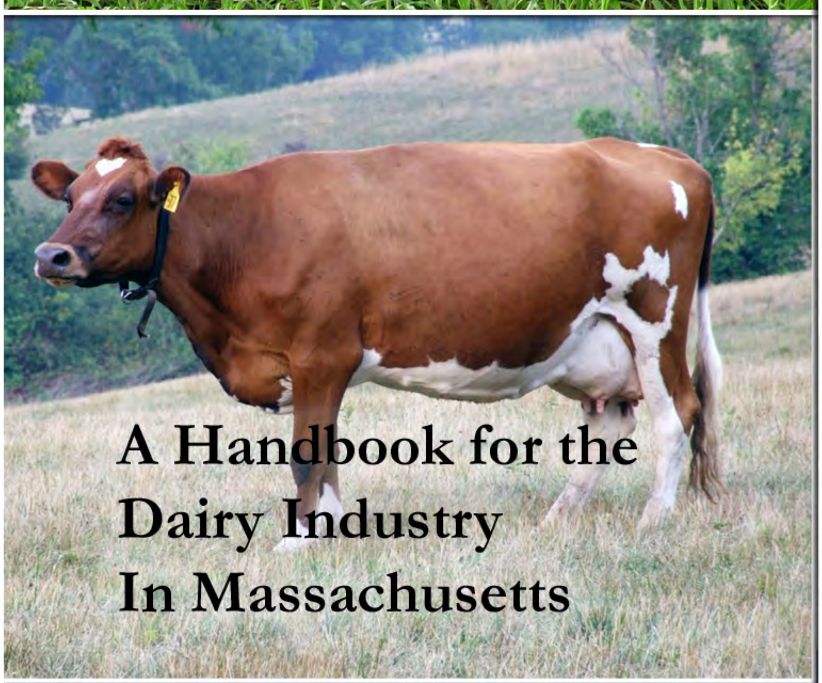
Dairy BMPs



A Handbook for the Dairy Industry In Massachusetts

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The Following Best Management Practices (BMPs) have been compiled by the University of Massachusetts Amherst Extension Crops, Dairy, Livestock, and Equine Team to represent standardized methods, techniques, and practices to help enhance Massachusetts dairy farming operations. BMPs refer to farming operations which provide efficient and effective use of resources, greatest economic returns, and the safest practices for workers and consumers, while reducing environmental impacts. There are many factors that impact one's choice to implement a BMP and therefore, depending on your farm situation, these practices should be adapted to best fit the farm's needs. By adhering to the recommendations stated within each BMP, dairy farmers are ensuring improvements to their farm operation. Each BMP provides practical and effective structural and non-structural information that may help to streamline the operation. A thorough understanding of the information provided in each factsheet is crucial for the successful application of each BMP. We encourage all dairy farmers use this handbook as a guideline and strive to utilize the most effective BMP for your farm. Your management choices will help to sustain the future of Massachusetts dairy farming by utilizing the most environmentally, economically profitable, and safest farming operations possible.

Acknowledgements
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Additional Resource Materials

Snieckus, Robert E. Ed. 2002. Dairy Environmental Handbook; Best Management Practices for Dairy Producers . National Milk Producers Federation. Arlington,VA. 175p. http://www.nmpf.org/publications/dairy_handbook

Burke, A, Dennis. 2001. Dairy Waste Anaerobic Digestion Handbook. Options for Recovering Beneficial Products. 57p. http://www.makingenergy.com/Dairy%20Waste%20Handbook.pdf.

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Basics of Pasture Management

Introduction

Pastures are a good source of forage and nutrients for dairy cattle. However, pasture management must emphasize utilization of all feed grown. The availability and quality of pasture forage consumed directly influences milk production. Cows are very selective in their grazing habits, first choosing tender young plants, which are easily eaten and most palatable. Furthermore, cows prefer to graze the top part of the plants consuming the leaves before the stems. Productivity of dairy cows as individuals and productivity on a per unit area basis both originate from the combined effects of (i) pasture species efficiency in capturing solar energy (sunlight), (ii) efficiency in forage harvested by the cow(s), and (iii) efficiency in conversion of the forage into animal growth or milk production.

The availability and quality of pasture forage consumed directly influences milk production.

Sufficiently high stocking rates are necessary to graze the whole area of a paddock.
Poor utilization results in selective overgrazing of the most palatable species, wasted feed, poor regrowth, and opening up of the sward with establishment of weeds. Continuous heavy grazing causes a reduction in legumes because of reduced energy reserves in legumes. High producing pasture species, on productive soils, have highest production with rotational grazing that allows a resting period for forage growth, and full recovery of reserves for regrowth. When growth is slower, the recovery period between grazings is lengthened.

The length of the rest period between grazings must be varied.
The rest period may be only 12-15 days after grazing in mid-April, but should be lengthened to 30-36 days after grazing in late August (Table 1). To be able to manage pastures and to provide animal-free rest periods there must be a sufficient number of paddocks. This is illustrated in Table 2 with the number of paddocks required at the season's end. Earlier in the season when rest periods are shorter fewer paddocks would be needed to complete one rotation of grazing. Surplus forage from paddocks not included in this first grazing may be harvested as haylage or hay, thus conserving feed for winter. Too often dairy farmers in New England adopt a modified version of set stocking or lax form of rotational grazing. With set stocking there is difficulty in matching feed supply to animal requirements and as a result many farmers under-stock continuously grazed areas.

To be able to manage pastures and to provide animal-free rest periods there must be a sufficient number of paddocks.

Table 1. Length of Rest Period.

Mid-Apr to mid-May	12-15 days
June 1	24
July 1	24
August 1	30
September 1	30-36

Table 2. Number of paddocks needed for a 36 day rest period.

Days Grazing	Number of Paddocks
½	73
1	37
2	19
3	13

Productivity of pastures is influenced by the availability of a soil nitrogen source.
This most economically can be provided by legumes fixing atmospheric nitrogen in root nodules. Fertility and grazing management must be designed to promote the growth and persistence of legumes in mixed grass and legume pastures. Other soil nutrients also must be in balance and are best checked by using a soil test.
Forage availability needs to be maintained to allow cows to produce milk to their fullest potential. When forage availability decreases, milk production decreases.

Therefore, it is crucial to maintain a good nutritious stand of pasture species.

Table 3. Guide for managing forage species and mixtures.

Species	Continuous grazing average height of pasture	Rotational grazing heights Before	After
	----------------- inches or stage	-----------------	
Bluegrass-white clover	2 to 3	4 to 6	1 to 2
Perennial Ryegrass	2 to 3	4 to 6	1 to 2
Orchardgrass-ladino clover	3.5 to 5	7 to 10	2 to 4
Alfalfa	N/R[1]	bud[2]	2 to 3
Alfalfa-grass	N/R	bud	3 to 4
Red clover	N/R	bud	2 to 3
Red clover-grass	N/R	bud	2 to 4
Birdsfoot trefoil	3.5 to 5	bud[3]	3 to 4
Birdsfoot trefoil-grass	3.5 to 5	10 to 12	3 to 4

N/R - not recommended to graze continuously
[2] Allow alfalfa to go to first flower at least once during the summer
[3] To replenish the stand, allow trefoil to go to seed once every two years

Correct height of grazing of varies with species. Continually grazing tall growing species such as orchardgrass to one inch will depress yield and cause a decline in plant vigor because of low residual leaf area and because tillers that store energy for regrowth are also partially grazed. Such management of alfalfa, which depends on the root reserves for regrowth, would soon lead to a stand decline, both in vigor and number of plants. Shorter growing species such as white clover, Kentucky bluegrass and perennial ryegrass can withstand grazing to one inch (Table 3). For legume-grass mixtures, light grazing over a prolonged period may lead to a reduction in legumes because of competitive growth of the grass. Continuous heavy grazing may also cause a reduction in energy reserves in roots that are needed for regrowth. Rotational grazing, with a short grazing period followed by an adequate regrowth between grazings, will promote persistence of legumes, and increase growth and quality of grasses. It may also increase profitability of the dairy farm enterprise.

Maintaining an adequate quantity of available pasture will influence dairy cow performance. If overgrazed cows cannot consume sufficient forage while undergrazing leads to much wasted feed through plant avoidance and trampling.

A well-managed pasture can provide enough energy and protein to support a cow producing 35 pounds to 45 pounds of milk with no little or no additional supplementations. In contrast, early lactation and higher-producing cows need additional grain to balance their diet. According to a study at Penn State, Holsteins producing more than 60 pounds of milk by consuming good quality pasture should be supplemented with 1 pound of grain per 4 pounds of milk. Mineral concentrate should also be feed. Generally, 12 pounds to 20 pounds of concentrate are fed to cows on pasture, when it is their only forge.

Other Considerations

Adequate fencing is needed to control cattle being managed particularly for rotational grazing. The age of cow and temperament will dictate the style and needed strength of the fence. There are many fencing options including permanent multi-strand high-tensile boundary fences, with or without being electrified, where reliability in containing animals is essential. The other extreme is a temporary single electrified polywire fence which is movable depending on size of paddock needed for grazing. Electrified tape and rope are sometimes used for making fences more visible.

Dairy cows also need access to water. On average a dairy cow requires 20 gallons of water daily. Research has shown that as the distance to the water source increases above 900ft the amount of pasture forage decreases. Access to water is needed in each pasture. If cows have to travel back to a centralized water tank near the barn then they are less likely to return to the pasture to continue grazing. Nutrient transfer is also influenced by location or portability of water.

As with any feed changes, adapt cows to pasture slowly. If sudden changes are made, cows may stop eating, thereby ceasing lactation. Bloat can also occur when heavily grazing legumes, such as clover and alfalfa. It is suggested to feed hay prior to turning out when bloat is considered to be a potential problem, or place Bloat Guard (poloxalene), a commercial surfactant, (powder) in the grain, water, or mineral premix or a solid block in the pasture field near the water source(s).

Resources

Amaral-Philips, D., R. Hemken, J. Henning, and L. Turner. *Pasture for Dairy Cattle: Challenges and Opportunities.* ASC-151. http://www.ca.uky.edu/agc/pubs/asc/asc151/asc151.pdf

Penn State Agronomy Guide. 2011-2012. Section 8: Pastures.http://extension.psu.edu/agronomy-guide/cm/sec8/sec810

For more information visit www.umass.edu/cdl

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Guidelines for Reseeding Pastures

Quick Guidelines to a Better Pasture Seeding:

1. **Set goals and make a plan.**
2. **Test your soils.**
3. **Choose appropriate mixture for cows.**
4. **Determine seeding rate.**
5. **Calculate fertilizer and lime requirements.**
6. **Know your weeds and manage before planting.**

Alfalfa can be pastured with careful management, however, it is autotoxic, and thus it can't be seeded into an existing stand of alfalfa.

Introduction

A productive pasture is contingent upon a good plan, careful management, and clear goals. Reseeding can be necessary to increase nutritional needs of the dairy herd, eradicate weeds, fill in bare spots, and improve the stand after disease problems or poor management. It is important to determine the reason behind the need for reseeding. For example, if perennial weeds caused a significant reduction in the stand then the weeds must be controlled before reseeding. Similarly, if soil pH or nutrient status is low then these parameters need to be corrected. Successful reseeding depends on several factors; field characteristics, soil fertility, time of seeding, plant species selection, development stage of dairy cow, and grazing management style. A plant's adaptation to the pasture depends on winter hardiness as well as soil type, drainage, fertility, and pH. If all of these factors are considered and managed accordingly, then your pasture forage can provide all the nutritional requirements for your grazing animals. A healthy pasture means healthier dairy cows with better nutrition and fewer diseases and parasites.

Site Selection

The topography of the land, such as terraces or sloped and shallow areas and soil water holding capacity, greatly affect the success of seeding by limiting equipment access and the application of amendments. Soil characteristics will often differ with the contour of the land, influencing the growth habits of the plant species in the pasture.

Soil Fertility

Soil should be tested to determine pH, and fertility. Soil samples may be sent to the UMass Amherst Soil Lab to be analyzed (http://www.umass.edu/plsoils/soiltest/).

In pastures, the optimal pH range is 6.5-7.0. Add lime according to your soil test prior to seeding. Incorporation of lime is better for the reaction of lime in soil since time is needed for a significant change. It is recommended that lime be added 6 months to a year before the desired change in soil pH. Exploration of the soil for nutrients by pasture plants is confined mostly to the root zone in the surface 6-8 inches of soil depth. Certain nutrients (P and Ca) do not move much in soil and correction of these nutrients with fertilizer, manure and lime is best done before seeding. Land with varying contours should have multiple soil tests to reflect the differing land forms and subsequent management areas.

Choosing the Best Mixture

The most productive and highest quality pastures are those that contain a mixture of grass species with one or more legume species. When selecting species for pasture, it is important to understand both grass and legume growths habits and match them to the soil characteristics and climate. Fields have differing soil types, thus planting the same mixture in each field is not advised.

The following factors will influence your choice in forage species:

- The type and age of livestock to be grazed
- The time of year desired for pasture availability
- The seasonal distribution of pasture growth
- Soil type, drainage, water holding capacity, fertility, and pH

There are two categories of forage species: cool season and warm season species. Cool season pasture species adapted to Massachusetts include orchardgrass, perennial ryegrass, Kentucky bluegrass, white clover, red clover, and alfalfa. Warm season species are not usually pastured in Massachusetts because of late growth and lower quality compared to cool season species. Some cool season species, such as alfalfa, red clover and reed canarygrass are more active in the summer. While a good summer pasture grass, reed canarygrass, has been placed on the invasive species list and therefore, cannot be seeded in Massachusetts.

Legumes- provide much protein and compliment grasses improving the quality of the pasture. Legumes also add nitrogen to the soil nitrogen fixing bacteria making it indirectly available to grasses. Clover can add 90-140 lbs N/ac/yr. In order for N fixation to occur, the legume seed must be inoculated with the correct bacteria, or it must be seeded into a previously inoculated field. White clover also called ladino clover is the the best adapted legume for grazing. Alfalfa can be grazed but must be managed similar to a hay crop. All clovers and alfalfa may cause bloat in cows, so they should not be seeded alone for grazing.

Grasses- provide roughage for cows by increasing their fiber intake. Adequate fiber is needed by lactating cows, however, if grasses are permitted to flower in spring they will become fibrous resulting in reduced animal intake and growth. Grasses are either sod forming or bunch types. Sod forming and those that form many tillers compete better with weeds. Orchardgrass is the most productive and gives early pasture. It is a bunch grass and requires aggressive management in spring. Kentucky bluegrass is a sod forming grass with early production but may go dormant in hot summers. Perennial ryegrass is the most palatable grass but some varieties may be winterkilled.

Methods of Planting

There are several different seeding methods, but the objective for each is always the same: obtain good seed to soil contact. This helps to ensure that the seed will germinate in a timely manner. Consider the erosion potential on every field and choose the appropriate planting method. In general, the heavier the soil and higher the moisture content, the shallower the seed should be planted. In contrast, the lighter the soil and the lower the moisture content, the deeper the seed should planted.

Minimum- Tillage- Tilling of soil allows for aeration, lessening of compaction, elimination of existing vegetation and residues, incorporation of lime and fertilizer into the soil, and to provide a smooth surface for seeding and the occasional hay harvest. A disk, field cultivator, or other tillage implement can be used although a plow may be needed to destroy the existing sod. Take care not to overwork the soil thereby destroying the soil structure. The most common seeders used are cultipacker seeder and a drill.

No-till- Helps to reduce soil erosion, conserve soil moisture, and reduces fuel and labor requirements. Soil pH must be corrected and existing vegetation must be controlled. Specialized no-till drills are needed for precise seed placement in soil. No-till performs best on sandy or silt loam soils.

"Frost Seeding" can be utilized from February till late March. The alternate thawing and freezing of the soil with the addition of rain will help incorporate the seed into the soil. Legumes, in particular, red clover, are the best choice for frost seeding. Grasses are difficult to frost seed.

Seeding Rate

The rate at which you seed depends on the species being planted, method and time of planting, climate conditions, type and number of grazing animals (stocking density), and intent of reseeding. If using coated seed, the planter may need to be recalibrated to account for the extra weight. Many companies sell seed as blends of several species and the usual seeding rate of a premixed blend is 25 lbs/acre. For recommended seeding rates of individual species see the Natural Resources Conservation Service (NRCS) Specification Guide Sheet for Pasture and Hay Planting (512) below in the Resources section.

Time of Seeding

- **Late winter/early spring-** is a difficult time to re-seed a pasture because of existing vegetation and weed competition in spring. Legumes can be frost seeded into an existing stand of grass but existing vegetation must be controlled.

- **Late summer/early fall-** is considered the best time to seed if a blend of species will be planted. When seeding late in the summer, soil moisture tends to become an issue but weeds are less competitive. Time your seeding accordingly so that soil moisture is available. This is also the best time to no-till.

