PN-AAP-364/
ISN-33604 /62

LIVESTOCK IN FARMING SYSTEMS RESEARCH AND DEVELOPMENT PROGRAMS*

by

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Introduction

The majority of animal products consumed within the world's tropical belt are produced on small farms, typically as part of a naturally integrated system of crop/livestock production. Tropical cropping systems within which livestock are only weakly integrated or not present include tropical plantation crops, slash and burn (swidden) agriculture, and some areas where time constraints in crop production severely limit farmers ability to feed and care for animals during certain periods of the year.

Typically, the animal production system found on small farms in the tropics has evolved over a considerable period of time in response to the natural endowments of the area, the feed inputs available from the prevalent crops and from off-farm sources, cultural factors affecting the care of animals and the use made of animal products, economic forces affecting inputs and outputs of the small farm, and government activities affecting the rural sector. An understanding of the operation of current crop-livestock production and marketing

*Lecture notes prepared for Farming Systems Workshop sponsored by Caribbean Agricultural Research and Development Institute, Port of Spain, Trinidad, April 26-27, 1979.

Components of the Crop/Livestock System

The general inputs into an animal producing unit are defined by Bowman (1977) in Figure 1. All these factors interact to jointly determine levels of efficiency within an animal production system.

Some general measures of efficiency which are commonly applied to animal production are (a) the proportion of male parents to female parents, (b) the reproduction rate of female parents, (c) mortality rates at all stages of the production cycle, (d) rate of replacement of parent stock, and (e) feed conversion efficiency (Reid, et. al., 1975). Table 1 presents some recent estimates of current standards for female reproductive efficiency and ceiling levels. Table 2 presents some trends in overall feed conversion efficiencies for well managed intensive animal production enterprises while Table 3 gives estimated present and ceiling levels for protein production efficiencies. Tables 1-3 indicate that substantial gaps exist between current and ceiling levels for various efficiency measures. However, even larger gaps currently exist between efficiency levels typically achieved with livestock produced by small farmers in the tropics [1/] and current efficiency levels achieved in the commercial livestock sector of developed countries. In almost every case, it is not technically or economically feasible for this latter gap to be closed completely but great potential exists to increase the efficiency of livestock production on small farms, particularly in conjunction with improvements in crop production efficiency and intensified crop production packages (Sprague, 1976; Plucknett, 1978); Javier, 1978).

1/ Some current efficiency levels of traditional livestock production systems for small farms are provided in APO (1976), FAO (1976), McDowell (1974 and 1978a), De Boer (1978) and Maner (1978).

One major factor which can heavily influence measures of efficiency based on output of meat, milk, or eggs is the multiple-purposes often served by livestock in a village situation. Following Turk (1975) and McDowell (1979), the major uses man makes of animals are:

Food -	Meat, milk, eggs, fats, gelatin.
Fiber -	Wool, hair.
Skins -	Hides, pelts.
Traction -	Crop production, cartage, packing, herding, irrigation pumping, threshing, passenger conveyance.
Waste Products -	Fertilizer, fuel, methane gas, construction, feed.
Storage -	Storage of capital or seasonal excesses of feeds and grains.
Conservation -	Use of crop-pasture or crop-hay rotations, seed distribution, ecological purposes.
Pest Control -	Control plants in waterways, weeds, snails in irrigation canals.
Cultural -	Exhibitions, fighting, pets, racing.
Inedible Products -	Fats, horns, hooves, bones, tankage, endocrine products.

These factors influence herd structure and herd structure often is a key survey indicator of the factors influencing farmers use of animals, particularly ruminants. The key herd structure variables are the age-sex distribution of animals as well as differences in breeds (if any) within this distribution.

The more important animal-related inputs into the cropping system itself depend upon the degree of integration and intensity of the system. Sprague (1976) develops these possibilities in some detail, with emphasis on soil and water conservation aspects. Potential inputs from animals include (a) the supply of nitrogen by legumes grown primarily for livestock feed, (b) soil improvement by perennial grasses and legumes, (c) animal manure for soil fertility and soil structural improvement, (d) improved control of certain plant pests, (e) draft animals for cultivation, and (f) better use of non-arable lands used in association with arable land. These inputs must be adequately accounted for in assessing the role of animals in crop/livestock systems as well as the more conventional outputs of meat, milk, eggs and fiber.

A more general model was developed by the Bellogio Conference on "Integrated Crop and Animal Production to Optimize Resource Utilization on Small Farms in Developing Countries" in October, 1978. The general relationships are set out in Figure 2 using as an example the "Honduran System" of Central America. The dark lines are strong flows or linkages while dashed lines represent weaker or less well integrated relationships. This flow chart is only representative of many farming systems found in the Caribbean and one of the first tasks of the

work teams will be to construct flow charts of the major linkages for each of the important farming systems found within their territories. The next step is to put percentages on the various flows, e.g., fuels for the household may come from the forest (70%) and from the market (kerosene) as purchased fuels (30%). Particular emphasis should be put on the disposition of crops and animals and the sources of animal feeds.

