Phosphorus Removal by Different Wheat-Stocker Cattle Production Systems

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Story in Brief

Grazing studies were conducted at two locations to measure phosphorus accretion in growing cattle grazing wheat pasture and total phosphorus removal in biomass from five winter wheat production systems. The production systems were 1) fall/winter grazing by growing beef cattle followed by grazeout, 2) fall/winter grazing followed by hay harvest, 3) fall/winter grazing followed by grain harvest, 4) no grazing followed by hay harvest, and 5) no grazing followed by grain harvest. Phosphorus accretion (g/kg) of carcass, empty body, and live weight gain of cattle was 7.5, 6.4, and 7.1, respectively. Removal of phosphorus from cattle-wheat production system is a function of total biomass removed. Production systems that removed wheat biomass as hay resulted in the greatest removal of phosphorus. The least amount of phosphorus was removed in the grazing only system where the only biomass removed was as cattle weight gain. There was no significant difference in the levels of soil test phosphorus with any treatments during the duration of this experiment. In systems where manure is repeatedly applied to the same fields, soil phosphorus levels will increase when phosphorus application exceeds phosphorus removal. Cattle-wheat systems that incorporate biomass removal as hay will result in the slowest rate of increase in soil phosphorus.

Key Words: Wheat Production Systems, Phosphorus Removal, Soil Phosphorus

Introduction

Land applications of manures and effluent from cattle feedyards have caused concern for surface water contamination in recent years (U.S. Environmental Protection Agency, 1996). Repeated application on the same land area has increased levels of soil phosphorus (P) in such a manner that states are now adopting livestock waste management recommendations that evaluate agronomic and environmental benefits (McFarland and Hauck, 1995; Natural Resource Conservation Service, 1995; Sharpley and Sisak, 1996). These regulations could limit P application in a sensitive watershed to the amount of P removed from the site during a growing season. To determine best management practices for a given site, it will be necessary to quantify P removed in the biomass. For sites with limited land resources for effluent application, it will be critical to determine the biomass P removal for a proper nutrient management plan. In a winter wheat-stocker operation, there are several forms of biomass in which P can be removed. These include cattle weight gain, forage as hay or silage, and grain. The objective of this study was to measure phosphorus accretion in growing cattle grazing wheat pasture and total phosphorus removal in biomass from five cattle-winter wheat production systems.

Materials and Methods

Five (5) treatments (Table 1) were used to determine the amount of phosphorus removed by selected production systems for winter wheat in the southern Great Plains. These represent common production systems for wheat-stocker production where the GZ-GZ treatment represents wheat used for grazing during the entire growing season. The GZ-H and GZ-GN treatments represent dual-purpose use of wheat for cattle grazing followed by hay or grain harvest, respectively. The final two treatments represent single purpose use of wheat for hay or grain production.

Table 1. Treatment structure for biomass removal from winter wheat production in the southern Great Plains		
	Wheat Biomass Management	
Treatment	Winter	Spring
GZ-GZ	Graze	Graze
GZ-H	Graze	Hay
GZ-GN	Graze	Grain
N-H	None	Hay
N-GN	None	Grain

These production systems were established in fields used for wheat grazing. Within these fields the N-H and N-GN treatments were established by constructing exclosures from wire panels (16 ft x 16 ft) in grazed pastures to prevent livestock from foraging inside the exclosures (Fig. 1). When cattle were removed during the late winter, exclosures were constructed to identify plots that were subsequently harvested for the GZ-H and GZ-GN treatments.

Figure 1. Exclosures in a wheat-stocker grazing system for the southern Great Plains at the Hartley, TX location during the 2000-2001 growing season.

Four (4) replications of each treatment, within a completely random experimental design, were established at each of two locations (OSU Wheat Pasture Research Unit; Marshall, OK and

Hartley Feeders; Hartley, TX) for the 2000-2001 growing season, and only at the Marshall location for the 2001-2002 growing season. The Hartley location utilized a modified grazeout period due to corn planting occurring in the spring of 2001; whereas, the Marshall location used a continuous wheat system throughout the grazing treatments. The modified grazeout period utilized a small plot harvester to remove forage from the plot following cattle removal to allow for corn planting in early April, 2001. All other treatments remained the same at both locations. Wheat hay and grain samples were collected for both growing seasons at the Marshall location and for the 2000-2001 growing season at Hartley.