Management During Establishment

A strong root system must be established prior to grazing. The roots systems in perennial forages are where food reserves are stored. If the roots are not strong enough, then animals may dislodge plants during grazing and there may not be enough reserves stored in the roots for the plant to survive winter. Practices to follow are:

- Never graze new stands during wet periods, especially on tilled fields.
- Test for root development by grasping a handful of desired plant material and tugging on it. If it is easily uprooted, then the root system is not sufficiently established and more growth should be allowed.
- Graze only when soil surface is firm and dry.
- Do not graze plants lower than 3-4 inches.
- Follow rotational or intensive grazing management practices for efficient use of pastures. After grazing, pastures should rest for a period of 24-30 days depending on the growth of the pasture plants.

Weed Control

Controlling weeds in newly seeded pastures is one of the most important aspects of pasture establishment. Weeds are considered "opportunistic invaders" such that if given the space, they will grow. Therefore, proper species selection and seeding rate will help to decrease the possibility of weeds.

- Increase seeding rate if weeds are expected.
- Apply broad spectrum herbicides, prior to no-till seeding to control existing vegetation.
- Grow a companion crop such as oat to help prevent weed growth in spring.
- Rotationally graze and mow or clip pastures if needed to remove seedheads and ungrazed excessive growth. Never let weeds go to seed.
- Mowing- is a good weed management practice because it suppresses weeds, promotes uniform grazing, and removes pasture plants of low palatability. Do not mow too early. If preformed too early, only the tops of the weeds will be eradicated, leaving the active buds, which will produce new growth. Mow pastures to a height of at least 3-4 inches, not lower.

Conclusion

Evaluate all pastures on a consistent basis to ensure proper management and that nutritional requirements of the dairy herd are being met. Adopting practical and environmental management techniques will ensure productive and healthy pastures for a long time.

Resources

Barnhart, S. 2002. *Improving Pasture by Frost Seeding.* Iowa State University Cooperative Extension Service. PM856. <http://www.extension.iastate.edu/Publications/PM856.pdf >.

Lewandowski, R. 2008. *Tips to Put Damaged Pastures Back into Production*. Ohio State University Cooperative Extension Service. <http://www.ag.ohio-state.edu/~news/story.php?id=4560>.

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Myer, D. and G. Triplett. *No- Tillage Forage Seeding into Sod*. Ohio State University Cooperative Extension. Service AGF-002-92. <http://ohioline.osu.edu/agf-fact/0002.html>.

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Managing Weeds in Pastures

The best defense against weeds in a dairy pasture is a dense, healthy sward of desirable pasture species

All poisonous plant problems are weed problems but not all weed problems are poisonous plant problems.

Introduction

Weeds are the most common pests of pastures. Weeds can invade pastures resulting in a reduction of both pasture quality and quantity. Several weeds have good nutritional value, however when compared with pasture grasses and other desirable forages, weeds have low recovery potential after summer stress and wear, are low in productivity, and do not provide winter cover. Weeds are strong competitors and can cause pasture renovation and establishment projects to fail. Some weeds such as wild garlic or field garlic (*Allium vineale*) and garlic mustard (*Alliaria petiolata*) when grazed by dairy animals can taint milk by imparting an unpleasant odor and/or taste. Some weeds can be poisonous to livestock and, under certain circumstances, can result in animal sickness or death. While poisonous plants can be a serious problem, avoid the temptation to view poisonous plants as poisonous plant problem and think of them as what they truly are, that being a weed problem. In other words, all poisonous plant problems are weed problems but not all weed problems are poisonous plant problems.

Pasture Scouting

The first step in the development of a pasture weed management program is to scout and identify all weed species in a pasture. Scouting of pastures and areas adjacent to pastures should be conducted on a regular basis. Pasture managers should get into the habit of scouting for weeds every time they are in the pasture. At a minimum, scouting should be done monthly during the growing season. Special attention should be given to those weeds that might be new in a pasture or those that are potentially toxic. All weeds should be correctly identified and recorded. The life cycle of each weed should also be determined and recorded. Regular scouting and accurate weed identification enables a pasture manager to plan and implement appropriate management strategies and evaluate the long-term effectiveness of those strategies.

Cultural Practices

The best defense against weeds in a dairy pasture is a dense, healthy sward of desirable pasture species. The growth habit and vigor of many pasture grasses and forage species make them well-suited to compete effectively with many weeds. In order for pasture species to reach their peak competitive advantage against weeds certain requirements need to be met. Soil fertility including soil pH should be corrected based on the soil test to insure pasture growth and productivity. Grazing frequency and intensity is another critical factor in the ability of pasture species to remain competitive against weeds. The amount of forage available can vary greatly and is affected by many factors including pasture species and vigor, pasture age, soil and environmental conditions and number of livestock being grazed. While horses are closer grazers than sheep, goats or dairy and beef cattle, if the frequency and intensity of grazing in not managed properly all animals have the potential to overgraze a specific pasture and increase the likelihood of weed infestations. The presence of summer or winter annual weeds in a pasture is a good indication the pasture is being over-grazed. Summer annual weeds might include smartweed, crabgrass, pigweed, common lambsquarters, yellow or giant foxtail, fall panicum and common ragweed. Winter annual weeds may include common chickweed, henbit, shepardspurse, annual bluegrass and purple deadnettle. When annual weeds occur in pastures, mowing can be an effective strategy to prevent these weeds from setting seed. The potential for over-grazing should be decreased through the development and use of a rotational grazing program in conjunction with correct animal to pasture ratios. Pastures that are under-grazed may also become weed infested. Lax grazing allows animals to be selective and often means over-grazing the more palatable species and opening up the pasture for less palatable weeds. Managing the pasture so that it is grazed evenly helps to eliminate the animal's ability to be selective in grazing. The use of a rotational grazing program, where pastures are permanently or temporary subdivided, can be used to adjust the size of the area provided for grazing. Neglect or poorly implemented cultural practices as well as over- and under-grazing can cause a pasture to become infested with weeds. In some instances, weeds may increase to a point where they comprise more than half of the vegetation in a pasture. At this time a pasture manager should consider renovating the pasture. Pasture renovation, while somewhat costly and time consuming, can be an effective and appropriate solution to many weed problems and in the long run result in a significant increase in the quality and quantity of pasture available for grazing. Prior to seeding, the pasture should be treated with glyphosate to control existing weeds especially those perennials which have the ability to propagate vegetatively. Products that contain glyphosate alone should be used. Renovation is best conducted in late summer through very early fall. Proper selection of pasture species and cultivars is a critical step in pasture renovation. Pasture species and cultivars that are best adapted to the type of grazing and site conditions will provide the best weed control.

Herbicide Applications

Pasture managers who routinely monitor their pasture and take the necessary action can prevent and reduce the chances that a pasture will become heavily infested with weeds. Although management plans that make the necessary adjustments in pasture species and cultivars, grazing habits and soil fertility can significantly reduce weeds in a pasture, pasture managers will from time to time need to consider the use of an herbicide. Herbicide applications are most commonly needed to control broadleaf, perennial weeds. Postemergent broadleaf herbicides for pastures selectively remove broadleaf weeds such as smooth bedstraw or wild madder (*Galium mollugo*), dandelion (*Taraxacum officinale*), curly dock (*Rumex crispus*), horsenettle (*Solanum carolinense*) and Canada thistle (*Cirsium arvense*) but will not injure or kill pasture grasses. These products may be a single herbicide or a combination of two and sometimes three different herbicides. The best time to apply these products is late summer and early fall, however any time in the growing season can be effective as long as the pasture species and weeds are not under moisture and/or high temperature stress. Read and follow the product label. Some products have grazing restrictions and animals must be removed from treated area for a specific amount of time. These grazing restriction periods may range from as little as "no restriction" to as much as the "next growing season" if lactating animals are to be grazed in treated areas. Grazing restriction can be found on the herbicide product label. Many pasture managers find it easier and more economical to hire a custom application company to make herbicide applications to their pastures.

Summary

On a final note, pasture managers should adopt an integrated approach when attempting to manage pasture weeds and improve both the quantity and quality of pasture available for grazing. All strategies and practices that have the potential to decrease weed growth in a pasture should be included in a weed management program. There is little, if any, agronomic or economic benefit in attempting to control weeds with herbicides if problems related to the frequency and intensity of grazing, poor soil fertility, and poorly adapted pasture species/cultivars are not corrected beforehand.

Resources

UMass Extension Weed Herbarium. http://www.umassgreeninfo.org/fact_sheets/weed_herbarium/common_name_list.htm

Herbicide Manual for Agricultural Professionals. "Weed Management in Small Grains,
Forage Legumes, and Pastures." 2004. www.weeds.iastate.edu/reference/wc92/WC92.../SmGrainsForPast.pdf

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Dairy Cow Stocking Rates

Overgrazing leads to environmental problems:

- **Water contamination**
- **Soil compaction**
- **Erosion**
- **Weed problems**

Undergrazing also causes problems:

- **Increased need for mowing**
- **Spread of less desirable plant species**

Livestock on pasture:

- **Stocking Rate describes how much livestock a farm can accommodate given pasture availability.**
- **Animal Density describes concentration of animals on a given pasture at a given time.**

Introduction

Pasture quality is affected by soil and water availability, as well as the mix of plant species. Animal species, size, and health, as well as animal density will influence pasture vigor. Overgrazing leads to a number of environmental problems, including surface and groundwater contamination by nitrogen and phosphorus found in animal urine and feces, soil compaction, weed problems, and erosion in areas where plant material has been largely or entirely destroyed.

Pasture Mix Selection

A mix of grasses and legumes provides the best pasture quality. Legumes give the benefits of high protein and superior palatability, as well as adding nitrogen to the soil. Grasses add roughage, grow rapidly and have high yield. A mix of species also ensures that when one is not growing well, another will. 'Cool season' grasses do best in cool, wet weather, while 'warm season' grasses grow when it is hot and drier. Sod-forming grasses such as Kentucky Bluegrass will stand up to trampling better than bunching grasses such as Timothy. Appropriate pasture management practices usually improve a poor pasture without the need to resort to total reseeding. A poorly growing weedy pasture will support fewer animals than a healthy pasture containing a variety of nutritious grasses and legumes.

Rotational Grazing

It is important that all pastures be given some "rest" time. Ideally, animals would begin grazing a pasture when plants are 6 to 10 inches tall and be removed when plants are no less than 3 inches tall. These heights are somewhat dependent on forage species. The vegetative period of growth of a species is the ideal time for grazing. Overgrazing can cause muddy conditions and soil erosion, killing desired pasture species and allowing for the introduction of weeds that tolerate compacted soils. On hilly land especially, rainwater runoff high in nutrients from animal feces and sediment will cause downstream pollution. Undergrazing is also undesirable as animals are likely to graze selectively, allowing less desirable plants to outcompete desired ones. Undergrazed pastures require more frequent mowing to keep undesirable plants in check, and especially to keep those plants from going to seed and spreading further. Subdividing pasture and rotating animals encourages livestock to eat a wider variety of plants. To maximize grazing efficiency, use a very high animal density for a very short time (intensive grazing). In a large pasture, animals have more grazing options and can be very choosy in plant selection. Pastures will recover when animals are moved elsewhere, and when necessary, mowing can be used to eliminate tall weeds when animals are moved out. Ideally, at least four pastures should be considered in rotational grazing. Pasture recovery typically takes from 2 to 6 weeks. Rainfall, temperature, soil fertility, and grazing intensity influence rate of pasture recovery.

Water for Growing Forage

Annual and seasonal rainfall patterns affect pasture growth, potential soil erosion and runoff problems. In general, greater rainfall during the growing season means more pasture growth. Most areas in Massachusetts receive about 45 inches of precipitation annually. Variations in soil water holding capacity based on texture, structure, and depth generally have more effect on pasture growth variation within the state than rainfall variation does.

On average, rainfall does not vary much among the grazing months of May through October. However, light intensity and duration as well as temperature variation influences growth of pasture plants. Excessive heat causes drying conditions. Pastures require constant monitoring.

Water for Drinking

Drinking water access is an important consideration in creating pasture subdivisions. It is most convenient not to move watering facilities, but rather to subdivide pasture such that the same watering facility can be accessed from several pastures. The down side of this is that animals will always be gathering in a single area which may lead to muddy conditions. If the area is not flat, soil erosion and nutrient runoff will also occur. A wheeled watering unit makes it easier to move the water and reduce mud. Note that if livestock are watered at a stream, and drink from the same location for extended periods, this can lead to mud and erosion problems as well as downstream pollution. Regular watering of animals at streams is almost never appropriate.

Stocking Rates

USDA defines one thousand pounds of live weight as one animal unit (AU). Animal Density (AD) is defined as (AU)/grazed acre. Stocking Rate is a function of animal density including consideration of percentage of the time the animals are on the pasture. A general starting ratio for stocking is 0.5 (500lbs of animal grazing per acre). A Jersey cow might be as much as one animal unit (1000 lb), so 2 acres of "average" pasture would be recommended per cow. Five to fifteen sheep or goats might also constitute one AU. Specific starting points for stocking rate vary according to the quality of the pasture. For example, 20 acres of "average" pastureland could support ten 1000 pound cows at a stocking rate of 0.5. Subdividing the 20 acres into four-5 acre pastures, rotating the pastures, and maintaining them well, would allow you to keep more than 10 cows on these pastures. Rotating 12 such cows on four 5 acre pastures would give an Animal Density of 2.4, with an overall stocking rate of 0.6 since the cows are only grazing a pasture ¼ of the time. Note that animal density should be much higher than 0.5 if animals are only grazing the pasture a fraction of the time. Use the following table to help adjust stocking rates to your own situation.

Decrease stocking rate if:	**Increase stocking rate if:**
Poor pasture quality	Excellent pasture quality
No pasture rotation	Rotating several pastures
Stony, ledgy hillside soils	Well fertilized land with low erosion potential
Regrowth is abnormally slow	Animals are given supplemental feed
Low rainfall or excessively drained (i.e. dry) area	Animals are avoiding species you would like them to eat

In general the higher the AD, the more intensive the pasture management required.

In order to preserve pastures, there are times when livestock should be removed. When the soil is wet, as it is for a period every spring, and livestock are outdoors, it is necessary to have an area which is well drained and flat for them to stay. This is often called a "sacrifice area" because plant growth in this area has been sacrificed. This area should be convenient to water and shelter. A small sacrifice area can save a large pasture.

Resources

Rainfall data: Massachusetts Department of Conservation and Recreation www.mass.gov/dcr/

Massachusetts Department of Agriculture Resources. 251 Causeway Street. Suite 500. Boston. MA 02114. Phone (617) 626-1700. Website: www.mass.gov/agr

USDA Economic Research Service www.ers.usda.gov/

New England Small Farm Institute www.smallfarm.org/uploads/uploads/Files/Stocking Rates.pdf suggests a stocking rate of 1 acre rather than 2 acres per one animal unit (1000 lbs). This assumes well managed pasture on high quality pasture land.

For more information visit www.umass.edu/cdl

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Conservation Tillage Systems

Conservation tillage:

1. Reduces erosion.
2. Builds up soil organic matter.
3. Reduces tractor miles.
4. Improves plant rooting through reduced soil compaction.

Introduction

Conservation tillage is defined as an agricultural cropping system in which residue from current year's harvest is left in the field. The following year's crop is planted within or around the residue in one of a number of systems discussed below. Conservation tillage greatly reduces erosion and runoff from rain and snow melt. Less soil loss from wind is also a benefit. In general, there will be fewer tractor drives over the field than under conventional tillage, thus reducing soil compaction, as well as time, energy, and tractor wear. Reduced compaction allows roots to spread more easily. Over time organic matter is built up in the soil. In most cases weeds are controlled by herbicides.

No till and strip till: In no till systems the crop is planted directly into the previous year's residue, while in strip till systems a narrow strip (approximately 6-10 inches wide) which will become the seed bed is cultivated. Strips may be tilled in either fall or spring, though fall tillage is preferred as it can aid in earlier soil warming in the spring.

Ridge till: In ridge till systems, permanent ridges 4-6 inches high are established and maintained using specialized equipment. Residue is cleared from the ridges to allow planting.

Mulch till: Mulch till is a catch-all term for other reduced tillage systems in which at least a third of the crop residue is left on the field following harvest.

Deep zone tillage

Deep zone tillage is considered a form of conservation tillage when crop residue is present. A reason for using deep zone tillage is to break up the compaction created from farm equipment driven repeatedly over a field. In deep zone tillage, only the zone directly beneath the area to be planted is tilled. Tillage is achieved using very deep (up to 20 inches) tines which break up any hard pack below the surface. A ridge 2-3 inches high is left for planting into. Fertilizer may be banded at planting.

Figure 1. An eager group of farmers watch as the Deep Zone Tiller is demonstrated.