The crucial step in analyzing potentials in the livestock sector which may result from more productive cropping systems is the construction of preliminary feed demand-supply balances for the small farmers livestock herds. This should preferably be done on a monthly basis but for the baseline survey, this will not be possible and estimates should be made on a quarterly basis where the quarters correspond as closely as possible to distinct seasons and distinct phases of the cropping cycle. Feed supply is calculated by applying approximate protein and digestible energy percentages to the quantities of feed moving through the flow chart in Figure 2. The major problem in estimating animal feed supplies under village conditions results from the input (usually substantial) by the "on farm: fallow" and "off farm: forest, pasture, roadsides, etc." This contribution to the animal feed supplies of grazing animals is virtually impossible to estimate directly. However, there is usually some portion of the year when virtually all grazing animals are supported by these two categories of land and during this period a reasonably accurate estimate can be made of the feed supplied by these sources since we can estimate the apparent feed which must be consumed by the animals to meet their feed demand.

The demand side can be calculated in a straightforward manner using animal feed requirements as a function of species, breed, animal size, daily weight gain or loss over the period of analysis, and the animals reproductive status. It should also be noted whether the animal obtained feed under confined conditions or by grazing. Summing up the feed required by all animals over the quarter gives the farm total for feed demanded.

A classification of animal feed sources is provided in Figure 3. McDowell (1977 and 1978b) also provided estimated TDN levels for some of the major sources of tropical feedstuffs for ruminants (Figure 4). The feed resource is emphasized because this will be the major variable altered by the testing and introduction of more productive cropping systems. Within the crop side, feed resources available on a worldwide basis are as follows:

1. Cereal grains - 5 major species.
2. Food grain legumes - 8 major, 15 minor species.
3. Oilseed crops - 5 major species.
4. Root and tuber crops - 5 major species.
5. Plantain and banana - 2 major species.
6. Sugar crops - 3 major species.
7. Vegetables - About 15 major, numerous minor species.
8. Fruits - 6 major, many minor species.
9. Other tree crops - 5 major species.

For ruminants, to utilize the maximum genetic potential of an animal typically requires total digestibility of the feedstuffs of about 70%. Digestibility in the range of 60-65% gives intermediate performance levels while digestibility of 55% (the range of most tropical forages - see Figure 4) allows animal performance in the range of 55-60% of the genetic potential of the animals. The minimum TDN for maintenance of ruminants is typically 42-45% while if it falls below 40%, cattle lose weight. The typical small farm feed output would be:

5% with TDN greater than 45%,

50% with TDN of 40-45%,

45% with TDN less than 40%.

The HYV's of wheat and rice typically have straw with TDN values less than 40% whereas traditional varieties generally provided straws which would at least provide maintenance requirements (McDowell, 1978b). The key to assessing the impact on ruminant animal productivity of a change in the cropping system will often be if the new or proposed system can increase the digestibility of the crop by-products and residues by 5-7%. This allows the intake of energy to rise to 1.5-2.0 times maintenance requirements so the animal productivity becomes much higher.

Another aspect to consider in conjunction with a potentially improved source of animal feed is the state of the small farmers animal genetic resources. For example, grading-up cattle requires more and better feed to allow the improved

animal to perform near its new genetic potential. Local breeds may require 3000 Mcal/year for maintenance. Native animals perform about as well as improved types at energy intakes up to 150% maintenance while at levels of 180% maintenance and higher the improved breeds begin to perform much better than local breeds. In most small farm situations in the tropics, available feed represents only 115-120% maintenance so no great advantage is shown by the improved breeds under village conditions (McDowell, 1978a).

Intensity of animal production also influences the feed consumed to produce a marketable animal. Cattle produced under a low energy ration gaining at a slow rate are assumed to reach their mature weight of 450 kg at 4 years. Total energy consumed would be about 15,000 Mcal of metabolizable energy (ME). Cattle fed on a high energy ration would reach the same weight in 2 years while consuming only 9,500 Mcal of ME. The difference is due to the wasted energy used on maintenance for the extra two years.

Tropical forages are often promoted as a promising means of increasing livestock production on small farms, particularly as a well integrated part of the farming system (Sprague, 1976). Both Plucknett (1978) and Javier (1978) offer a number of suggestions as to how this has been done under small farm systems as well as listing some promising species.

Intensification of forage production can be carried out by the following means (Plucknett, 1978):

1. Cut and carry systems using cultivated forages.
2. Catch cropping after a main crop.
3. Intercropping where the second crop can serve as a forage crop or provide additional crop by-products or residues.
4. Multiple cropping.
5. Special purpose crops.
6. Multiple purpose hedges and fodder trees.
7. Supplementation by tethering or grazing on non-arable land.
8. Improvement of existing cropping system by:
   a. Genetic improvement of a crop to improve its feeding value.
   b. Treatment of crop residues and by-products.
   c. Supplementation to improve the digestibility of existing feed resources.
   d. Introduction of additional inputs into the cropping system such as fertilizer and irrigation.

