

# A PROFIT-OPTIMIZING MANAGEMENT TOOL THAT CONSIDERS DAIRY NUTRIENT INPUTS AND PLANT NUTRIENT OUTPUTS

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## ABSTRACT

The production of excess on-farm manure is placing continuous pressures on dairy producers to meet or exceed standards for environmental regulations while maintaining profitability and competitiveness. Evaluation of the effects of recycling nutrients on the profitability of the whole farm enterprise is important for a dairy operation. The objective of this study was to extend the application of farm profit maximizing models to consider ration formulation, crop selection and manure utilization. The farm profit framework was used to compare surplus nutrient application restriction costs over double and triple cropping systems and over dairy herd production levels. Triple cropping forage systems have no advantage over double cropping systems in Georgia, USA and lower milk producing herds are equally economically disadvantaged by restrictions on surplus nutrient applications as are herds with high milk production levels.

**KEYWORDS.** Balancing animal nutrient requirements, Plant nutrient output and requirements, Profit maximization, Surplus plant nutrient application restrictions.

## INTRODUCTION

The dairy industry in the United States has shifted towards highly intensive, specialized and localized production systems driven by competitive economic, social and political forces. For more efficient milk production, animals are confined in loafing areas where they deposit large amounts of manure that must be collected, stored and used as plant nutrients to irrigate forage crops in the place of or addition to conventional inorganic fertilizers. As livestock population becomes spatially concentrated (Kellogg et al., 2000), the production of manure nutrients can exceed the assimilative capacity of croplands available for manure application (Lander, Moffitt and Alt, 1998). From water-quality standpoint, environmental concerns center around nutrient runoff from crop fields. As a result, regulators are focusing on the ways to induce confined animal producers to operate in manner to protect the environment while maintaining profitability and competitiveness.

Manure nutrient management decisions have several important dimensions, including the storage and handling practices, rate, timing and method of application, and off-field practices to mitigate pollution. On the farm, the level and/or variability of economic returns to crop and livestock production may be affected by each of these dimensions. Researchers around the United States have used economic models to assess the environmental risks as well as the on-farm cost of manure handling with specific emphasis on land application of manure rates to meet the requirements of a nutrient management plan (Ribaud et al., 2002; Innes, 2000; Fleming, Babcock and Wang, 1998). Other researchers used an optimization framework to predict how a

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representative farm's return or costs would change under an N and/or P-based restriction on manure applications (Huang and Magleby, 2000; Huang, Magleby and Somwaru, 2001).

Most of these studies focused on the balance between manure nutrient production and crop nutrient uptake. However, few of these models incorporated costs associated with crop and livestock production, feed intake and manure excretion, storage, hauling, and application as well as environmental considerations (Henry et al., 1995; Thompson et al., 1997).

Recent work has been devoted to balancing manure nutrient production, crop nutrient uptake and animal nutrient requirements (Somda et al., 2003). Somda's paper reported on the development of a farm linear programming model for selecting cropping systems that match dairy cows' nutritional needs to forage production with manure as primary nutrients source.

Our work is a continuation of the work reported by Somda with the specific objective of performing a whole farm economic evaluation of the results from a intensive forage research program conducted at Tifton research facilities, University of Georgia USA. The intensive forage consisted of triple cropping forages to increase forage production per unit of land while increasing the land's capability of utilizing plant nutrients from animal manure.

## **MATERIALS AND METHODS**

### Linear Programming Model

The objective function of the model is to maximize profit over the sale of milk and other produced crops. Manure nutrients can be stored for short periods, but must be utilized by crops grown on the farm within one year. Dairy ration are balanced by nutrient requirements of any selected production level within cow capabilities. Manure nutrient production is a function of the chosen milk production level. Ration nutrients are selected from corn silages, hay, winter small grain forages, farm-grown crops of corn grain, cotton seed hulls, and purchased concentrates and minerals.

Cow numbers or land available can be pre-selected. Crop nutrient requirements are based on selected yields, but can be lowed or raised to reflect soil surpluses or shortages.

### Data Sources

Nutrient concentrations for forages were taken from a study evaluating triple forage cropping system at the dairy research farm in Tifton, Georgia.

The commodities available for use in dairy rations are those typically available in Georgia. Nutrient requirements for milking cow performance and maintenance were derived from DART ration formulation and adjusted for production level and period. Prices of inputs are those realized by Georgia farmers. Ration ingredient costs are either purchase price or cost of producing the ingredient. Variable and fixed costs are included.

## **RESULTS AND DISCUSSION**

The evaluation reported in this paper compares triple forage cropping system and double forage cropping system under milk production levels of 32 and 41 kg (70 and 90 pounds) per day. The manure disposal capacity per year was determined by requiring all effluent to be used within a 12-month period but by allowing storage over cropping periods. The lower milk capacity herd modifies the absolute severity of the phosphorus and nitrogen surplus restrictions in that there is less income involved to be increased or decreased although the percent changes are approximately equal or greater (Tables 1 and 2). The cost per cow was less for the lower milk production level but the restriction cost per unit of milk was higher.