Data Collection. Phosphorus removal from the sites was determined from the quantities of biomass (i.e., cattle, wheat hay, and grain) produced and the P concentration in each of the biomass products. Wheat hay and grain samples were collected at harvest, and cattle were weighed at the time of each management change.

Soil Sampling. Soil samples from 0-15 cm and 15-30 cm were taken prior to wheat planting at both locations to determine the level of P in the plot areas. Sampling sites were clearly marked for future reference. Procedures for soil sampling consisted of 1) drying the soil at 100ºC for 6 to 12 hours; 2) grinding the soil samples to pass through a 2-mm screen; 3) extracting the soil with Mehlich III extract (Mehlich, 1984) for soil testing of P level and other nutrients of interest (Fe, Zn, Cu, and K). The samples were used as a baseline for P uptake. Post-treatment samples were collected following the grazeout period at each site.

Crop Production. The seeding rate for the Hartley location was 90 lb/acre, while at Marshall it was 110 lb/acre with 50 lb/acre of 18-46-0 applied in the row at planting. Typical winter wheat crop production practices were utilized at both locations. These practices include fertilization based on yield goals, weed control, and insecticide applications.

Forage Sampling. Forages were harvested from the exclosures once in the spring by hand-clipping from a .203 M^2 area of the plot to determine biomass production following the restriction from grazing. Sub-samples from the plot were collected, dried for 48 h at 60ºC in a forced air oven, and were then ground to pass a .5-mm screen. The sub-samples were used to determine dry matter content and P concentration in the plant tissue. Phosphorus concentration and other nutrients of interest were determined following digestion of the plant tissue in HNO_3-H_2O_2.

Grain Sampling. Grain was harvested from a 11.14 M^2 area within the exclosures with a Hege plot combine to determine grain production after grazing. Sub-samples were collected, dried for 48 hr at 60ºC in a forced air oven then ground to pass a .5-mm screen. Grain sub-samples analyzed for nutrient concentration in the same manner as forage samples.

Phosphorus Accretion (removal) by Growing Cattle. Six Santa Cruz steers that grazed wheat pasture at Marshall were harvested during the 2000/2001 wheat pasture season to determine phosphorus accretion in stocker cattle grazing winter wheat pasture. Phosphorus concentration of carcass and offal was determined and P accretion in carcass, offal, empty body, and live weight was determined by linear regression as previously reported by Gibson et al. (2002). These data were also used in calculating P removal in cattle weight gain at the Hartley location.

Statistical Analysis of Data. Means for biomass production, P concentration, and total P removal were calculated for each production system within location and year.

Results

Weather/Type of Wheat Pasture Year. Year 1 (Marshall): The wheat pasture year of 2000/2001 was a very poor year for growth of cattle, and was characterized by a very dry late summer and early fall, and record low temperatures in November and December which resulted in very little growth of wheat. January and February remained consistently cold and wet. The fall/winter grazing period was only 70 d (January 10 to March 21), and was followed by a short grazeout from March 21 to April 11 (21 d).

Year 2 (Marshall): With the exception of a severe ice storm on January 29 and 30, the 2001/2002 wheat pasture year was excellent for growth of cattle. The fall/winter grazing period was from November 15 to March 13, 2002 (118 days). At a stocking rate of 0.59 steers per acre, total weight gain of steers was 271 lb. Because cattle were shipped at the end of the fall/winter grazing period, a grazeout period was not included.

Biomass Production. Cattle biomass removed from the continuous grazing treatment for 2000-2001 was 128 and 295 lb/acre at the Hartley and Marshall locations, respectively (Table 2). Wheat biomass from the Hartley location was greater than the Marshall location for hay and grain production. In addition biomass removal was greater for hay than grain at both sites for both years. At the Marshall location for 2001-2002 season, cattle biomass was 160 lb/acre and wheat biomass was greatest where hay was harvested.

Phosphorus Concentration. Phosphorus concentrations of wheat hay and grain were 1.7 and 2.7 mg/kg, respectively. These concentrations are consistent with other studies related to plant P uptake. Phosphorus accretion (removal) by steers grazing wheat pasture was 7.5, 6.4, and 7.1 grams per kilogram of carcass, empty body, and live weight gain, respectively, as previously reported by Gibson et al. (2002).