Conservation vs. Conventional Tillage

Differences in practices include planting methods, fertilizer application methods, weed control, and end of season field treatment. If using minimal tillage, as opposed to no till, it is best to plant into a higher ridge, rather than a valley. This is more easily accomplished if the row width remains constant from year to year, or if cultivated strips are used. Specialized no till planters are used for seeding. In general when using conservation tillage all fertilizer should be banded next to the crop rather than broadcast over the entire field. Weed control is nearly always accomplished with use of chemical herbicides. However it is possible to use cover crops such as tillage radish to smother weeds in crop rotations. It is also possible to lay plastic mulches (with modified-for-no-till equipment) for aid in weed control. For conservation tillage to be most effective, the crop residue needs to be chopped into small pieces. This can be accomplished as a part of the combining process for many crops. The following link contains pictures, as well as information comparing conventional and reduced tillage systems, as well as some pointers for those unfamiliar with using reduced tillage.
http://www.extension.umn.edu/distribution/cropsystems/DC8483.html#onfarmres

Resources

Penn State University. Soil Management:Conservation Tillage. http://extension.psu.edu/soil-management/conservation-tillage-information

Rangarajan, A. and B. Leonard. Cornell *Guidelines for Deep Zone Tillage in Vegetable Production*. Cornell University. http://www.vegetables.cornell.edu/reducedtillage/PDFs/Guidelines%20for%20DZT%202010.pdf

The University of Minnesota. USDA/NRCS: http://www.mda.state.mn.us/protecting/conservation/practices/constillage.aspx#Similar

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Transitioning to a Pasture- Based Grazing Operation

Farmers utilizing the pasture-based system have found that cattle have less feet and leg problems, and thus lower culling rates.

Introduction

Transitioning to a pasture-based system can be economically competitive as long as milk production decline is minimized, the cow's nutrient requirements are met and pastures are managed intensively to maintain rumen pH values from 5.8 to 6.2 that will support optimal digestibility, nitrogen flow, and desirable components. If pasture quality is less than 35% NDF and over 80 percent digestibility, rumen pH can drop below 5.8

Farmers utilizing the pasture-based system have found that cattle have less foot and leg problems, and thus lower culling rates.

Importance of Genetics

Selection of the genetics is very important in a pasture-based operation. In the U.S., ninety percent of the cattle genetics are Holsteins. They have been bred for a conventional farm operation and the ability to produce in excess of 20,000 pounds of milk per year. In pasture-based operations, they are looking for a smaller framed animal similar to the Jersey, Guernsey or Ayrshire body type. These breeds can also be cross-bred to add hybrid vigor.

Producing and managing quality pastureland can have a major impact on herd performance and return.

Forage Quality

Pasture quality is also extremely important in a pasture-based operation. Producing and managing quality pastureland can have a major impact on herd performance and return. By establishing the type of pasture needed to meet a herd's nutritional requirements, producers not only protect animal health, but also reduce the cost of veterinarian visits. To determine whether your pasture should be improved, ask yourself, "Are there more weeds than consumable grasses?" If weeds have the upper hand, you probably have lower-quality forage, since the desirable grass is competing with weeds for nutrients and moisture. Also, check for signs of plant disease, which can cause forage quality to decline.

When animals graze, the food choices they make is another forage quality indicator. They naturally tend to choose the highest quality forage available. When they would rather eat the hay you put out than grass growing in the pasture, it's a sign forage quality is low.

Body condition is another criteria to use in measuring forage quality. If you see changes like weight loss or deteriorated body condition, it's a sign of poor nutrition. Unfortunately, at that point it requires a great effort to help those animals recover.

Conventional dairies are often skeptical of switching to pasture-based for fear of lost production and profits, which won't necessarily result. The record grain prices make it increasingly difficult to make money on a grain-based dairy. And, grazing is sustainable. What the cows eat, they later drop as fertilizer. The key is to do your research and be prepared to not expect the high herd average that you did with a conventional grain-based operation

Economics

The Department of Applied Economics and Management at the Cornell University College of Agriculture and Life Sciences has collected and published business summaries for 30-50 NY dairy farmers that make use of Intensive Grazing on their farms. In Table 1 are some of the excerpts from the Dairy Farm Business Summaries (DFBS).

Table 1. Intensive Grazing vs. Confinement Farms: Average 1996-2006*

Item	Grazing Farms	Confinement Farms
Number of cows	91	90
Milk sold/cow	17,025lbs.	18,982lbs.
Operating cost/ cwt	$10.73	$11.40
Total cost/cwt	$16.21	$16.81
Net Farm income/cow	$467	$365
% Return on equity	3.94%	1.18%
Purchased feed+crop exp./cwt	$5.05	$5.29
Veterinary medicine exp./cow	$65	$87
Machinery cost/cow	$509	$591

Summary

Conventional dairies are often skeptical of switching to pasture-based for fear of lost production and profits which isn't necessarily justified. The record grain prices make it increasingly difficult to make money on a grain-based dairy. And, grazing is sustainable. What the cows eat, they later drop as fertilizer. The key is to do your research and be prepared to not expect the high herd average that you did with a conventional grain-based operation.

Resources

Benson, Fay. Hard Times Make for Easy Choices. Graze NY educator with the South Central NY Dairy Team. http://counties.cce.cornell.edu/wyoming/agriculture/pdfs/HardTimesMakeforEasyChoices.pdf

Benson, Geoffrey, A. Journal of International Farm Management. Vol. 4. No.2. February 2008. North Carolina State University. Raleigh, NC http://www.ifmaonline.org/pdf/journals/Vol4_Ed2_Benson.pdf

National Sustainable Agriculture Information Service. 2009. Dairy Production on Pasture: An Introduction to Grass-Based and Seasonal Dairying. http://www.attra.org/attrapub/PDF/grassbaseddairy.pdf

Rayburn, Edward, B. 2006. *Managing and Marketing for Pasture-Based Livestock Production.* Natural Resource, Agriculture, and Engineering Service. http://www.nraes.org/nra_order.taf?_function=detail&pr_booknum=nraes-174

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Calculating Land Base Requirements for Manure Application

The factors which most often limit the amount of manure that can be applied to a cropland are:
- **existing soil fertility levels**
- **manure nutrient content**
- **crop nutrient needs**
- **site limitations, slope**
- **runoff potential**
- **leaching potential**

Introduction

Animal manure should be considered an economical source of crop nutrients. However, applying excess nutrients to a crop field wastes valuable nutrients resulting in possible crop damage suppressing yield and can be harmful to the environment by contaminating surface or ground water. One crucial step in manure management is to understand the capacities of each parcel of land in which manure will be applied for optimal manure utilization. When planning a new operation or expanding an existing operation, enough land area for manure application must be included in the plan.

The factors which most often limit the amount of manure that can be applied to a cropland are the existing soil fertility levels, manure nutrient content, crop nutrient needs, site limitations, slope, runoff potential, and leaching potential. These factors will ensure that enough land area is available in future years to prevent nutrient buildup in the soil beyond suggested agronomic and environmental levels. Nitrogen and phosphorus are usually the limiting nutrients for manure application. All manure contains measurable amounts of both. Applying levels that exceed crop nutrient requirements may lead to nutrients entering surface waters or leaching into ground water. Certain practices including manure incorporation into soil and intensive control of runoff at the application site can minimize environmental impacts from manure application.

If the land base is determined to be inadequate, arrangements must be made to reduce manure production (reduce herd size) or find alternative outlets for manure. Neighbors may own land with poor soils; manure could improve the productivity of these soils. There may also be opportunities to compost manure and sell it to area gardeners and landscapers.

Required information

In order to calculate the required minimum land base, producers will need the following information:

- Number of lactating cows, dry cows, heifers, and calves.
- Average weight of animals.
- Crop type which receives most of the manure.
- N removal by the crop (lbs/acre).
- P2O5 removal by the crop (lbs/acre).

Enter the above values into the following worksheet to find out if sufficient land is available for the amount of manure that is currently generate at your farm.

Land Base Requirement Worksheet

Herd Information

	Average weight (lbs)	Table values (lb N/yr/lb cow)		Nitrogen Excretion (lb N/yr)
Number of lactating cows:_______	x ________	x 0.172	=	____________
Number of dry cows:____________	x ________	x 0.135	=	____________
Number of heifers:______________	x ________	x 0.111	=	____________
Number of calves:_______________	x ________	x 0.120	=	____________
		TOTAL	=	____________

	Average weight (lbs)	Table values (lb P_2O_5/yr/lb cow)		P Excretion (lb P_2O_5/yr)
Number of lactating cows:_______	x ________	x 0.077	=	____________
Number of dry cows:____________	x ________	x 0.045	=	____________
Number of heifers:______________	x ________	x 0.032	=	____________
Number of calves:_______________	x ________	x 0.077	=	____________
		TOTAL	=	____________

Field Information

Crop receiving manure: ________________________ Yield goal:____________

N removal by crop:_____________ (lbs N/acre)

N-based Land Base = $\dfrac{\textit{Total N excretion (lbs/year)}}{\textit{N removal (lbs/acre)}}$ *=_______acres*

P removal by crop:_____________ (lbs P_2O_5/acre)

P-based Land Base = $\dfrac{\textit{Total } P_2O_5 \textit{ excretion (lbs/year)}}{P_2O_5 \textit{ removal (lbs/year)}}$ *=_______acres*

Nutrient Removal by Crops Commonly Grown by Dairy Producers in Massachusetts

Crop	lb N		lb P_2O_5	
Alfalfa Hay	5.6	per ton	15	per ton
Alfalfa Haylage	4.5	per ton	10	per ton
Grass Hay	4.0	per ton	13	per ton
Corn Silage (35% dry matter)	2.2	per ton	5	per ton
Corn Grain	0.9	per bushel	0.4	per bushel

Resources

Davis, J., R. Koenig, and R. Flynn. 2010. *Manure Best Management Practices: A Practical Guide for Dairies in Colorado, Utah, and New Mexico.* Colorado, Utah, and New Mexico Cooperative Extension Servicehttp://extension.usu.edu/files/publications/publication/AG_WM-04.pdf.

Johnson, J., and D. Eckert. *Land Based Application of Animal Manure.* AGF.208-95. Ohio State University Cooperative Extension Service. http://ohioline.osu.edu/agf-fact/0208.html

Lander, C., D. Moffitt, and K. Alt. 1998. *Nutrients Available from Livestock Manure Relative to Crop Growth Requirements.* Natural Resource Conservation Service. http://www.nrcs.usda.gov/technical/NRI/pubs/nlweb.html.

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Grazing of Wetlands in Waterfowl Production Areas in Massachusetts

The purpose for grazing wetlands is not for livestock production or revenue, but rather to economically manage the type and abundance of plants in Waterfowl Protection Areas.

For questions about grazing livestock in a WPA, contact the U.S. Fish and Wildlife Service in Hadley, MA.
northeast@fws.gov

Introduction

Waterfowl Production Areas (WPAs) are wetlands or grasslands critical to waterfowl and other wildlife, acquired pursuant to the Migratory Bird Hunting and Conservation Stamp Act or other statutory authority. The U.S Fish and Wildlife Service oversee the WPAs. The state office is located in Hadley, MA.

Grazing of WPAs is a desirable management practice under the right conditions and objectives. In general, grazing at the right time and amount can cause undesirable plants to decrease and preferred plants to increase. The purpose for grazing wetlands is not for livestock production or revenue, but rather to economically manage the type and abundance of plants in Waterfowl Protection Areas.

Massachusetts Wetlands Protection Act

Prior to grazing animals in wetlands or near waterways, you need to familiarize yourself with the "*The Massachusetts Wetlands Protection Act*" Massachusetts General Laws, Chapter 131, SS 40 which states that any person proposing to "remove, dredge, fill, or alter any bank, fresh water wetland, coastal wetland, beach, dune, flat, marsh, meadow, or swamp bordering on the ocean or on any estuary (a broad mouth of a river into which the tide flows.), creek, river, stream, pond, or lake, or any land under said waters or any land subject to tidal action, coastal storm flowage, or flooding other than in the course of maintaining, repairing or replacing, but not substantially changing or enlarging, an existing and lawfully located structure or facility used in the service of the public and used to provide electric, gas, water, telephone, telegraph and other telecommunication services, without filing written notice of his intention". In order to legally work in any wetland, a person must be conducting a clearly exempt activity, or must obtain a permit known as an Order of Conditions from the local conservation commission

Benefits of Grazing and Laws to Follow

Wetland grazing has been shown to provide desirable plant response. With the right timing and amount of grazing pressure, plants such as reed canarygrass, river bullrush, and cattails can be severely injured. The extensive root systems are literally shredded by the cows' hooves as they move through the wetland. Species such as smartweed, burreed, barnyard grass, spikerush, and other desirable plants can flourish after the undesirable species have been injured or killed. If plant regrowth is limited, the wetland will provide open water during spring and fall migration.

Many cities and towns have adopted local wetland laws that are more restrictive than the State's Wetland Protection Act. Conservation commissions administer local and state laws governing wetlands. They are also responsible for open space planning, and acquisition and maintenance of land set aside for conservation through direct ownership or through conservation restrictions. Applicants must also obtain a list of abutters from the Assessors Office so that the abutters can be notified of the proposed project. The application, called the Notice of Intent (NOI), which describes the type and boundaries of resource areas and the type of work proposed, is submitted by the applicant to the Conservation Commission along with supporting plans. A professional engineer generally must stamp plans. A copy of the NOI is also submitted to the regional office of DEP, which issues a project number for the proposed activity. A legal notice is published in a local newspaper. Upon completion of these steps, the Conservation Commission opens the public hearing of the proposal. If the project is approved or approved with conditions, the Commission has up to 21 days to issue an Order of Conditions (OOC). Abutters, a group of 10 citizens, or the applicant have 10 days to appeal an approval to DEP. If the proposal is denied, the applicant can appeal the decision to DEP. If the project is appealed, MassDEP will issue a Superseding Order of Conditions (SOOC), either confirming or altering the original Order. Forms: WPA Form 3 Notice of Intent at http://www.mass.gov/dep/water/resources/noi.htm

Resources

Massachusetts Association of Conservation Commissions, 10 Juniper Road, Belmont, MA 02478
Phone: 617-489-3930, Email: staff@maccweb.org
Website: http://www.maccweb.org/index.html

Massachusetts Wetlands Protection Act, Massachusetts General Laws, Chapter 131, SS 40, Massachusetts Department of Environmental Protection.http://www.mass.gov/dep/water/laws/ch131s40.pdf . Phone: 617-292-5695

Northeast Regional Office, U.S. Fish and Wildlife Service, 300 Westgate Center Drive, Hadley, MA 01035-9587.
Phone: 413-253-8200. northeast@fws.gov
Website: http://www.fws.gov/northeast/ma.htm

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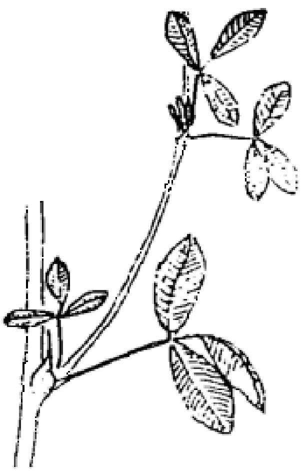
Alfalfa

Description and Adaptation of Alfalfa (*Medicago sativa*)

Origin

Comes from Asia minor, a semi-arid region where insufficient moisture is the chief limiting factor to plant growth. With little or no leaching, soils were neutral in reaction and generally well supplied with minerals. The name "alfalfa" comes from the Arabic language, meaning "best forage". Alfalfa was carried across North Africa and southern Europe to Spain, from Spain to the West Coast of South America, and from there to California about 1850.



Plant Characteristics

Root system - Long, thick, sparsely branched tap root with few small roots. Where soil conditions favor deep rooting, tap root may penetrate 15 to 20 feet. Deep rooting habit (where possible) makes alfalfa a very drought resistant plant. Lack of abundance of small feeding roots may account for part of the difficulty in getting satisfactory inoculation.

Stems - Moderately strong, woody, upright stems are high in fiber. For this reason and others, alfalfa is chiefly a hay and not a pasture plant. Stems arise from a "crown" or part of the plant close to the soil surface. The crown increases in size each year and may measure 12 inches or more in diameter. As a crop of stems begins to flower, new stems or "shoots" start to grow from the crown. This periodic development of new shoots (every four to six weeks during the growing season) explains why alfalfa is so productive. Two, three and even four crops can be harvested in one season. In the Imperial Valley in southern California, ten crops of alfalfa are harvested in one year.

Leaves - These are palatable and nutritious but can be easily lost during drying especially if raked below 40% to 50% moisture.

Flowers - Typically, small "bean" type flowers occur individually. Medicago sativa (alfalfa) has purple flowers; *Medicago falcata* (a trailing, cold resistant species) has yellow flowers. Most cool region varieties have come from *sativa* x *falcata* crosses for winter hardiness. Flower color is "variegated" - from purple to almost white and light yellow.

Soil Adaptation

The soil requirements of alfalfa are exacting. Drainage must be good and high fertility levels must be maintained. A constant supply of available calcium, magnesium, potassium and boron is essential. A pH of 6.5 or above should be maintained.

Diseases and Insects

Alfalfa is plagued with many serious diseases and insect pests in humid regions. Leaf spot diseases are especially serious with first cutting. Several insects, including alfalfa weevil and leafhopper, are potentially serious pests.