The phosphorus surplus restriction was the most constraining. Adding zero nitrogen surplus restriction to the phosphorus 125% surplus restriction did not change either the double cropping scenario or the triple cropping scenario (Tables 1 and 2).

**Table 1. Comparison of effects on cow carrying capacity, costs per cow and profits per hectare of limits on surplus phosphorus and nitrogen applications through manure on double cropping and triple crossing systems,<sup>a</sup> for cows producing 41 kg (90 lb) of milk per day.**

Phosphorus and nitrogen limit	Number of cows per 0.405 ha (acre)	Cost per cow	Profit per 0.405 ha (acre)	Restriction cost per 45 kg (cwt) milk
-----U.S. dollars-----				
Double cropping				
N max limit = 100% of N min limit and P max limit = 100% of P min limit	0.5	4287	964	2.02
N max limit = 100% of N min limit and P max limit = 125% of P min limit	0.8	4010	1291	.97
N max limit = 125% of N min limit and P max limit = 125% of P min limit	0.8	4010	1291	.97
N max limit = 150% of N min limit and P max limit = 150% of P min limit	1.0	3833	1685	.28
N max limit = 150% of N min limit and P max limit = 250% of P min limit	1.3	3763	2144	0.00
Triple cropping				
N max limit = 100% of N min limit and P max limit = 100% of P min limit	0.6	4244	967	1.64
N max limit = 100% of N min limit and P max limit = 125% of P min limit	0.9	3885	1514	.32
N max limit = 125% of N min limit and P max limit = 125% of P min limit	0.9	3882	1517	.32
N max limit = 150% of N min limit and P max limit = 150% of P min limit	1.1	3854	1738	.16
N max limit = 150% of N min limit and P max limit = 250% of P min limit	1.7	3907	2602	0.00

<sup>a</sup> Land and manure storage costs not included.

**Table 2. Comparison of effects on cow carrying capacity, costs per cow and profits per hectare of limits on surplus phosphorus and nitrogen applications through manure on double cropping and triple crossing systems,<sup>a</sup> for cows producing 32 kg (70 pounds) of milk per day.**

Phosphorus and nitrogen limit	Number of cows per 0.405 ha (acre)	Cost per cow	Profit per 0.405 ha (acre)	Restriction cost per 45 kg (cwt) milk
-----U.S. dollars-----				
Double cropping				
N max limit = 100% of N min limit and P max limit = 100% of P min limit	0.6	3478	820	2.34
N max limit = 100% of N min limit and P max limit = 125% of P min limit	0.9	3206	1099	0.88
N max limit = 125% of N min limit and P max limit = 125% of P min limit	0.9	3206	1099	0.88
N max limit = 150% of N min limit and P max limit = 150% of P min limit	1.2	3061	1430	0.30
N max limit = 150% of N min limit and P max limit = 250% of P min limit	1.5	2978	1826	0.00
Triple cropping				
N max limit = 100% of N min limit and P max limit = 100% of P min limit	0.8	3311	964	1.40
N max limit = 100% of N min limit and P max limit = 125% of P min limit	0.9	3173	1113	0.48
N max limit = 125% of N min limit and P max limit = 125% of P min limit	0.9	3173	1113	0.48
N max limit = 150% of N min limit and P max limit = 150% of P min limit	1.3	3111	1468	0.20
N max limit = 150% of N min limit and P max limit = 250% of P min limit	2.2	3158	2349	0.00

<sup>a</sup> Land and manure storage costs not included.

## Double Cropping Versus Triple Cropping

Triple cropping had more carrying capacity than double cropping with the nitrogen restrictions and the high phosphorus restrictions. But under the 100% phosphorus restriction, the carrying capacity of the double cropping system was very close to that of the triple cropping system. The triple cropping system had the advantage of having growing crops available year round for manure application except for harvesting periods and periods of water saturated soils from rain.

## **CONCLUSION**

The farm profit model is very effective in handling dairy ration formulation, milk production level, and manure utilization for plant nutrients. Phosphorus surplus application restrictions were more constraining than nitrogen restrictions. The double cropping system with 15% higher yields of temperate corn silage and rye clover and with these higher yields providing a 15% greater manure utilization capacity was only approximately equal to the triple cropping system with 100% restriction on phosphorus. As the restrictions on phosphorus surplus were reduced, the advantage of the triple cropping system increased. Although the carrying capacity was larger, the lower productive herds have lower efficiency in utilizing forages in respect to milk output and, therefore, have a higher ratio of plant nutrient output to milk production. Since the model is an animal and plant nutrient formulation tool, it needs to be run when feed ingredients, plant nutrient and milk prices significantly change and when crop yields are below projections and when available soil nutrient levels change. Similar made formulations can be used for beef cattle and for swine and poultry operations even though forages are not part of swine and poultry diets.

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