The concentration of P in plant biomass was similar for grain and hay at both locations, however P concentration in grain was greater than hay. At Marshall, P concentrations were similar for the hay for both years, however there was an 18% increase in grain P concentration for the 2002 harvest.

Table 2. Biomass production and phosphorus removal from a cattle-wheat grazing system at Hartley, TX and Marshall, OK for 2000-2001 and at Marshall, OK for 2001-2002

Location	Treatment	Cattle Biomass Removal (lb/acre)	Cattle P Concentration (g/kg)	Wheat Biomass Removal (lb/acre)	Wheat P Concentration (g/kg)	Total Biomass P Removal (lb/acre)
2000-2001						
Hartley	GZ-GZ	128	7.1[a]	0	0	.89
Hartley	GZ-H	128	7.1	11,113	1.5[b]	16.25
Hartley	GZ-GN	128	7.1	4,485	2.7[c]	12.09
Hartley	N-H	0	0	11,990	1.7	20.90
Hartley	N-GN	0	0	6,354	2.6	16.92

2000-2001						
Marshall	GZ-GZ	295	7.1	0	0	2.09
Marshall	GZ-H	21	7.1	5,480	1.7	9.65
Marshall	GZ-GN	21	7.1	3,884	2.7	10.58
Marshall	N-H	0	0	8,259	1.7	14.54
Marshall	N-GN	0	0	3,936	2.7	10.86
2001-2002						
Marshall	GZ-GZ[d]	160	7.1	0	0	1.13
Marshall	GZ-H	160	7.1	2,578	1.9	6.10
Marshall	GZ-GN	160	7.1	921	3.1	3.99
Marshall	N-H	0	0	4,046	1.7	6.97
Marshall	N-GN	0	0	1,233	3.3	4.16

[a]This represents the P concentration in g/kg of live weight gain for the cattle