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Birdsfoot Trefoil

Description and Adaptation of Birdsfoot Trefoil (*Lotus corniculatus)*

Origin
First cultivated in northern Europe.

Plant Characteristics:

Root system - Strong branched tap root with many smaller roots.

Stems - Relatively small stems arising from a crown semi-erect or upright in growth habit. There is less fiber than in alfalfa or red clover.

Leaves - Palatable and nutritious. Occur alternately either side of the stem. Each is composed of five leaflets, three apical and two basal resembling stipules.

Flower - Large "bean' type yellow and/or orange flowers. "Corniculatus" is from the Latin word meaning 'yellow'.

Soil Adaptation
Birdfoot trefoil is adapted to loam soils with good moisture holding capacity, and also to heavy clay soils. It is not adapted to sandy soils. High soil temperatures appear to spur root diseases. It is the legume of choice where drainage or acidity are problems. It will tolerate low levels of fertility but is exceptionally productive only in soils with good fertility.

Birdsfoot trefoil is a slow growing perennial legume adapted to cooler climates. It is slow to establish and because it is a light loving plant it will not withstand much competition at the seedling stage. Successful inoculation is difficult. Birdsfoot trefoil is more tolerant of grazing than alfalfa and red clover, and will normally outlive red clover by several years. Bloat is not a problem with Birdsfoot trefoil.

Resources

Bush, T. 2002. Plant Factsheet: Birdsfoot Trefoil.
USDA NRCS Rose Lake Plant Materials Center, Lansing, Michigan
www.plants.usda.gov/factsheet/pdf/fs_loco6.pdf

Chernery, J. H., and Hall. *Birdsfoot Trefoil*. Agronomy Fact 20. Penn State University Cooperative Extension Service. www.pubs.cas.psu.edu/Freepubs/pdfs/uc087.pdf.

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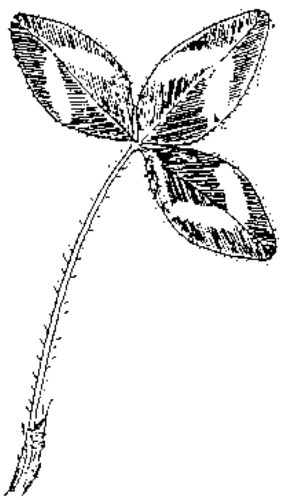
Red clover

Description and Adaptation of White Clover (Trifolium pratense)



Origin

First cultivated in northern Europe.

Plant Characteristics

Root system - Well developed tap root with many small roots contributes to drought tolerance and ease of inoculation.

Stems - Strong, upright woody stems, are high in fiber. A better choice for hay than grazing plant.

Leaves - Palatable and nutritious.

Flower head - The pink to red flower head is made up of many (100 or more) small typical legume flowers.

Soil Adaptation

Red clover will grow in a wide variety of soil types, from sandy loams to silty clay loams with moderate to high levels of fertility. Red clover is relatively easy to establish and will grow on soils that are too acidic or too wet for alfalfa to flourish. It is a short-lived perennial which persists for only one and a half to three years. It is also susceptible to disease.

Resources

Forage Information: Species Identification. Perdue University.
www.agry.purdue.edu/ext/forages/ForageID/forageid.html

For more information visit www.umass.edu/cdl

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White clover

Description and Adaptation of White Clover (*Trifolium repens*)

Origin
White Clover was first cultivated in northern Europe. Ladino clover is a large form of white clover, originated near Lodi in the Po River Valley in northern Italy.

Plant Characteristics

Root System - A seedling plant develops several small short tap roots. Additional short fine roots arise at the nodes of trailing stems which spread over the ground. Because of the relatively small shallow root system, white clover, including Ladino, is very sensitive to dry weather.

Stems - Main stems trail on the ground surface, but many upright stems or petioles, some bearing leaves and some seed heads, arise at nodes. Stems and leaves are soft and succulent, making white clover and Ladino the most palatable and nutritious of the clovers.

Flower head - Flower heads and flowers are white and smaller than those of red clover.

Soil Adaptation
White clover is adapted only to soil with moderate to good moisture relationships. Ladino clover and New Zealand type white clovers are among the most productive, palatable, and nutritious legumes available, especially for pasture. The most serious problem is animal bloat, thus these clovers must be grazed with caution. Ladino clover is larger leafed and more suited to hay situations when combined with grass than Dutch or common white clover. All of these white clover types are suitable for pastures

Resources

Forage Information: Species Identification. Perdue University.
http://www.agry.purdue.edu/ext/forages/ForageID/forageid.htm

Natural Resources Conservation Service. Plant Profile: White clover.
www.plants.usda.gov/factsheet/pdf/fs_trre3.pdf

For more information visit www.umass.edu/cdl

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UMass Extension

Kentucky Bluegrass

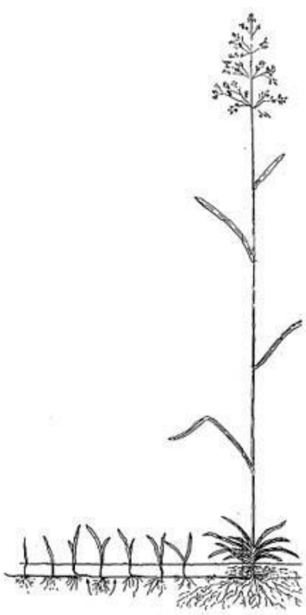
Description and Adaptation of Kentucky Bluegrass (*Poa pratensis*)

Plant Characteristics

Kentucky bluegrass is a long lived sod-forming perennial grass. Stems grow 1 to 2 feet in height when allowed to grow uncut.
Leaves are narrow and dark-green and 2 to 7 inches in length. The inflorescence is a pyramid-shaped panicle about 2 to 8 inches long.
Kentucky bluegrass reproduces by rhizomes as well as by seed. New tillers with their roots, grow from the nodes along the rhizomes, continually filling the spaces left by the death of the older tiller tufts. Each tiller tuft may only survive for two years.
Kentucky bluegrass is a palatable pasture plant making very early growth in the spring. It becomes the dominant grass species in most older pastures. It withstands close and continuous grazing, but becomes nearly dormant in midsummer when daily maximum temperatures approach 90$_0$F. Growth resumes with the return of cool weather in the fall. Kentucky bluegrass is not a good hay crop.

Adaptation

Kentucky bluegrass is adapted to the humid and sub-humid sections of the northern United States. It does best under cool, humid conditions on highly fertile soils which are not prone to drought. Kentucky bluegrass grows best on heavier soils with a pH above 6. In pasture mixtures, bluegrass is generally seeded with other grasses, and clovers. Usually two to three years are required to produce a good sod from seeding. Because of its dense turf, bluegrass is also the most popular lawn grass in America.



Resources

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www.cropsoil.psu.edu/extension/facts/agfact50.pdf

Natural Resources Conservation Service. Plant Profile:Kentucky Bluegrass.
http://plants.usda.gov/java/profile?symbol=POPR

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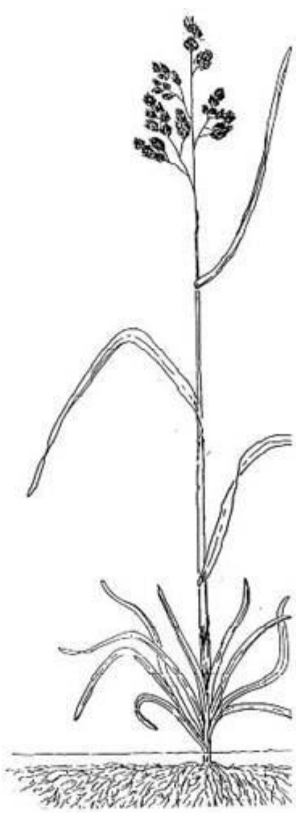
Orchardgrass



Description and Adaptation of Orchardgrass (*Dactylis glomerata)*

Plant Characteristics

Orchardgrass, a long-lived perennial, is a distinctly bunched type of grass with folded leaf blades and compressed sheaths. It is non-sod-forming without rhizomes. The flowering stems (culms) are smooth and from 2 to 4 feet high. The inflorescence is a thickly clustered panicle 3 to 6 inches long. Panicle branches have a few one-sided dense clusters of green or purplish spikelets.

Adaptation

Orchardgrass is shade tolerant and is a vigorous, tall, rapid grower. It is next to Kentucky bluegrass in being one of the earliest to start growth in the spring. It continues growth to quite severe frosts. It is more heat resistant and drought resistant than timothy or smooth bromegrass and makes excellent regrowth in the summer period. It tolerates the 3-cut system used with intensive alfalfa production better than other grasses. Orchardgrass must be well managed to limit its competition with legumes and for acceptable feed value. Orchardgrass will not stand close continuous grazing and is best adapted to medium-textured well-drained soils.

Resources

Forage Information: Species Identification. Perdue University.
http://www.agry.purdue.edu/ext/forages/ForageID/forageid.htm

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Reed Canarygrass

Description and Adaptation of Reed Canarygrass *(Phalaris arundinace)*

Plant Characteristics

Reed canary grass is an erect, long-lived, clumpy perennial with coarse rhizomes. It grows 2 to 7 feet tall with leafy stems. Under proper hay and pasture management it makes a dense, close sod. It spreads by rhizomes as well as by seeds. Seed spread occurs when its mature seeds shatter unevenly from an inflorescence, a semi-dense panicle 2 to 8 inches long. Reed Canarygrass may become weedy or invasive. In Massachusetts, because it may displace desirable vegetation in wetlands, it has been placed on the invasive species list. Thus, it is prohibited to buy seed and plant new fields of Reed Canarygrass.

Adaptation

Reed canary grass is a wetland grass that also does well on peat and well drained land. It can be used for pasture, silage or hay as well as for erosion control. It starts growing early in spring and is both summer and winter hardy. Having a long growing season, its forage is palatable and nutritious and will yield 3 to 5 tons per acre. To obtain best forage, the grass should be kept from becoming coarse and from reaching maturity. First grazing should be made before jointing or between early and full head. This latter management will probably require clipping. The cutting for hay should be between the early and full head stage. Second cutting should be based on the appearance of new basal sprouts near the soil surface.

Resources

Forage Information: Species Identification. Perdue University.
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Natural Resources Conservation Service. *Plant Guide: Reed Canarygrass*.
http://plants.usda.gov/plantguide/pdf/pg_phar3.pdf

For more information visit www.umass.edu/cdl

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Smooth Bromegrass

Description and Adaptation of Smooth Bromegrass (*Bromus inermis*)

Plant Characteristics

Smooth bromegrass is an erect, sod-forming perennial ranging in height from 20 to 40 inches. Pure stands of bromegrass are likely to develop a sod-bound condition in three years, unless fertilized with nitrogen. Growth begins in early spring and continues into late fall. Bromegrass makes high quality hay or silage. Protein content is relatively high and crude-fiber content is relatively low. It is a palatable pasture plant especially suited for spring grazing. Smooth bromegrass matures later in the spring and produces less summer growth than orchardgrass.

Adaptation

Smooth bromegrass is a widely adapted cool season grass. It can be grown on a wide variety of soil types, but grows best in moist, well-drained clay and silt loam soils. It produces satisfactorily on sandy soils when there is sufficient moisture. It is also able to survive periods of drought and high temperatures.

Resources

Forage Information: Species Identification. Perdue University.
http://www.agry.purdue.edu/ext/forages/ForageID/forageid.htm

Natural Resources Conservation Service. *Plant Guide: Smooth Bromegrass*.
http://plants.usda.gov/java/profile?symbol=BRIN2

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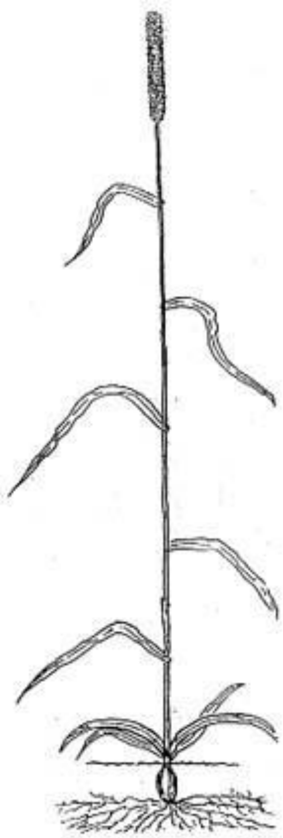
Timothy



Description and Adaptation of Timothy (*Phieum pratense*)

Plant Characteristics

Timothy is a relatively short-lived perennial. It is a bunched grass with a shallow, compact and fibrous root system. It has erect flowering stems (culms) 20 to 40 inches tall topped with a dense, cylindrical spikelet inflorescence. Spikelets are only one flower but it is a prolific seed producer. Leaves vary in length from a few inches to about a foot. Timothy is different from most other grasses because of a basal internodal swelling of the stem which can be used for identification.

Adaptation

Timothy is adapted to cool and humid climates. It is more cold resistant than most cultivated grasses but is not drought resistant. It is better suited to finer textured soils and even tolerates poorly drained soils yet not wet or droughty soils. It produces an excellent first cutting each year, but tends to be summer dormant if temperatures exceed a mean temperature of 77°. It is a good companion grass for legumes but will not stand close grazing or trampling. It survives poorly in alfalfa mixtures harvested under 3-cut or 4-cut systems.

Resources

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Forage Information: Species Identification. Perdue University. http://www.agry.purdue.edu/ext/forages/ForageID/forageid.htm

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Basic Nutrient Management for Dairy Farms

A nutrient management plan helps ensure that nutrients are used efficiently for economic production of feed and animal products.

Due to the complexity of the calculations and vast knowledge that a nutrient management planner requires, computer software is often used to aid in decision-making.

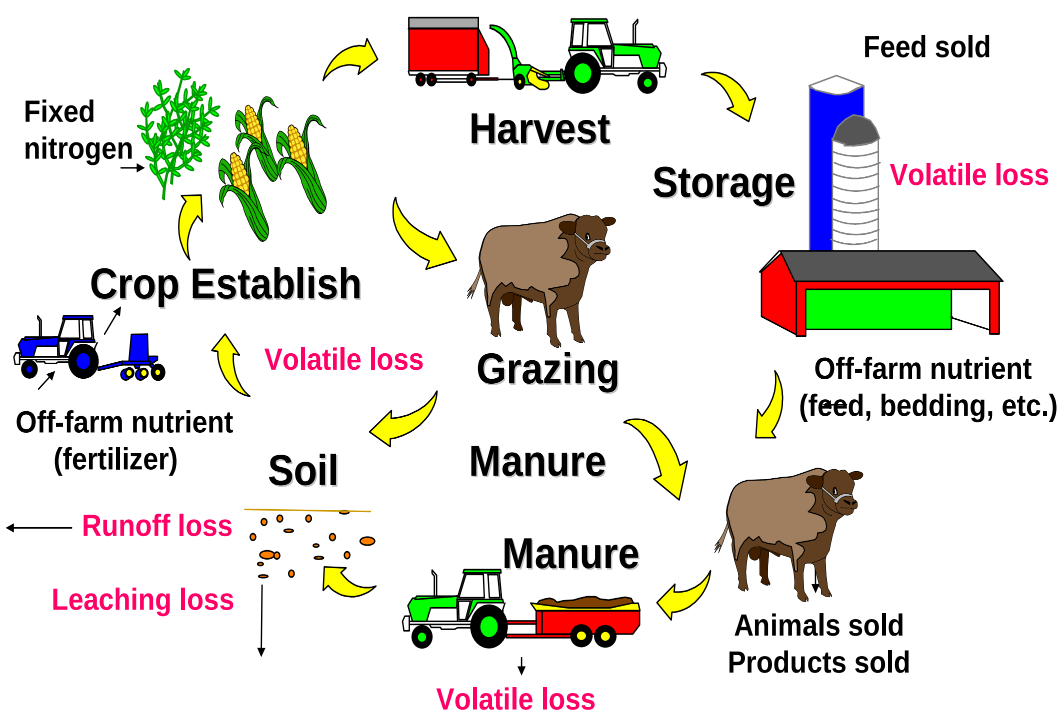
Introduction

Nutrients, whether in fertilizer or organic amendments such as manure and compost, are an essential crop input and a major cost for crop production. On a typical livestock farm nutrients are recycled from soil, to crops, to animals, and finally, to the soil as manure (Figure 1).

Nutrient recycling on most farms does not form a closed loop and farmers usually purchase off-farm nutrients to compensate for those lost in various ways to the environment. Farmers may also unknowingly apply nutrients in excess of recommended rates. For example, some farmers may apply commercial fertilizers without proper regard to the nutritive value of their manure. This can harm crop production, incur additional costs, and jeopardize soil and water quality. Similarly, the application of too little nutrients can sacrifice yield, quality, and profits.

