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Calculate how much manure nitrogen you can add to intensively managed dairy grazing fields

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Intensive grazing systems for heifers and dry cows are increasingly being adopted by dairy producers to reduce operating costs and lower management needs for manure disposal and nutrient input. To optimize production and minimize environmental impact, it is necessary to understand the nitrogen (N) fluxes in these intensive grazing systems.

Grazing livestock play an important role in the ecology of forage fields because livestock consume nutrients in forages that subsequently are converted into energy and tissue and exported out from the ecosystem. Nutrients ingested by livestock may be returned to the field in feces and urine. However, only a portion of the excreted nutrients are available for plant uptake because of nutrient losses from volatilization.

Over time, forage growth declines when soil nutrients become depleted. The need to reverse the negative balance of nutrients in the fields creates an opportunity to use and recycle nutrients that may be in excess in other parts of the dairy production system. The need to replenish N on intensively grazed fields supports the additional application of manure or effluent.

Net balance of N

The net balance of N in a grazing system is the difference between the amount of N deposited on the ground in feces plus urine that is available for uptake in forage production and the N consumed by the animals through forage ingestion. Consequently, the actual amount of N incorporated into the forage is the N excreted on the field in

feces and urine less the amount of N lost or volatilized as ammonia before being taken up by the plants. The amount of N volatilized after excretion varies according to weather and soil conditions from 20 to 80% of the excreted N (Table 1).

Nitrogen excreted

The amount of N excreted by heifers and dry cows can be calculated as a function of the live body weight (LBW) of the animals, following standard values. For example, the USDA Agricultural Waste Management Field Handbook

Table 1. Parameters to calculate grazing N balances, some common or default values, and their normal ranges.

parameter	common/default	normal range
¹ LBW heifers (lbs.)	---	330-1,430
¹ LBW dry cows (lbs.)	1,600	1,400-1,800
² ADG heifers (lbs/day)	1.98	1.1-2.43
³ DMI dry cows (lbs.)	28.8	28.8-33.6
⁴ CP forage (%)	26.5	20.9-32.1
N volatilized (%)	50%	20-80%
⁵ DM forage yield (tons/ac/mo.)	0.75	0.375-1.125

¹ LBW = live body weight
² ADG = average daily gain
³ DMI = dry matter intake
⁴ CP = crude protein
⁵ DM = dry matter

(<http://www.info.usda.gov/CED/ftp/CED/neh651-ch4.pdf>) indicates that heifers excrete 0.31 lbs of N and dry cows 0.36 lbs of N for every 1000 lbs of LBW.

Nitrogen intake

Nitrogen intake can be calculated by converting the crude protein (CP) content of the consumed forage to N amounts, based on a 6.25 to 1, CP to N conversion ratio. Crude protein intake can be calculated by multiplying the forage dry matter intake (DMI) by the forage CP con-

tent. For example, according to the National Research Council (<http://www.nap.edu/catalog/9825.html>), intensively managed forages may contain between 20.9 and 32.8% CP on a dry matter basis (Table 1).

Dry matter intake

The DMI needs to be calculated differently for dry cows and for heifers. Dry cows consume between 1.8 and 2.1% of their LBW daily on a dry matter basis. Whereas DMI for heifers is based on the average daily gain (ADG) in addition to the actual LBW. The National Research Council has an application that predicts heifers' DMI according to those parameters and can be downloaded at: <http://books.nap.edu/html/dairy-model>.

Depletion of N in grazing systems

Considering no feed supplementation, the net N balance of a dry cow or heifer grazing activity is a negative value that reflects higher amounts of N intake than amounts of N returned to the plants through feces and urine excretion. Consequently, this depletion of N in the soil requires additional N applied to grazing fields, bringing the opportunity to replenish N through addition manure application for sustained forage production.