The main disadvantages of tropical forage grasses for intensification of livestock production on small farms would be (a) competition for arable land with food and fiber crops which provide a quick return; (b) the high growth period coincides with the high growth period of traditional grazing resources; (c) the improved tropical forage varieties are fertilizer responsive so high fertilizer inputs are needed to realize the potential of these species;

(d) most species are propogated vegetatively so high labor inputs are needed during the wet season when crop labor inputs are also high; (e) these grasses develop extensive sods which, while highly desirable for improving soil structure and soil conservation, make it difficult for a small farmer to break up with a hoe or animal plows for resumption of the cropping cycle; and (f) the cut and carry system, which these intensive forages make feasible, may be too labor intensive for the Caribbean region where wage rates and the opportunity cost of labor tend to be higher than in areas where cut and carry systems are widely used. The production levels of some tropical forages are given in Figure 5.

Modelling Considerations

The efficiency measures discussed so far are based on feeding trials or reproduction experiments using single animals as the experimental unit. The appropriate unit for evaluation in a farming system research project is the productivity of a herd/flock or groups within the herd/flock. Thus we must account for inputs required to produce an animal up to its productive period, the inputs required to raise and maintain the breeding stock, the input costs of reproduction or losses from infertility and mortality, as well as the basic uses to which a herd is put and the influence this has on herd/flock structure and offtake.

The approach usually assumes total energy supply to the animals as fixed and budgets out the animal production options taking care to account for feed energy used by the items listed above. A good example is provided by McDowell (1974, p. 11) where the influence of increased lambing rates on production of the entire flock is considered under a fixed energy supply of 120,000 Mcal ME for sheep production. Table 4 illustrates the basic values required for the calculations (A, D and E), while Sections B and C give output levels. Doubling the lambing percentage (% of lambs weaned and sold) increases total lamb weight marketed by 38, 52, and 42% for the three "lamb weight at turnoff" assumptions, respectively.

McDowell (1974; pp. 13-14) also gives an example of the potential supplies of human food available from a 2 ha plot of maize yielding about 60,000 Mcal ME from grain and stover (Table 5). The stover will feed 4.3 cows producing at 500 kg milk/cow. This low output is because stover provides only 64% of the needs of a 450 kg cow producing at a high level of 10 kg milk per day. Table 5 provides the output when all grain is consumed by humans while Table 6 shows the changes which result when one ha of maize is harvested for human consumption and one ha of grain is used to supplement the 2 ha of stover. The ration now contains 2.5 Mcal/kg ME as opposed to the "stover only" diet which supplies 2.0 Mcal/kg ME. The system now feeds 5.3 cows weighing 450 kg each and producing 3,055 kg milk per lactation. Table 6 also indicates the possibilities for producing meat rather than milk by fattening bulls from 300 kg up to 400 kg. The total feed energy from stover plus 1 ha grain gives 2,300 kg gain as opposed to 700 kg gain on stover alone.

The research work plan can now be seen to consist of (a) the initial survey stage which provides information needed to define the system and its parameters; (b) define constraints to increased crop and livestock production; (c) a crop experimentation stage which defines some promising cropping systems; (d) a livestock experimentation stage designed around more efficient use of the more productive cropping systems along with better practices regarding disease control, parasites, and culling; and (e) an active development stage where the more promising crop/livestock technical packages are tried over a range of environments and over a range of socio-cultural conditions. The key aspect remains the ability to substantially increase the productivity of the cropping system (Banta, 1973; Okigbo, 1978; Harwood, 1978).

Species Considerations

Dairy cows and dairy goats fit well within farming areas having reasonable access to milk collection centers, milk processing plants, or direct consumer markets. Dairy goats seem ideally suited for the small farmer but, in terms of productive efficiency, generally lag behind dairy cows (Sands and McDowell, 1978). Goats may offer better potential for meat production, particularly in drier areas with plentiful supplies of browse (McDowell and Bové, 1977).

Sheep are well adapted to most areas of the Caribbean and are widespread. They offer excellent potential for utilizing crop residues and off-farm grazing areas in combination. Sheep are also held by landless families in rural or urban areas, a group which could indirectly benefit from higher output cropping systems as more crop residues become available for use by these producers.

Pigs and poultry would have the greatest potential where cropping systems are developed that are capable of supplying relatively low cost sources of high energy feeds that can be supplemented by compound feed mixes.

practices can assist us in explaining current efficiency parameters of livestock on small farms (which are typically low by developed country standards) as well as the rationale for input levels into livestock production and the mix of products derived from livestock. This basic understanding of how the system operates must be regarded only as the first step, however. The next step is to define and quantify the constraints limiting animal production. The integration aspect implies that major emphasis is needed on the current productivity of the cropping system. This is the first stage for the biological research teams operating at both the experiment station and farm level. The research objectives must focus on experimentation with various cropping systems, how these more productive cropping systems alter existing animal production possibilities, and how further constraints to animal production can be eliminated to allow the small farmer to increase the total productivity of the farm.

The third and final stage is on-farm testing with combinations of livestock enterprises in conjunction with some of the more promising cropping systems, ie. cropping systems which show the most promise for improving the combined income from crops plus livestock production. The most promising systems can then be applied on a brood scale, thus leading into the "development" phase in which credit, markets and public services must be brought together in a development package.