A nutrient management plan helps ensure that nutrients are used efficiently for economic production of feed and animal products, as well as for the protection of air and water quality. Development of a nutrient management plan requires integrated knowledge about soils, cropping systems, crop nutrient needs, nutrient sources, nutrient application timing, and method of application.

Figure 1: Flow of nutrients on a typical crop/livestock farm where nutrient import exceeds nutrients lost from the farm through crops, animals and animal products in the form of sales.



Components of a Nutrient Management Plan

Developing a nutrient management plan is a complex task and requires collecting information about farm resources and current as well as past farm management practices. This information includes but is not limited to:

a) Nutrient inventory; including nutrient status of the soil, nutrient content in manure, nitrogen fixation by legumes, and nutrient availability from cover crops and previous crop.
b) Crop nutrient requirements based on; type of plant, yield expectation, and nutrient removal by crop.
c) History of cropping management; including crop rotation, manure application in the past, and cover crop.
d) Information about type and number of animals, manure storage capacity, and spreader capacity.
e) Environmental risk assessment for individual fields which requires information about soil, topography, flooding frequency, as well as current cropping management.

Due to the complexity of the calculations and vast knowledge that a nutrient management planner requires, computer software is often used to aid in decision-making. University of Massachusetts Extension has developed and uses FarmSoft for generating a nutrient management plan. The program calculates manure and /or fertilizer rates to meet nutrient needs and helps identify fields receiving excess nutrients. The program also calculates a site vulnerability index, highlights any major environmental concerns associated with individual fields, and prioritizes fields for receiving manure.

Resources

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Nutrients and Water Quality

The nutrients of greatest concern, relative to water quality, are nitrogen (N) and phosphorus (P) where N management mainly concerns groundwater quality.

Application of a nominal rate of N fertilizer before corn emergence followed by measuring soil NO_3 in the top 12" of the soil when corn is about 10-12" high is highly recommended.

Introduction

Successful crop production depends on an adequate supply of nutrients to the crops in order to achieve maximum yield. However, soil nutrients need to be managed properly to meet the fertility requirements of crops without adversely affecting the quality of our valuable water resources.

On a typical dairy farm, all nutrients are cycled from soil, to crops, to animals, and finally back to the soil as manure. However, nutrient recycling on almost all farms is not a closed loop system and nutrients leave the farm in various ways. Sold feed, animals, and animal products such as milk, cheese, and meat are examples of nutrients that are leaving the nutrient cycle in a good way. There are other ways, however, whereby nutrients leave the farm and will be lost to the environment. Examples include soil erosion, phosphorus runoff, nitrogen leaching, and manure ammonia volatilization which not only make nutrient cycling inefficient but also impose negative impacts on water quality. Dairy producers must then purchase off-farm nutrients (fertilizer) to compensate for those that have left the farm in any form. A proper nutrient management plan helps ensure that nutrients are used efficiently for economic production of feed and animal products, as well as for the protection of air and water quality.

The nutrients of greatest concern, relative to water quality, are nitrogen (N) and phosphorus (P), where N management mainly concerns groundwater quality.

Phosphorus

Phosphorus (P) is an essential plant nutrient required for photosynthesis, respiration, root growth, among many other critical functions. Plant roots absorb dissolved or soluble P from the soil solution. While soils generally contain 500-1000 ppm of total P (inorganic and organic), most of the P is bound to soil particles and is unavailable for use by plants. The concentration of P in the soil solution of fertile soils is typically very low (0.01-1 ppm) and a value of 0.2 ppm is commonly accepted as the concentration of soluble P needed to meet the nutritional needs of most agronomic crops. The solubility of P is controlled by many factors including soil moisture, temperature, pH, and concentrations of certain nutrients such as calcium, iron, manganese, and aluminum in the soil solution.

When manure and crop residues are decomposed by soil microorganisms (mineralization), inorganic forms of P are released for plant use. Phosphorus mineralization to meet plant needs is often slow, particularly when soil temperature is low. Therefore, crops grown in cold and wet conditions often respond positively to the application of P starter fertilizer.

A major loss of P is through surface runoff. Just a small amount of P in surface waters, including ponds and lakes, stimulates the excessive growth of aquatic weeds and algae (eutrophication). The consequences of increased aquatic plant and algae growth include the depletion of dissolved oxygen contents of the water resulting in fish kill, as well as reduced aesthetics and recreational values of the lakes. Critical levels of P in surface water that can trigger algae bloom have been reported by USEPA (2000) to be as low as 0.01 ppm for the lakes. Sometimes the visible impact of P on water quality can occur miles away from the point where P leaves the land and enters a body of water.

On dairy farms with relatively long history of manure application, P level in the soil is likely to be far above the level required for optimum crop production. This situation increases the risk of P transport to the surface water and accelerates eutrophication. Phosphorus in P rich soils may even be prone to leaching and therefore contaminating groundwater.

Nitrogen

Plants require large amounts of N for their normal growth. All types of N, with no exception are very soluble and can easily be leached into groundwater if not managed properly. Applying the appropriate rate of N fertilizer and proper timing of application can have a substantial effect on reducing NO_3 leaching into underground water.

Many corn fields in Massachusetts receive fall application of N, primarily as manure. This practice, if not integrated with cover cropping, can greatly increase the risk of N leaching into groundwater by fall and spring precipitation. In fields with a long history of manure application, the rate of N release, through mineralization after corn is planted, is faster than N uptake by plants. In general, farmers can expect between 10-40 lb N per acre released by mineralization for each percent of soil organic matter. Application of a nominal rate of N fertilizer before corn emergence followed by measuring soil NO_3 in the top 12" of the soil when corn is about 10-12" high is highly recommended. This N management method is known as Pre Side-dress Nitrate- N Test (PSNT). If the PSNT indicates that the soil NO_3 content is below a critical level (25 ppm), additional N fertilizer is immediately side-dressed. The amount of N for side-dress is determined by measured soil N content.

Resources

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UMass Extension

Healthy Soils

A single manure application or planting cover crop will not increase the percent organic matter significantly. It takes time and patience to improve the soil organic matter level.

Introduction

Healthy soils sustain productivity, maintain environmental quality, and enhance plant and animal health. Some characteristics of healthy soils include good soil tilth, good soil drainage, large population of microorganisms, sufficient (but not excessive) levels of essential nutrients, and low weed pressure. The key to soil health is organic matter. Soil Organic Matter (SOM) is the fraction of the soil consisting of plant and animal residues in various stages of decomposition. Organic matter contains organic carbon and nitrogen. Carbon is a source of energy and nitrogen is a source of protein for microorganisms in the soil. Some of the microorganisms are pathogens which cause plant disease but in a healthy soil the vast majorities of these organisms are beneficial and help prevent any one type of organism such as a plant pathogen from being dominant.

SOM Consists of Three Distinct Parts

Living organic matter (about 15%) consists mainly of bacteria, actinomycetes, fungi, protozoa, and algae, which are also called decomposers. Other living SOM include nematodes, insects, earthworms, plant roots and small animals.

Dead organic matter (about 15%) serve as food for living organisms and include dead microbes, old plant roots, crop residues and bodies of larger insects and animals.

Very dead organic matter (about 70%) are well decomposed, dark colored organic substances also called humus. Humus continues to decompose, but at a very slow rate.

Why is SOM important?

Organic matters improve many physical, chemical, and biological characteristics of the soil, including water holding capacity, cation exchange capacity, pH buffering capacity, and chelating of micronutrients. Furthermore, well-decomposed SOM improves soil structure by increasing aggregation, enhancing biological activities in the soil, slowly releasing nutrients, and suppressing some diseases. A loss of SOM can lead to soil erosion, loss of fertility, compaction, and general land degradation.

What Factors Influence the Amount of SOM?

The average SOM in most Massachusetts soils ranges between 1-5 % where a minimum of 4% SOM is desirable. The maintenance and enhancement of soil organic matter is crucial to the soil health and sustainability of farming systems. The accumulation of SOM within soil is a balance between the return or addition of plant and animal residues and their subsequent loss due to the decay of these residues by microorganisms and mismanagement of soil. To keep the current level of SOM, about 4 tons of dry matter should be added annually to the fields. This could be problematic when silage corn is almost no plant residue is returned to the soil. Use of soil amendments such as manure, compost and/ or on-time establishment of cover crops is necessary.

Factors Affecting SOM

In general, any factor that affects soil microbial activity also affects SOM breakdown**T**

Temperature-Soil temperature has a marked influence on microbial activity. The optimum soil temperatures for bacterial activity are in the 70 to 100° F range, but some activity may occur in as low as 40° F, although at greatly reduced rates.

Oxygen-Soil microbes require oxygen and water for their respiration and when soil is compacted or saturated with water, respiration slows down which in turn reduces decomposition of SOM.

Soil pH-Under acid conditions, bacterial activity, which is responsible for most of the decomposition of organic matter, is greatly reduced. Soil fungi responsible for breakdown of SOM are generally less affected by low pH.

Best Management Practices to Increase SOM

Soil organic matter level depends on both uncontrollable factors i.e. weather conditions, and controllable factors i.e. soil management. Managing SOM is a balancing act of additions; crop residues, manure, and compost and losses; decomposition plus erosion.

Addition of organic materials including animal manure, compost, cover crops (green manure), and some off-farm materials such as municipal leaves and food residuals will increase SOM. Agricultural practices also have a significant effect on improving SOM levels:

- Cover crops: Increase SOM directly when residues are returned to the soil. This practice protects soil against erosion and helps to retain and cycle nutrients.
- Crop rotations: Perennial forages (hay-type crops) develop extensive root systems which add new organic matter to the soil when they die. They also reduce the rate of decomposition of SOM because the soil is not continually being disturbed.
- Tillage practices: Conventional plowing and disking breaks down natural soil aggregates which allow for wind and water erosion. They also expose the soil to direct sunlight which increases the rate of SOM decomposition.

Increasing the percent organic matter in the soil takes time and patience. It is unlikely that a single incorporation of manure or planting cover crop will noticeably increase the percentage of organic matter. Repeated application of an organic amendment in combination with reduced tillage will improve the organic matter level

Resources

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Poole, T. 2001. *Soil Organic Matter*. University of Maryland Cooperative Extension Service., Fact sheet # 783. www.**extension**.umd.edu/publications/pdfs/fs**783**.pdf

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Sampling Soils for Meaningful Results

Four Steps of Soil Testing:

1. **Collect the soil samples**
2. **Analyze the sample**
3. **Interpret the results**
4. **Make fertilizer and lime recommendations**

Introduction

The objectives of soil testing are

- to accurately determine the status of nutrients.
- to accurately determine the availability of nutrients.
- to clearly indicate any deficiency or excess that may exist.

Soil test results can be used to determine specific crop nutrient needs for profitable and environmentally sound application of fertilizer, lime, and organic soil amendments including manure or compost. Applying fertilizer or manure without the benefit of a good soil test is like throwing money away. Without the proper guidance of a soil test, a farmer could lose profit due to lower yields or unnecessary expenditures.

Figure 1. Proper sampling technique is critical for good results.

Four Steps of Soil Testing:

- Collect the soil samples
- Analyze the sample
- Interpret the results
- Make fertilizer and lime recommendations.

The first step is the responsibility of the farmer while the next three are performed by a soil testing lab. Each step is important for meaningful and necessary results.

Collection of Soil Samples From a Field

Taking a soil sample that is truly representative of a field's characteristics is very important. Poor sampling gives misleading test results. Large differences are often found in nutrient levels of samples taken from different parts of the same field. These differences usually are not sampling or testing errors but are actual variations in fertility patterns. To minimize the effect of these inherent fertility differences, this established sampling procedure should be followed:

Taking a soil sample that is truly representative of a field's characteristics is very important. Poor sampling gives misleading test results.

- The closer the samples are taken to planting time, the less chance there is for changes to occur. Nitrogen levels tend to vary a lot so sampling near the time of planting is best. However, soil samples may be taken either in the fall or spring. Fall sampling ensures that test results are ready in plenty of time for spring or for fall fertilization when weather conditions are good and time is not so critical.
- Take soil samples every 2-3 years. Keep a record of soil test results on each field to evaluate long term trends in nutrient levels.
- Each soil sample should be a composite of soil cores taken from a similar area. When sampling, avoid unusual areas such as eroded sections, dead furrows, flooded areas, fertilizer bands, and fence lines. Divide each field into uniform soil and past cropping areas.

- Assign a permanent identification name/number for long-term record keeping. Fertility trends over a period of years provide important information, indicating the adequacy of a fertilizer program (too much, too little, or the correct amount.
- To sample an area of one soil type, take at least 15-20 small samples or cores at random from each area to give a composite sample at tillage depth (upper 6-8 inches for most crops). For perennial pastures or hay crops (cases where the soil is not annually mixed), sample only to 4 inches deep.
- Use a soil probe or soil auger to collect the samples (See the Figure 1). You can also use a shovel or spade for shallow samples.
- The subsamples should be collected into a clean plastic container and mixed together well.
- From this composite sample remove about a cup of soil and allow it to air drywithin12 hours of sampling. Place the sample into a Zip-Lock bag for shipping. Label the outside of the bag with your name, address, field, and intended crop.

Resources

Soil samples can be sent through standard mail services to UMass Soil Testing Lab, West Experiment Station, UMass, Amherst, MA 01003. For further information contact the Soil Test Lab (413-545-2311).

For testing services and price list log on to: http://www.umass.edu/plsoils/soiltest/services1.htm

For results and interpretation of soil test log on to: http://www.umass.edu/plsoils/soiltest/interp1.htm

For more information visit www.umass.edu/cdl

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Soil Acidity and Liming

The pH of a soil should always be tested before making management decisions that depend on the soil pH.

Aglime reacts slowly and may not promote plant growth immediately after application. The finer the lime material, the faster the aglime corrects the soil pH.

Introduction

Soil acidity is a major concern in Massachusetts. Correcting soil acidity (pH) is a fundamental step in productive plant growth. The pH of a soil should always be tested before making management decisions that depend on the soil pH.

Why do soils become acidic?

The major causes of acidity are:

Acidic parent materials: Soils that developed from certain material such as granite are likely to be more acidic than those developed from limestone.

Wet climate: In heavy rainfall areas, such as in Massachusetts, as water passes through the soil, the basic soil cations including Ca, Mg, and K are gradually leached and replaced with acid cations like Al and H^+.

Organic matter decay: Decaying of organic matter releases CO_2 which reacts with water to form acids.

Crop management: Harvesting high-yielding forages, such as corn silage or alfalfa which both contain significant amounts of basic elements i.e. Ca, Mg, and K, has a significant effect on soil acidity. Much more complex cations are removed by grains as compared to leaf and stem. Application of ammoniacal nitrogen fertilizer also may influence soil acidity.

What is the significant of soil pH?

Soil pH influences many soil characteristics that are important to its quality. Characteristics included:

Availability of nutrients to plants: In acidic soils some important nutrients such as phosphorous, magnesium, and calcium become less available to plants. Moreover, soil pH affects microorganism activities that are responsible for breaking down organic matter as well as many chemical reactions that are taking place in the soil. Thus, the availability of nitrogen, sulfur, and phosphorus to plants will be reduced.

Aluminum and manganese toxicity: Under acidic conditions, Al^{+++} that normally is firmly attached to the soil particles begins to dissolve and enters into the soil solution. Small amounts of Al^{+++} in the soil solution can prohibit root growth of many plants. Similarly, high Mn^{++} concentration interferes with the growth of aerial parts of plants and therefore, significantly reduces final yield.

Pesticide effectiveness: Many pesticides are effective only if soil pH is appropriate. In acid soils the pesticides may change to an undesirable form, becoming ineffective. Their degradation in the soil may not happen as expected, and could pose a problem for the next crop.

Plant diseases: Sometimes, many plant diseases are caused or exacerbated by extremes of pH, because this makes essential nutrients unavailable to crops or because the soil itself is unhealthy. For example, chlorosis of leaf vegetables and potato scab occurs in overly alkaline conditions, and acidic soils can cause clubroot in brassicas.

How is soil pH modified?

For many crops, the ideal pH range is between 6.0 and 7.0. When pH is below the optimum range adding liming material such as calcium carbonate will correct the soil pH. As lime dissolves in the soil, Ca^{+2} attaches to soil particles, replacing the acid cations (H^{+}). Carbonate reacts with H^{+}, forming CO_2 and water, thus soil becomes less acidic.

How much lime is needed?

Lime recommendation is based on soil testing and the amount of liming material required to correct the soil pH is often specified by the soil testing labs. Although soil pH is a good indicator of the need for liming, a buffer pH measurement is necessary to determine the quantity of soil acidity to be neutralized in order to change the soil pH. The most important source of buffering in an acidic soil is the exchange of lime through cation elements, like Ca^{++}, which attach to the surface of soil particles. As the crop removes such elements from the soil solution, attached elements move into the solution. In time, reserve elements are depleted enough to cause acidity.