Carrying capacity

There are limitations to the capacity of the fields to sustain grazing heifers and dry cows. Carrying capacity is the maximum number of animals that can be grazed on a forage field for a determined period of time. Carrying capacity can be calculated as the forage field productivity of consumable forage divided by the DMI required for the animals. The consumable forage should discount forage losses due to trampling, fouling, decomposition, manure deposits, etc. from the total forage production. For example,

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the consumable forage for intensive managed grazing fields may be between 0.375 and 1.125 tons dry matter/acre/month.

Grazing management N removal

Grazing management includes decisions such as the selection of the type and weight of animals, the number of animals, the duration of the grazing activity, and the forage species in the field.

In selecting grazing management options, it is recommended to contrast the proposed grazing activity with the forage field's carrying capacity in order to not exceed it. In some circumstances, exceeding carrying capacity may be allowable for a short period of time when it is done with the intention of consuming accumulated forage growth.

The N removal on a field in a period of time can be calculated by multiplying the animal net N balance by the number of animals and by the days of grazing, and dividing it by the number of acres in a forage field. The overall N removal in a field should include all N removal activities of different groups of animals, for different grazing periods.

Feed supplementation

It is common to provide supplemental feed to grazing heifers and dry cows. A simple way to introduce feed supplementation in the calculations is to assume that the supplemented N would provide the same amount of N that otherwise would be ingested through grazing. Knowing the N content of the supplemented feed allows calculating the amount of reduced grazing forage and consequently the adjusted N intake from forage, which can be used to recalculate the N balance in the grazing system.

Nitrogen removal at maximum carrying capacity

Levels of N removal in grazing programs lasting 180 days at maximum carrying capacity and common or default values of Table 1 with no feed supplementation are displayed in Figure 1. The carrying capacity is between 2.4 and 5.1 for unbred heifers, between 1.7 and 2.2 for bred heifers and 1.8 for dry cows. At maximum carrying capacity, smaller heifers remove more N than larger ones and dry cows remove less N than heifers.

Intensive grazing systems may require between 290 and 335 lbs of additional N to replenish N removed by grazing animals in a six-month period.

Change of N balance by changes on selected management practices

The N balance in a grazing system is impacted by the following conditions, in decreasing order: percentage of crude protein in forage, feed supplementation, forage productivity, percentage of N volatilization after excretion, and dry matter intake of animals.

Crude protein has a major impact on the N balance. An increase from 20.9 to 32% in CP of the forage results in a decrease in N balance of

48% for unbred heifers, 50% for bred heifers, and 56% for dry cows. Feed supplementation has also a major impact on N balances. For every supplementation of 10% of the daily N requirement, the N removal will decrease 11.5% for unbred heifers, 12.0% for bred heifers, and 13.0% for dry cows.

Forage productivity or biomass accumulation has a moderate impact on nitrogen balance. Changes in forage production are translated to the same proportion of changes in the N balance.

Volatilization of N to the air has a moderate-low impact on N balance: The more N that is volatilized the more negative the N balance is. For every 10% change in N volatilization, the N balance change is about 3% for unbred heifers, 4% for bred heifers, and 6% for dry cows.

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<http://animalscience-extension.tamu.edu/dairy/wdn.html>