[b]This represents the P concentration of the hay only

[c]This represents the P concentration of the grain only

[d]Fall/winter grazing only

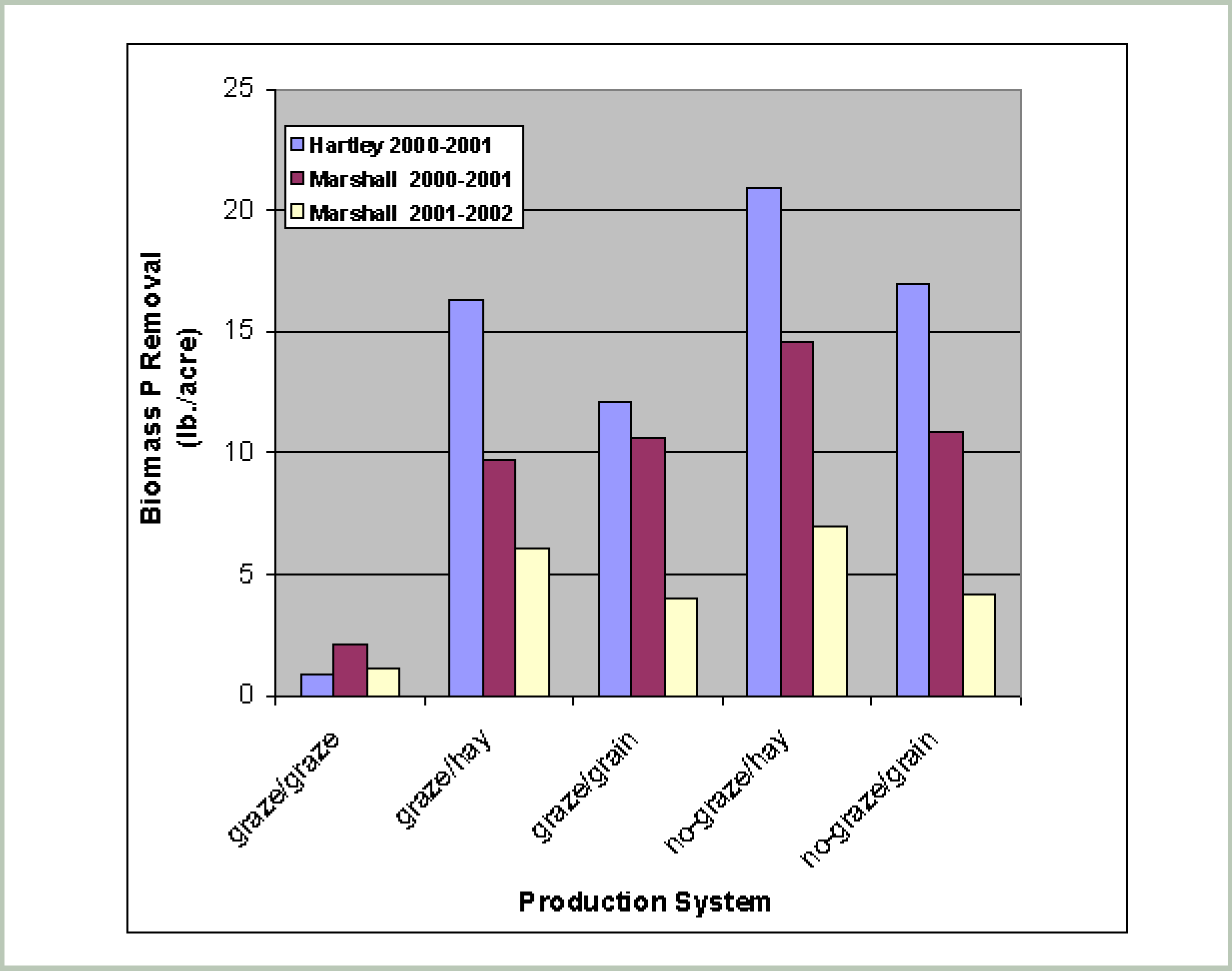
Phosphorus Removal. Total phosphorus removal at Hartley was greatest in the no graze-wheat hay system (21 lb/acre) and least in the grazeout system (.89 lb/acre), and was a function of total biomass removal. A similar ranking of production systems for total phosphorus removal was observed each year at Marshall. Although P concentration in grain was greater than hay, more biomass was produced in the N-H and GZ-H systems than the grain only system. Therefore, systems that maximize total phosphorus removal were those that maximized biomass removal.

The quantity of P removed from the no graze-wheat hay system at Hartley would be equivalent to the amount applied from 2 t of feedlot manure (assuming 21 lb P_2O_5 t) or approximately 1.75 acre-inch of lagoon effluent (assuming 1 lb P_2O_5/1000 gal). Many production systems apply more than 2 t of manure or 2 acre-inch of effluent per year. Thus, soil build-up is an issue. At the measured levels of P removal, there will ultimately be a build-up of soil P where P additions are greater than P removal. If phosphorus applications continue at levels greater than plant removal, additional land will be required for manure application in systems where sensitive water bodies exist.

Soil Test Phosphorus Levels. Soil test values did not change significantly during the period tested (Table 3). Net changes in soil test P ranged from +24.1 to -29.8 mg/kg for the graze/grain and no- graze/grain treatments, respectively, at the Hartley location. This is not consistent with the P removal data in figure 2 where the greatest amount of P removed in the biomass was with the hay production. However soil test P values will fluctuate with sampling time and these errors are within the sampling error. If no additional phosphorus was added to the hay or grain systems the soil test P levels would decrease however, this could take many years to accomplish at soil test levels greater than 120 mg/kg.

Table 3. Initial and final soil test P for Hartley, TX and Marshall, OK locations for the 2000-2001 growing season

		Pre-experiment Soil Phosphorus (mg/kg)	Post-experiment Soil Phosphorus (mg/kg)	Net Change
Hartley 2000-2001	Graze/graze	100.8	77.1	-23.7
	Graze/hay	137.0	114.5	-22.5
	Graze/grain	113.4	137.5	24.1
	No-graze/hay	132.3	122.1	-10.2
	No-graze/grain	95.4	65.6	-29.8
Marshall 2000-2001	Graze/graze	45.7	44.1	-1.6
	Graze/hay	45.2	54.7	9.5
	Graze/grain	33.3	53.6	20.3
	No-graze/hay	40.0	55.4	15.4
	No-graze/grain	29.6	48.8	19.2



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