Some Important Tips for Liming:

- Clay soils and soils with high organic matter have a larger reservoir than sandy soils; therefore more lime is required to correct the soil pH.
- Unlike fertilizer, aglime reacts slowly and may not promote plant growth immediately after application. The finer the lime material, the faster the aglime corrects the soil pH.
- The limestone recommendation is based on the use of a liming material that is equivalent in neutralizing power to pure calcium carbonate. If the purity of liming material is 80%, then recommendation rate must be adjusted by multiplying by 100 ÷ 80.
- When a high rate of lime is recommended, (4 tons or more per acre) two applications, with 6 months time between them, is highly recommended.
- Under minimum or no-till systems the top 1-2" inch of soil becomes rapidly acidic. If surface layer has a low pH, establishment of legumes must be delayed for a minimum of 6 months until lime reacts with the soil.

Resources

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For more information visit www.umass.edu/cdl

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Pre-Sidedress Nitrate-N Test (PSNT)

The amount of nitrate present at PSNT sampling is directly related to the N supplying capability of the soil for the entire growing season.

Introduction

The pre-sidedress nitrate-N soil test (PSNT) is nitrogen management tool, conducted in late spring that can be used to aid in more accurate nitrogen management decisions for corn production. It is an especially appropriate test for fields with relatively high in organic matter. The PSNT therefore, is almost exclusively promoted for fields that have received manure or other organic amendments or where corn is following a forage legume crop. This is because the availability of nitrogen from organic matter decomposition (mineralization) is often unknown. The PSNT conducted on soils that do not have a manure history or previous forage legume crop rarely show nitrogen levels high enough to merit a decision.

Over-application of N from fertilizer and manure can result in N loss throughout the growing season, and especially after crop harvest in the fall, which increases production costs.

The PSNT should be conducted when corn measures 10–12 inches from the surface of the ground to the center of the whorl (about 5-6 weeks after planting) (Figure 1). The amount of nitrate present at PSNT sampling is directly related to the ability of the soil to supply N during the entire growing season. At this stage of corn growth, N released from organic matter and fertilizer N will move rapidly to the active root zone even if the fertilizer is not incorporated into the soil.

Figure 1. Sample 10 to 12 inches from the surface of the ground.

Nitrogen transformations occurring in soils are dynamic and strongly influenced by environmental conditions because they are a direct result of biological soil activity. During cold spring weather, the rate of mineralization is low and PSNT results may not be accurate. Also, in dry seasons, PSNT results may not be accurate since movement of N to the active root zone is limited.

The PSNT should be conducted when corn measures 10–12 inches from the ground surface to the center of the

How to Collect Samples

The PSNT soil sample should be collected from 0 – 12 inches deep and represent areas of the field that have similar soil properties and past management histories.

- Make a composite of 25-30 soil cores from each sample area by thoroughly mixing all the soil in a clean bucket before removing the subsample for analysis. The large number of cores is important due to non-uniformity of manure application.
- Always take the soil cores from the center of planting rows.
- Subsamples should be spread in a thin layer on a non-absorbent paper as soon as possible.
- Include with soil sample: field identification, your name, address, phone number, and testing fee. Send up to one cup of dried soil placed in a zip lock bag to:

  Soil Testing Lab
  West Experiment Station
  University of Massachusetts
  Amherst, MA 01003
  (ph. 413-545-2311)

Interpreting your PSNT Results

Depending upon the PSNT level, a farmer receives an estimate of the likelihood of seeing a response to additional nitrogen fertilizer, but will not receive an actual nitrogen recommendation from soil lab. Results of the lab analysis are usually reported in parts per million (ppm) nitrate-N. However, pounds of actual nitrogen per acre can be estimated by multiplying ppm nitrate-N (in the top 12 inches of soil) by 4. PSNT values of 25 ppm or higher are unlikely to benefit from additional nitrogen fertilizer and the higher the value the less likely the need for supplemental nitrogen. The problem arises when PSNT values are less than 25 ppm. PSNT values below this level may or may not respond to additional nitrogen fertilizer, but the stock recommendation would be that they do require more nitrogen. The following table, (Table 1) can be used to determine N fertilizer requirement for various PSNT values in Massachusetts:

Table 1. Sidedress N fertilizer recommendations for silage corn based on PSNT and the corn silage yield potential*

	Corn silage yield goal (tons/acre)			
Soil NO_3-N test level (ppm)	17	21	25	28
	Sidedress N recommendation (lbs N/acre)			
0 - 10	100	130	160	180
11 - 15	75	100	125	145
16 - 20	50	75	100	120
21 - 25	25	50	75	90
25+	0	0	0	0

* Based on field data from Massachusetts, Connecticut, Pennsylvania, and Vermont.

Resources

Beegle, D., et. al. 1999. *Pre-sidedress Soil Nitrate Test for Corn.* Penn State University Cooperative Extension Service. http://cropsoil.psu.edu/extension/facts/agfact17.pdf

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UMass Soil Testing Lab. http://www.umass.edu/plsoils/soiltest/

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End-of-Season Corn Stalk Nitrate Test (CSNT)

Introduction

Nitrogen (N) management is often a challenge in obtaining an economically optimum yield. This is because many factors influence nitrogen behavior in the soil, including its source, timing, and especially weather condition. A crop displaying dark green growth, late in the growing season, indicates that it has been over fertilized. This can be a problem especially with manure if mineralization has not been taken into account. On the other hand some visual symptoms of nitrogen deficiency late in the season may not always indicate a yield loss. Reliable tests for detecting N content of corn plants can improve profitability and reduce the potential for nitrate contamination of water supplies.

The lower portion of a corn stalk tends to function like a reservoir for nitrate N (NO_3-N). During the grain-filling period, corn plants suffering from inadequate N availability tend to remove N from this reservoir as well as from lower leaves. Conversely, when corn plants are over fertilized, nitrate will accumulate in the lower portion of stalks without contributing to a greater yield. This may result in plants that are dark green in color.

Measuring the nitrate concentration in the lower portion of corn stalks, at the end of the growing season can be useful in determining nitrogen deficiency, sufficiency, or excess. Studies over a wide range of conditions have shown remarkably similar relationships between the amount of N found in the lower stalks late in the growing seasons, and the likelihood that corn had been under or over-fertilized (Figure 1). The Cornstalk Nitrate Test (CSNT), by itself or along with pre-sidedress N test (PSNT), can be used to gain confidence in the nutrient management and planning process. In years with a cool and/or wet spring, microbial activity responsible for decomposing organic matter is low. Under this condition, PSNT results may indicate the need for N fertilizer even though sufficient N may still be released from soils' organic reserves when the temperature rises. The end-of-season cornstalk nitrate test can confirm if fertilizer was needed and help farmers decide on proper N application adjustment for future years.

Measurement of nitrate concentration in the lower portion of corn stalks at the end of the growing season can be used to determine nitrogen deficiency, sufficiency, or excess in corn silage.

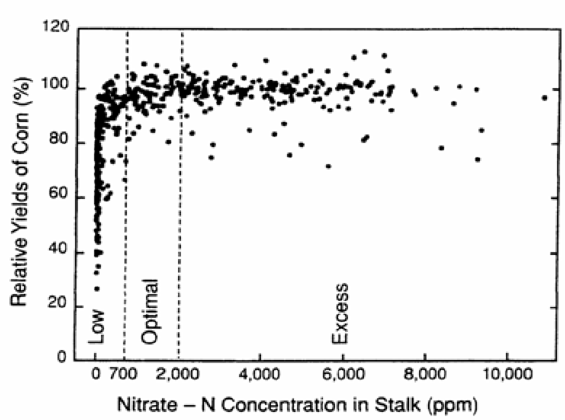

Figure 1: Corn yield and stalk N relationship

Sampling Procedure

The test requires collecting corn stalks at the end of the season just before harvest. For grain corn, stalk samples should be taken between one and three weeks after there has been a black layer formation on 80% of the kernels.

- Collect samples from 15 random plants for every 10 acres of field
- Cut an 8 inch segment of stalk starting 6 inches above ground level (Figure 2)
- Remove leaf sheaths from the segments
- Avoid stalks damaged by disease or insect
- Areas with differing soil types or management histories should be sampled separately
- Place segments in a paper bag (not plastic as it promotes fungal growth) and dry or freeze for later analysis.

Send samples to:

Dairy One Forage Lab
730 Warren Rd.
Ithaca, NY 14850
Ph: 1-800-496-3344
Fax: 607 257-1350
Call ahead to ensure analysis.

Figure 2. Samples should be taken 6 inches from the soil.

Interpretation of Stalk Nitrate Concentration

Stalk nitrate concentrations for silage corn can be divided into four categories;

The **Low** category (<700 ppm):
Indicates corn plants could have benefited from higher N fertilizer application. Visual signs of N deficiency usually are clear when nitrate concentrations are in this range.

The **Optimal** category (700-2000 ppm):

Indicates high probability that N availability was within the range needed to maximize profits for the producer. The higher end of this range is more appropriate when fertilizer N is relatively inexpensive and grain prices are relatively high. The lower end of the range is most appropriate when fertilizer N is relatively expensive and grain prices are relatively low.

The **Excess** category (> 2000):

Indicates that N in the field was in excess of what is needed for optimum economic yields. Not only might this represent an economic loss, but it may also indicate a potential for nitrogen loss to the environment. Nitrogen management should be evaluated to determine why the N supply was excessive and management changed accordingly

Resources

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Soil Amino Sugar Test

Soil amino sugar is highly correlated with responsiveness of soils to fertilizer-N. More amino sugar in soil decreases the response of corn to N

Introduction

In humid areas including Massachusetts, the result of soil N measurements prior to planting is not accurate and most often cannot predict N needs for the coming growing season. In these regions, using Pre-Sidedress Nitrate Test (PSNT) which predicts N supplying capacity of the soil during the entire growing season is recommended. This soil testing method is especially appropriate for those cropping systems where producers are utilizing animal manure. However, using PSNT is not always accurate and convenient since: a) soil samples should be collected during busy growing season; b) it cannot be used in fields where nitrogen fertilizer or manure has been applied in a band application; c) may be much less accurate when used on sandy soils or soils with poor drainage; d) results may not be accurate if the weather condition is wet and cold and therefore, N release processes through bacterial activities is slow. That is why in some growing seasons under or over N fertilization occurs; even when management practices on a farm remain unchanged. While excessive N application increases the risk of environmental pollution as well as production costs, insufficient application of N may cause significant yield reduction.

Attempts have been made to introduce an alternative technique for determination of N sufficiency in soil for corn production. Ideally, a soil test for N would estimate the supply of organic N that gradually but continuously releases NO_3^-. This approach however, would be effective only if the organic N compounds are readily mineralized and highly correlated to fertilizer-N responsiveness.

Soil Amino Sugar Test (Illinois Soil N Test)

Most often, the total N content of soils is much higher than N available to the crop. The total soil N of an acre of soil is usually greater than 2,000 pounds per acre, while a high yielding corn hybrid in Massachusetts requires about 180 pounds per acre. Therefore, there must be some component of total soil nitrogen that acts as a reservoir for the growing crop.

Researches in Illinois reported that among various organic fractions in the soil, concentrations of amino sugar N is highly correlated with responsiveness of soils to fertilizer- N. In other words, accumulation of amino sugar N in soil reduces the yield response of corn to N fertilization. In these studies, soil concentrations of amino sugar N have shown a high correlation with both yield and fertilizer-N response.

For Soil Amino Sugar Test

- Soil samples should be collected from a depth of 8 inches.
- Sampling should be done 6-8 weeks after manure spreading or cover crop plow down to avoid any ammonium –N released in the soil by newly added organic materials.
- Results indicate organic N mineralization potential of the soil which is valid for 2-3 years. Therefore, when using this method, annual soil sampling is not needed.

How to Interpret the Results

When amino sugar N concentration of the soil is greater than 250 mg kg^{-1}, the corn plants most likely will not respond to additional N because there is enough readily mineralizable organic N in the soil. In this situation about 20-30 pounds of N in the starter fertilizer can be used. However, when amino sugar N concentration in the soil is less than 200 mg kg^{-1} corn plants will most likely respond to N fertilizer application. The rate of N fertilizer can be determined as follows:

- 180 lbs N/acre for yield goal of 24 tons per acre, 160 lbs N/acre for yield goal of 20-24 tons per acre, and 140 lbs N/acre for yield goal of less than 24 tons per acre.
- Recommended N rates should be reduced if manure is applied in spring.
- Nitrogen credit from spring applied manure depends on rate of manure application, nutrient content of manure, and how fast manure was incorporated into the soil.
- Inorganic N in manure which accounts for almost half of the N is readily available after application. However, the rate of N release from organic N in manure is about 35, 12, and 5% in years 1, 2, and 3, respectively.
- As an example, if 6000 gallons of manure that contains 25 pound N per 1000 gallons was spread in spring and incorporated immediately into soil the total N credit for this season will be:

Inorganic N = 6000/1000 × 25 × 50% = 75 pounds
Organic N = 6000/1000 × 25 × 50% × 35% = 26 pounds
Total N credit = 101 pounds

The soil amino sugar test has potential economic implications for production agriculture, and also should be of value for controlling NO_3^- pollution of ground and surface water.

Resources

Khan, S. A., R. L. Mulvaney, and R. G. Hoeft. 2001. A simple soil test for detecting sites that are nonresponsive to nitrogen fertilization. Soil Sci. Soc. Am. J. 65: 1751-1760.

Cornell University.Nutrient Management Spear Program Agronomy Fact Sheet Series: www.nmsp.css.cornell.edu

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Guidelines for Nitrogen Applications on Agronomic Crops in Massachusetts

Over-application of nitrogen can mean a decrease in profits and an increased potential for ground water contamination.

Introduction

Adequate nitrogen is essential for optimum crop production. However, applying excess nitrogen can have serious environmental consequences. Nitrogen, in the form of nitrate, is extremely soluble in water and will be carried down below the root zone as the water drains. Over-application of nitrogen can mean a decrease in profits and an increased potential for ground water contamination.

Nitrogen dynamics in the soil are very complex with over 98% of the nitrogen in the top 6" of soil is 'tied-up' in soil organic matter and not readily available for plants. Nitrogen is released slowly as microorganisms decompose the soil organic matter. The rate of release increases as soils warm. This makes it very difficult to estimate nitrogen needs for the season based on a soil test taken before planting. The largest demand for nitrogen by corn, for example, begins 30-40 days after emergence. If soluble nitrogen fertilizer is applied at planting, much of it may have been lost from the soil root zone through leaching by the time the corn has its greatest nitrogen requirement. In determining nitrogen fertilizer rates it is important to be aware of all nitrogen sources on the farm and to give them adequate nitrogen fertilizer credits.

Nitrogen Sources on Farms

Soil Organic Matter - Organic matter is approximately 5% nitrogen by weight. As it decays, nitrogen will be released in a form suitable for plant use. About 10-40 lbs/acre of fertilizer equivalent-N will be available in a growing season for every 1% of organic matter in the soil. Rate of N release is dependent on soil temperature, pH, moisture, oxygen and type of organic material. For example, a soil with an organic matter content of 4% in average will supply about approximately 80 lbs N/acre.

Manure - Animal manures supply nitrogen to crops, but the fertilizer equivalent from manures will vary greatly depending on such factors as animal species, moisture content, handling and storage, and the elapsed time between spreading and incorporation. If manure is applied, it is important to know the analysis and the amount that you are spreading. If for example 20 tons/acre of dairy manure (10 lb N per ton in average) is applied and incorporated into soil the same day, then approximately 120 lbs/acre of nitrogen is available that year. Even though 200 lbs of nitrogen would be added to the soil, only 50 to 60% of that nitrogen is available the first year with the remainder becoming available in subsequent years. However, if the manure is incorporated after 48 hours or later only 40 lbs/acre of nitrogen will be available. More than 60 lbs will have been lost to the atmosphere and through runoff. Liquid portion of manure contains almost 50% of the total N and nearly 90% of the potassium. Therefore, it is very important to conserve the liquid portion of the manure.

Legumes - Legumes can supply substantial amounts of nitrogen when incorporated. The amount of nitrogen will vary widely depending on the legume species, the amount of time that it has been allowed to grow before incorporation, in addition to other climatic factors. The fertilizer equivalent can be as high as 100 lbs/acre from a reasonable stand of alfalfa, or a good stand of hairy vetch planted in early to mid-September and incorporated in late May.

Non-legume cover crops - Non-legumes such as winter rye and oat are not as rich in nitrogen as legumes; however they will conserve nitrogen in the field and eventually release it when incorporated.
Many non-legumes are very efficient in 'mopping-up' nitrogen that is still available in the soil after crops are harvested. This emphasizes the importance of seeding cover crops soon after harvest since most of the leaching of nitrates in the Northeast occurs in the fall and spring. We are recommending that legumes be seeded in combination with grasses like rye and oat so that less nitrate will move below the root zone. Although legumes can fix nitrogen from the atmosphere, most are not as efficient as grasses in taking up nitrogen from the soil.

Composts - Composts can also be used to add nutrients and organic matter to the soil. Composting dairy manure can be used to help stabilize nitrogen in excess to crop requirement. Composts vary in their nitrogen supplying capacity and even though nitrogen is stabilized, some can supply substantial amounts of nitrogen.