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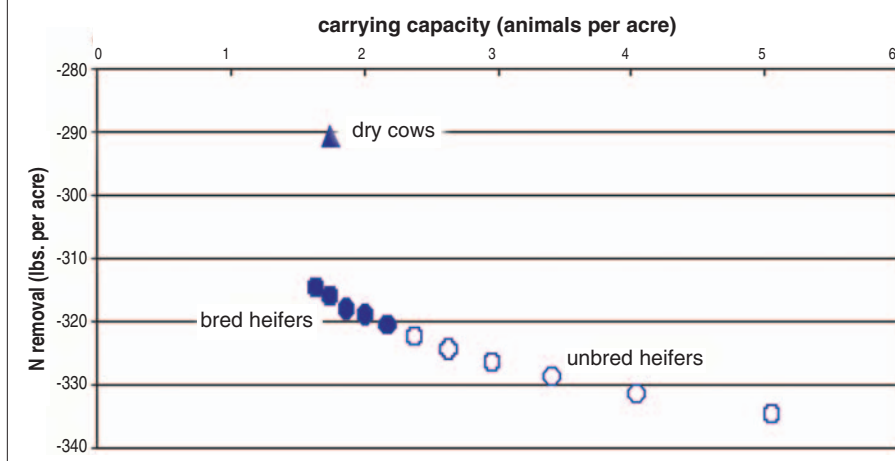
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Nitrogen Budget for Cool Season Grasses for Dairy Heifers and Dry Cows													
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Dairy	Permit #						Period	10/1/2006		to	4/1/2007		
Weight (lbs)	DMI	CP intake	N intake	N excretion	N remain	Net Balance	Carrying Capacity (CC) animals/acre	Grazing Management					
	ADG (lbs)	%CP Grass	(lbs/day/animal)		% Volat.	DM (tons/acre)		Animals (#)	Days (#)	Acres (#)	N Supplement (lbs/day/animal)	N removal lbs/acre	Exceeds CC?
Heifers													
Unbred													
330	9.89	2.62	0.32	0.10	0.05	-0.27	5.1	400	150	100	0.10	-160.91	NO
440	12.36	3.28	0.52	0.14	0.07	-0.46	4.0						
550	14.68	3.89	0.62	0.17	0.09	-0.54	3.4	10	5	1		-26.87	YES
660	16.89	4.47	0.72	0.20	0.10	-0.61	3.0						
770	18.99	5.03	0.81	0.24	0.12	-0.69	2.6						
880	21.02	5.57	0.89	0.27	0.14	-0.75	2.4						
Bred													
990	22.99	6.09	0.97	0.31	0.15	-0.82	2.2						
1100	24.90	6.60	1.06	0.34	0.17	-0.89	2.0						
1200	26.76	7.09	1.13	0.37	0.19	-0.95	1.9						
1320	28.59	7.58	1.21	0.41	0.20	-1.01	1.7						
1430	30.37	8.05	1.29	0.44	0.22	-1.07	1.6	40	95	10		-405.07	YES
Dry													
	%BW												
1600	1.8	28.80	7.63	0.72	0.58	0.29	1.7	300	120	200	0.5	-77.96	NO
Total											-670.81	PRINT	

Figure 2. The Grazing-N application. Source: <http://dairy.nmsu.edu:Tools>

Figure 1. Removal of N for different groups of heifers and dry cows at maximum carrying capacity for a period of 180 days.



Note: Live body weights (LBW) of unbred heifers are: 330, 440, 550, 660, 770, and 880 lbs; LBW of bred heifers are 990, 1100, 1200, 1320, and 1430 lbs; LBW of dry cows is 1600 lbs; average daily gain (ADG) of heifers is 1.98 lbs/day; dry matter intake (DMI) of dry cows is 28.8 lbs; crude protein (CP) of forage is 26.5%; N volatilized is 50%; and dry matter (DM) forage yield is 0.75 tons/acre/month.

Changes in DMI result only in marginal changes in the predicted N balances. For heifers, a change on ADG from 1.1 to 2.4 lbs/animal/day results in only a 0.34% N balance change for 330-lb. unbred heifers and only a 0.02% for 1430-lb. bred heifers; for dry cows, a change from 1.8 to 2.1% of DMI results in only a 4.34% change in N balance.

How can I customize and perform my own calculations?

You can use the Grazing-N, a spreadsheet created by the New Mexico State University Dairy Extension Program. The Grazing-N is a user-friendly application, freely, and openly available at <http://dairy.nmsu.edu:Tools> (Figure 2). The Grazing-N uses all the rationale described above to perform nitrogen balances on intensively managed grazing systems to user-defined parameters.

The Grazing-N has two files associated with it. One file is a user-guide of how to use the application and the other is a document that describes in detail all parameters and calculations used in the application. Both documents can also be downloaded at: <http://dairy.nmsu.edu:Publications>. For more information contact Victor E. Cabrera at 505-985-2292 x107, or by e-mail at vcabrera@nmsu.edu