., GOMEZ, G., FLORES, Z. and BUITRAGO, J.** Unextracted cottonseed in diets for monogastric animals. II. The effect of boiling and oven vs sun drying following pretreatment with a ferrous sulfate solution. *Journal of Animal Science* 40(4):648-654.
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* This list includes only the journal articles published outside CIAT's series.