Chemical Fertilizer - Most formulations of chemical fertilizer are readily available to crops soon after soil application. This however, is accompanied by a high leaching potential. Spring applications of chemical fertilizers coupled with the usual wet conditions at this time of the year increase the danger of leaching. As mentioned above, the greatest amount of nitrogen uptake by corn begins several weeks after plant emergence. Timing fertilizer applications to coincide with this time of greatest demand by the crop will make for more efficient fertilizer utilization.

Recommended Nitrogen Rates for Agronomic Crops

Corn Silage-Recommended nitrogen rates are based on yield goals and should be reduced by the N credits from previous crops, previous manure application and current manure application. In Massachusetts the following rates are recommended:

- 140 lb N/ac for less than 20 ton corn silage per acre (or <100 bu/ac)
- 160 lb N/ac for 20 to 24 ton corn silage per acre (or 100 - 130 bu/ac)

 180 lb N/ac for greater than 24 ton corn silage per acre (or >130 bu/ac)

Legume Based Hay-Nitrogen fertilizer application is not generally recommended for forage legume hay crops including alfalfa, clovers and birdsfoot trefoil. These legumes can fix sufficient atmospheric N to supply the needs of both the legume, and the grass in legume-grass mixtures. Adding nitrogen may encourage competition from the grass and from weeds as stands thin or are damage by harvest equipment or by winter conditions.
Use of a starter fertilizer during establishment of up to 20-60-20 lb (N-P2O5-K2O) per acre may be beneficial especially in cool soils without a history of manure application. Band placement if possible to maximize the benefit of the phosphorus is highly recommended. Do not use any nitrogen in no-till seeding as this will encourage weed competition. Application of manure when surplus to needs of the corn crop is possible to vigorous alfalfa stands and to stands that are running out. It is not recommended to stands in early stages of decline or to legume-grass hays where there is a desire to retain the legume.
For legume grass mixtures use the grass hay maintenance recommendation for hay crops that have little or no legume component. For example if the amount of birds foot trefoil has declined to 30% or less use the grass hay recommendation.

Grass Hay-For all perennial grasses seeded alone apply 40-40-40 lb per acre, banding if possible. Do not apply any nitrogen as plow down. Applying 30 lb N per acre in late summer of the establishment year can be beneficial.

For established grass apply up to 150 lb N per acre per year in split applications. Apply 50 to 60 lb/acre when the grass first greens up and 50 lb/acre after each cutting. The amount applied after each cutting should be based on the expected yield for the next cutting.

Pasture-Fertilizing pastures with nitrogen is not recommended if the legume content is greater than 30% because the legumes (usually clovers or trefoil) provide adequate nitrogen through N fixation. If there is less than 30% legume, fertilize similar to grass hay with 100 to 150 lb N per acre per year depending on the productivity and growth cycle of the species. Split applications applying at least three times, early spring, early summer, and late summer, with no more than 50 lb N per acre at any one time.

For more information visit www.umass.edu/cdl

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UMass Extension

Nitrogen Management for Corn Production

Nitrogen Management Strategy Must Include:

1) Predicted yield goal

2) Application timing

3) Potential sources of available N such as manure, crop residues, N contribution from previous legume crop

4) Crop rotation

5) Cover crop utilization

6) Soil properties

Introduction

Nitrogen is often the most limiting nutrient in producing crops. Often times, farmers tend to over apply this nutrient due to an increase in its cost, concerns about environmental pollution and demands for mandatory nutrient management planning, farmers should have a comprehensive knowledge of N management strategies and develop a detailed management plan for optimal nitrogen use.

Nitrate (NO_3^-) is the common form of nitrogen in soil and the form which plants can assimilate into energy. Since NO_3^- is a negatively charged ion, it will not be held by soil particles, which are also negatively charged. Therefore, N can easily leach as rainwater flows through the soil. In sandy soils, N leaching occurs even more rapidly. This is because of the soil's structure, which has low water holding capacity. Deep channels developed by water flow patterns and fauna in the soils allow for faster leaching of soluble N in water. N is also readily leached through the process of decomposition of organic matter. Due to the increased availability of air in sandy soils, microbes quickly degrade plant residues, releasing N into the soil. If not utilized properly, the N released will be leached before being useful to the next crop planted.

Any N management strategy must include:

1. Predicted yield goal
2. Application timing
3. Potential sources of available N such as manure, crops residues, and N contribution from previous legume crop
4. Crops rotation
5. Cover crop
6. Soil properties

How much N does corn require?

Soil mineral N content is very sensitive to environmental factors including rainfall and temperature. Therefore, testing the soil before or at the planting time cannot predict how much N will be available when crop enters its rapid growth stage. UMass extension strongly recommends that on manured fields little or no nitrogen starter be applied. A Pre-sidedress Soil Nitrate Test (PSNT) should be used to determine if organic sources of N in the soil such as manure and crop residues are adequate to meet the needs of the crop. Details on PSNT can be found in CDLE Pub. 08-12 http://www.umass.edu/cdl/BMPs/PreSidedress%20Nitrate%20Test%20(PSNT)%2008-21.pdf).

In general, there is potential to reduce N rates by 20% if farmers sidedress rather than apply N at planting. For example if the recommendation on a clay loam soil is 125 lbs of N as broadcast prior to planting then a rate of 100 lbs N/acre is recommended if it is going to be sidedressed. Reduction in fertilizer application rate will be even higher when soil contains more sand. For grain corn production, using 1.1 pounds of N per bushel of expected yield and then subtracting all of the appropriate credits for nitrogen is recommended

The following table (Table 1) shows N fertilizer recommendations in Massachusetts for silage and grain corn with various expected yield levels.

Table 1. Nitrogen recommendation for silage and grain corn production in Massachusetts

Silage corn:					
Expected yield (ton/acre)	17-20	21-24	25-28	29-32	>33
Nitrogen Recommended N (lb/acre)	100	130	160	180	200
Grain corn:					
Expected yield (bushel/acre)	100	125	150	175	>200
Nitrogen Recommended N (lb/acre)	100	130	160	190	220

When to apply?

The goal of a good N management program is to have maximum nitrate in the soil when plants are rapidly growing and minimum residual nitrate in the soil at harvest. The young corn plants produce little amount of dry matter and pick up only small amounts of N, P_2O_5 and K_2O. Because corn plants start growing rapidly in mid June, delaying N fertilizer application until plants reach 12 inches tall (6-8 weeks after planting) can significantly reduce N leaching and reduce cost of purchased fertilizer. When corn is planted into a field high in residual N because of previous manure or legume crops, often no yield advantage can be found by fertilizing the crop at planting.

Nitrogen Sufficiency Tests

Pre-sidedress Soil Nitrate Test (PSNT) is a useful testing method for confirming whether the N credit from organic sources such as manure and cover crops are adequate to meet the needs of the corn crop.

Evaluation of the color of the leaves determined by using a handheld chlorophyll meter is also a pre-sidedress test that predicts if remobilization of N from soil organic matter is sufficient for optimum yield production.

The end-of-season test for cornstalk NO_3-N is an effective indicator of optimal and above-optimal supplies of available N for silage corn. Details on using end-of-season cornstalk NO_3-N test (CSNT) as a N management tool can be found in CDLE Pub. 08-22 http://www.umass.edu/cdl/BMPs/End%20of%20Season%20Corn%20Stalk%20Nitrate%20Test%20(CSNT)%2008-22.pdf.

Determination of N application rate should be based on the price of corn and the cost of N fertilizer. The "most economical rate of nitrogen" or "optimal rate" is not the N rate that generates the highest corn yield but the rate that produces the highest economic return. Nitrogen rates for corn should be reduced when either N fertilizer prices are unusually high or corn prices are unusually low. For example, traditionally in grain corn production N rate recommendations have been calculated at price ratio 5, which means that the value of a pound of N is 5 times greater than a pound of corn. So, when N fertilizer was $0.30 per pound, at price ratio 5 the value of corn was assumed to be $0.06 per pound or $3.36/bu. The value of corn is based on the expected selling price with drying, storage and handling costs.

Resources

Bandel, Allan V., et al. "Nitrogen Recommendations for Corn Using the Pre-Sidedress Nitrate-Nitrogen Test." Factsheet 559. University of Maryland Cooperative Extension Service. http://extension.umd.edu/publications/PDFs/FS559.pdf

Beegle, D. and P. Durst. 2003.*Nitrogen Fertilization of Corn.* Agronomy Facts 12. Penn State University Cooperative Extension Service. http://cropsoil.psu.edu/extension/facts/agronomy-facts-12

Wolkowski, R.P., et al. "Nitrogen Management on Sandy Soils." Publication number A3634. University of Wisconsin-Extension. http://www.soils.wisc.edu/extension/pubs/A3634.pdf

For more information visit www.umass.edu/cdl

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This publication has been funded in part by the Massachusetts Department of Agricultural Resources and the Massachusetts Farm Bureau Federation, Inc.

Conservation Buffers for Reducing Non Point Source Pollution

Use conservation buffers to separate streams and wetlands from:

1. **Pastures.**
2. **Cultivated fields.**
3. **Manure piles.**
4. **Paddocks.**
5. **Farm shops.**

Introduction

Conservation buffers are strips of land in permanent vegetation designed to protect wetlands and bodies of water. Protection includes control of erosion and absorption of runoff, including runoff containing contaminants such as nutrients, pesticides or other pollutants. Conservation buffers may also be used as wildlife habitat.

Some examples of conservation buffers

A grassy strip between a field and a wetland can be a conservation buffer. The strip may be mowed several times a year to keep it from growing up to brush.

Shrubberies can also be effective conservation buffers. They can attract wildlife which may be beneficial (insect-eating birds) or detrimental (blueberry-eating birds). Shrubberies can also block wind, but may be difficult to maintain at a manageable size.

Some examples of uses of conservation buffers

Fertilization of agricultural fields, whether through manure or purchased fertilizer, often results in leaching of nutrients. A conservation buffer between the agricultural field and nearby wetland can absorb at least some of these “runaway” nutrients. Excess nitrogen and phosphorous are particularly harmful to aquatic systems.

A hillside farm pasture, sloped gently toward a stream, is fenced 50 ft away from the stream, allowing space for nutrients from manure to be absorbed before reaching the stream. Not allowing the animals access to the stream bank also preserves the bank and keeps the stream cleaner.

Regulations

Placement and width of conservation buffers is often a matter of common sense, but in some cases regulations exist. Massachusetts regulations define a buffer zone as extending 100 ft horizontally from the wetland. Activities within 100 ft of a wetland, if they will affect the wetland, may require approval from a local conservation commission or Massachusetts DEP. Stricter regulations exist for areas within 50 ft of wetland or streams. Slopes greater than 15% also require special consideration. Agricultural activities are regulated somewhat differently from other development (see pp.46-47 of http://www.mass.gov/dep/service/regulations/310cmr10b.pdf). Placing permanent vegetative conservation buffers can significantly reduce impact on wetlands and reduce the safe distance between a wetland and an agricultural activity.

Resources

The Massachusetts wetlands protection act relates primarily to modification or direct destruction of wetlands, but also addresses wetland protection: http://www.mass.gov/dep/water/laws/ch131s40.pdf

The following contains additions to the above Wetlands Protection Act, and includes more specific provisions than the original act. Pages 46-47 pertain specifically to agriculture: http://www.mass.gov/dep/service/regulations/310cmr10b.pdf

Improvement of wildlife habitat through use of conservation buffers: http://www.umass.edu/nrec/pdf_files/final_project.pdf

For more information visit www.umass.edu/cdl

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Cover Cropping to Reduce Nitrogen Leaching

The nitrogen in manure is water soluble and volatile. If plant roots do not take up the N, it will rapidly leach by rainfall or can be lost through ammonia volatilization.

Cover crops such as winter rye or ryegrass are especially efficient in recovering nutrient residues that are left from previous crop and fall applied manure. They also help recycle nutrients in the soil.

Introduction

Cover crops should be considered an integral component of a sustainable farming system. They help to prevent soil erosion, improve soil structure and quality, and suppress weeds, pests, and diseases, among other benefits. In Massachusetts and other states, the capacity of manure storage facilities in dairy operations are designed to hold a certain amount of manure produced within a six-month period. Therefore, dairy farmers traditionally empty their storage in the fall and apply it to their harvested crop fields. If the fields do not have adequate ground cover by cover crops valuable nutrients released from manure , in particular, nitrogen (N) will be lost. The nitrogen (N) in the manure is water soluble and volatile. If plant roots do not take up the N, it will rapidly leach by rainfall or can be lost through ammonia volatilization. These two processes can lead to environmental implications such as water pollution and also decrease the overall effectiveness of manure as nutrients resource for the crop. Therefore, it is recommended to plant an appropriate cover crop at the right seeding time to gain the most benefit from the manure while improving the overall soil fertility.

Multi year research conducted at the University of Massachusetts Crops, and Animal Research and Education Farm looked at the effects of cover crops planting date on soil nitrogen levels after corn harvest. Soil samples were taken from various depths over a period of time to determine the soil N availability. Figure 1., below shows that by the end of October, the soil N content in all sampling depths was almost zero. The results of the research clearly indicates that if nitrogen is not absorbed by cover crops it will be lost to the environment by rainfall during the fall before ground is frozen.

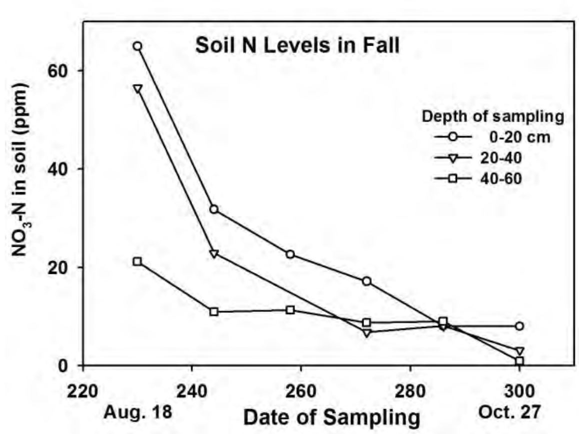

Figure 1. N loss from fall manure applied to a field with no cover crop

Some cover crops such as winter rye or ryegrass are especially efficient in recovering nutrient residues that are left from previous crop and fall applied manure. These cover crops also help recycle nutrients in the soil. A well-established cover crop is required for maximum nutrient recovery, which can be over 100 lb N per acre.

Cover Crops Seeding Date

The ability of the cover crop to absorb nitrate from the soil is affected by the degree of colonization of the soil by roots. Cover crop seeding date is important for producing adequate canopy and root before cool weather slows or stops growth. During most years in Massachusetts, seeding dates after mid September will result in plant growth that is not adequate to efficiently uptake nutrients released from manure decomposition.

In Massachusetts, cover crops should be seeded in early September to achieve good establishment and be effective in nutrient retention and erosion control.

As displayed in Figure 2, the seeding date significantly effects cover crop establishment. The earlier a cover crop can be planted the more effective it will be because the greater biomass and root structure has the capacity to retains more nutrients. Any delay beyond the effective or critical date for seeding cover crops will reduce benefits. Early seeding of corn silage and choice of a shorter season maturing hybrid helps to ensure an earlier harvest date and increases the chance of seeding a cover crop near the optimum date for maximizing nitrogen accumulation.

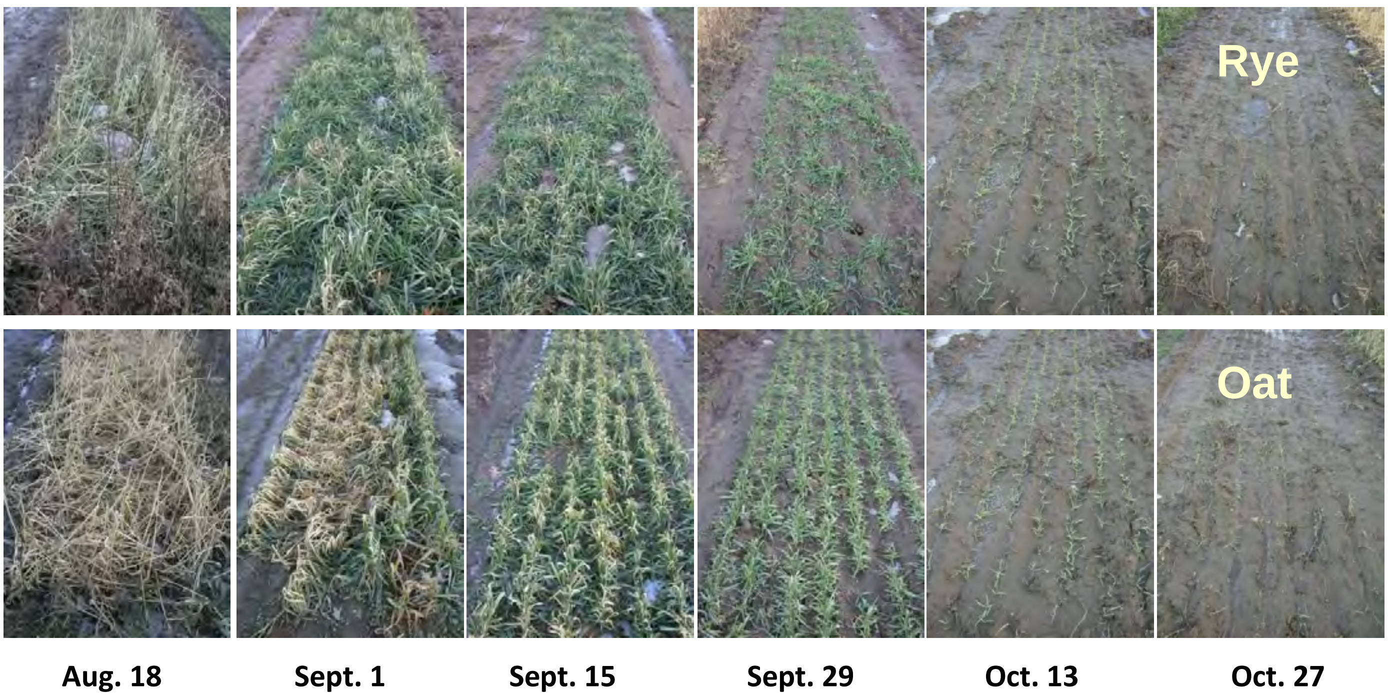

Figure 2. Rye and oat cover crops growth performance planted at different seeding dates.

Resources

Sullivan, Preston. 2003. Overview of Cover Crops and Green Manures:Fundamentals of Sustainable Agriculture. ATTRA Publication IP024. http://attra.ncat.org/attra-pub/covercrop.html

Jabro, J., and Upendra Sainju. Cover Crops: Improving Soil Quality and Productivity. USDA. http://www.ars.usda.gov/Research/docs.htm?docid=10538

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Estimating Manure Inventory

The purpose of a manure inventory, in conjunction with a manure and soil analysis, is to estimate the amount of manure produced on a farm and therefore, to calculate the amount of nutrients excrete by dairy cows.

Factors such as, animal species, age, feed ration, bedding characteristics, storage structures, and manure handling will greatly effect manure production and nutrient levels.

Introduction

One of the most challenging aspects of dairy farm nutrient management is developing a system for manure application on fields. This involves estimating the amount of manure produced on the farm, in conjunction with manure analysis; to plan for defined application rates for land in productivity. Manure management should be a top priority for any dairy farm. Mismanagement of manure can diminish its value while having adverse effects on the environment. When used appropriately, manure has significant agronomic and economic value. Manure improves soil biological activity, tilth, and chemical properties of the soil. The purpose of a manure inventory, in conjunction with a manure and soil analysis, is to estimate the amount of manure produced on a farm and therefore, to calculate the amount of nutrients excrete by dairy cows. A manure inventory will also assist in determining if sufficient land is available for agronomic utilization of manure nutrients.

Manure production and nutrient excretion value varies by body weight of the animal and often does not account for large variations in feeding types and amounts. Other factors such as, animal species, age, feed ration, bedding characteristics, storage structures, and manure handling will greatly effect manure production and nutrient levels.

Calculations

Each ton of manure produced by dairy cows contains approximately 10 pounds of nitrogen (N), 4 pounds of phosphorus (P_2O_5), and 8 pounds of potassium (K_2O) (Table 1). The actual concentration of these nutrients in stored manure will be influenced by storage losses and dilution from water (rainfall and milk wash waste water) as well as bedding.

Table 1: Average daily manure production and nutrient content of manure. Values are based on animal unit (1000 lb) and do not include bedding*.

*Adapted from: The Agronomic Guide 2011-2012. College of Agricultural Sciences, Penn State University. http://extension.psu.edu/agronomy-guide/cm/tables/table1-2-13.pdf

Animal Type	Daily Production	Analysis Units	N	P_2O_5	K_2O
Dairy Cow Lactating (liquid)	13 gal	lb/1000gal	28	13	25
Lactating (solid)	106 lb	lb/ton	10	4	8
Dry	82 lb	lb/ton	9	3	7
Calf and heifer	87 lb	lb/ton	7	2	7

Manure production on a dairy farm can be estimated by using the following formula:

Manure production = Number of Cattle x Average Weight of Cattle (lb) ÷ 1000 (animal unit) x Daily Manure Prod. x Manure Collection Period (days) + Estimated Percent of Bedding in Manure.

Example: You have 10 lactating cows, each with an average weight of 1250 pounds. The animals are on pasture for 5.5 months (mid April through early October). You usually add about 5% bedding to the manure.**Total annual collectable manure (without bedding) =**
10 (animals) x 1250 (avg. wt.) ÷ 1000 (animal unit) x 106 (daily manure prod. from Table 1) = 1325 (lb/day). 1325 x 195 (days kept in barn) =
258375 (lb manure/year).

Total waste production (with bedding) =
258375 x 0.05 = 12919 (lb bedding added to the manure).
258375 + 12919 = 271294 (lb/year) or: 271294 ÷ 2000 = 136 (ton/year).

In the above example, nutrient inventory for the farm can be calculated as:
136 x 10 = 1360 lb N, 136 x 5 = 544 lb P_2O_5, and
136 x 8 = 1088 lb K_2O

Considerations

Manure nutrient inventory for a farm is only practical if used in conjunction with proper on-farm management practices including manure storage and handling, application method; correct timing for optimal crop uptake, and manure analysis.

Resources

Natural Resources Conservation Services. *Manure Inventory Sheets*.
http://www.ut.nrcs.usda.gov/technical/technology/planning/conservation_plan/CNMP_Inventory_Sheet.pdf

Penn State Agronomy Guide. Part 1, Section 2: Soil Fertility Management. *Manure Nutrient Content*.
http://extension.psu.edu/agronomy-guide/cm/sec2/sec29c

For more information visit www.umass.edu/cdl

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Manure Storage for Dairy Operations

Proper storage, handling, and application of manure from dairy operations can protect Massachusetts's water resources and increase profits for animal and crop enterprises.

Introduction

Dairy manure is a valuable fertilizer resource and can reduce a producer's commercial fertilizer costs by about $50 per acre. If mishandled, however, dairy manure can contaminate surface and ground waters. Proper storage, handling, and application of manure from dairy operations can protect Massachusetts's water resources and increase profits for animal and crop enterprises.

Store or Spread?

Accumulated manure can cause health, odor, and water quality problems if not properly dealt with. One option is to collect the waste daily, load it in a spreader, and spread it on cropland, hayland, or pasture. This is time consuming and also has to be done regardless of the soil moisture, weather, or time of year. Spreading on saturated soils compacts and compromises soil quality; spreading on frozen soils can lead to offsite runoff of manure. The alternative to daily spreading is to stockpile or store the manure for a period of time, at which point it may be spread or hauled away and utilized beneficially elsewhere. Therefore benefits of manure storage include:

- Reduce the need for frequent hauling and land spreading.
- Allows for land spreading at a time when soil and climatic conditions are suitable.
- Allow nutrient application at or near the crop's growing season.

Limitations of Manure Storage

Manure storage is generally a large capital cost item. Most producers want to invest this capital where it produces a good income stream (cows, housing, milking parlor etc). Manure storages are not noted for producing a large income stream. The large capital cost of storage contributes to a large annual cost for depreciation, interest, repairs, taxes and insurance. The cost of putting manure into storage and removing it must be considered in annual cost.

Stored dairy manure generally smells more offensive than fresh manure. Measures should be taken to minimize the effects of odors. Also, the cropping seasons in spring and fall are very busy times with narrow windows of time to get all the work done. The need to empty large manure storage at either or both times can constrain the dairy operation.

Manure Storage Design

Calculating the capacity of manure storage needed for a dairy operation is not difficult with the assistance from UMass Extension staff or your county NRCS office. The choices for storage facilities include, but are not limited to metal, concrete, and fiberglass. Lagoons can be excavated if the physical space required is available.

Dry Storage

Typical dry storage facilities are designed to handle the solid manure from dairy cattle separated or scraped solids from dairy operations and other materials such as bedding.

Advantages include:

- Less volume due to high solids content of greater than 15 percent dry matter.
- Fewer odors since bacterial action producing compounds is reduced at lower moisture levels.

- Less runoff potential.
- Relatively high nutrient retention.

Disadvantages include:

- More labor in manure collection and handling (mechanical vs. hydraulic handling) than liquid storage.
- Runoff management from storage areas.
- Labor and equipment requirements for the larger number of loads to haul and spread for land application.

In higher rainfall areas, solid manure storage facilities usually have a concrete bottom and may have concrete walls to confine the solids and provide a push wall for stacking and loading of the solids. Examples for dairies are picket dam storage and solids settling basins. Contaminated runoff from these facilities must be managed in an environmentally sound manner.

Proper roofing should be considered to avoid runoff. The roof will divert additional moisture to the manure and will ease handling during inclement weather. Composting may also be an integral part of the solid manure storage system.

Liquid Storage

Liquid manure storage facilities (lagoons) are earthen structures but are larger than those designed for slurry storage due to the additional treatment volume. Since they are earthen structures, site investigations for proper soil material, rock, or bedrock characteristics and water table elevation must be performed as part of the site evaluation. A seal on the lagoon bottom and sides must be constructed to meet permeability standards required by regulation or good construction practice. A source of dilution water (usually a pond or lake) may be needed to maintain the lagoon treatment volume. Adding dilution water reduces the effects of salts in the lagoon during periods of low rainfall when evaporation may reduce the treatment volume below the design level.

Advantages of lagoon storage of manure may include cost per animal unit and their ability to store large amounts of manure and/or runoff. Disadvantages of lagoons may include lack of appropriate soil materials for construction, the need for solids separation or sludge removal equipment if bedding or other non-biodegradable materials are present, aesthetic appearance and/or public perception, and relatively high nitrogen losses and greenhouse gas emissions.

Slurry Manure Storage

Slurry manure storage facilities store manure in slurry form that is between 5 to 10 percent dry matter. One type is the under-floor pit in which manure is deposited directly into the pit through slatted floors. Other slurry manure storage facilities may be fabricated or earthen structures.

Fabricated manure storage tanks are usually concrete or coated metal with a glass lining and may be above or below ground. Manure is usually pumped into the tank from a collection sump or reception pit. Agitation is necessary to suspend solids and facilitate complete removal of the contents. If odor control is needed, storages can easily be covered.

Figure 1. Slurry manure storage tanks store manure that is between 5 and 10 percent dry matter.

Slurry manure can also be stored in earthen structures or basins. Since storage volume can be obtained at less cost in an earthen basin, these facilities are chosen when manure and wastewater volumes are large. These structures require a high degree of planning to ensure that proper seal occurs at the bottom of the basin. If the native soils will not seal, imported soil or geo-textile fabrics need to be used. A disadvantage of these structures is the potential for higher odor problems.

Resources

Animal Manure Management. Livestock and Poultry Environmental Stewardship Curriculum. http://www.extension.org/animal+manure+management

Dairy Environmental Handbook; Best Management Practices for Dairy Producers. http://www.nmpf.org/publications/dairy_handbook

For more information visit www.umass.edu/cdl

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Sampling Dairy Manure

Introduction

Manure contains ample amounts of nutrients and is considered to be an integral component of dairy farm nutrient management. Significant amounts of Nitrogen (N), Phosphorus (P), and Potassium (K) as well as small amounts of trace minerals are present in dairy manure and can be utilized as a main source of fertilizer for dairy operations, thereby potentially reducing input costs. It is important to have an understanding of the nutrient concentrations contained in the manure when planning for land application. An analysis of manure nutrients is required in order to calculate the amount of manure needed to supply enough fertility to support crop growth. Nutrient content will fluctuate depending on the diet and age of the cow, the type and amount of bedding, handling and storage, seasonal precipitation, among other management differences. For example, the nitrogen content of solid dairy manure may vary from 3 to 33 lb/ton and the phosphorus content from <1 to 35 lb/ton. In order to account for these differences, annual sampling is highly advised to track nutrient difference and maximize the economic value of manure. Separate, representative manure samples must be collected and analyzed for each form (liquid or solid) of manure applied each year. Devising an effective sampling program must take into account time, method, and frequency of sampling.

Keep track of the beginning, middle, and end portions of application, so that analyses can be correlated to appropriate land application reference.

When is the Best time to Sample Manure?

Ideally, manure should be sampled during or just prior to hauling for land application. This will provide the most accurate nutrient analysis because the manure has been agitated ensuring a representative sample. However, when sampling during agitation or hauling, the results from the lab analysis will not be sent back in time to include in the current years nutrient management plan, but analysis can be used for planning the following year's fertility plan, and to adjust additional fertilizer applications.

Take manure samples annually for three years, followed by samples every 4-5 years. Keep records on file for management references. If storage(s) are emptied twice a year, it is recommended to sample in both spring and fall since the varying storage temperatures in summer compared to winter will affect manure nutrient levels.

Take manure samples annually for three years, followed by samples every 4-5 years. Keep records on file for management references.

Methods of Sampling

In general, a composite sample, which is comprised of numerous sub-samples, is needed for every form and site where manure is contained and used as a soil amendment. The more subsamples taken, the more accurate the results will be. Based on your manure management follow these instructions for taking a precise manure sample.

Sampling Liquid Manure (less than 10% solids)

Dairy manure (about 12% solid as excreted) is often collected and stored as liquid slurry in earthen, concrete, or steel storage structures. For safety and time appropriateness, it is recommended to sample during application. However, if challenges exist where you are unable to sample at application, then sample with caution from storage facilities such as lagoons due to hazardous gases and the potential for accidents.

General Requirements for Handling a Liquid Manure Sample

1. For your final composited sample, label a clean and sealable, wide-mouth plastic container with your name, the name of the farm, date, and sample identification

number with a dark colored waterproof marker. Do not use glass or galvanized containers for gases will expand and may break the glass and the metal interferes with analysis

2. Agitate manure slurry storage for 2 to 4 hours before sampling taking care to prevent erosion of earthen structures or tearing of liners.
3. Follow one of the following sampling methods and take 10-20 sub-samples using an appropriate sampling devise.
4. Place all sub-samples in a larger clean plastic container, such as a 5-gallon bucket and mix contents thoroughly to suspend solids.
5. While contents are being mixed, scoop out manure and fill composite sample container three quarters full. Mixing ensures all particle sizes get into the sample.
6. Freeze sample immediately to prevent microbial activity, in particular ammonia nitrogen loss.
7. Send for analysis, by placing frozen sample in a Styrofoam or plastic cooler with ice packs to keep the temperature down. It is advised to use a rapid transit courier and avoid sending on a weekend or holiday.

Sampling Liquid Manure During Land Application

Samples should be taken from different loads, which represent the beginning, middle, and end of the application process.

By Tanker Truck

- Collect sample as soon as tank is filled since solids will immediately begin to settle unless the tanker has an agitator.
- Sample with a clean container such as a small to medium sized plastic container attached to a long pole. Dip pole into tanker and take appropriate number of sub-samples.
- Follow the above "General Handling Requirements".

By Irrigation Systems

- Place several catchment containers, such as plastic coffee cans, randomly throughout the field.
- After manure has been irrigated, immediately collect containers and compile together into one main bucket.
- Follow procedure as described above in "General Requirements for Sampling Liquid Manure".

Sampling Liquid Manure from Storage Facilities

Caution must be taken to avoid potentially fatal accidents when sampling from a liquid storage facility. Gases released from storage are highly concentrated and can be harmful. Wear a self-containing breathing mask if necessary. Never sample alone, always have at least two people to perform the procedure.

- Sample using a probe to obtain a vertical profile of manure. Construct a probe by cutting a piece of PVC piping that is a foot longer than the depth of the storage facility. Then, run a piece of string or rod that is longer than the pipe through the inside. If using a rod, make sure to bend the top end so it does not fall out. Next, securely attach a rubber stopper or ball to the end of the pipe. This will allow you to plug the pipe once your desired depth of sample is achieved.
- Place pipe with stopper open into manure storage to the full depth.
- Pull string or rod to close the pipe.
- Slowly pull up the pipe being careful not to spill contents.
- Release sample into a clean 5-gallon bucket.
- Repeat these steps till you have 10-20 sub-samples that represent all points within the manure site.
- Follow procedure as described above in "General Requirements for Sampling Liquid Manure".

Sampling Solid Manure (greater than 20% solids by weight)

Solid manure handling systems contain much more bedding as compared to liquid manure and also typically have more storage sites such as barn gutters and dry stacks. Therefore, it is recommended that solid manure be sampled from each storage site separately as followed and possibly several time throughout the year. Stratification of nutrients occurs in manure piles, so it is advised to sample while loading or during application.

General Requirements for Handling a Solid Manure Sample

1. For your final composited sample, label a clean and sealable, wide-mouth plastic container, or zipper locked freezer plastic bag, with your name, the name of the farm, date, and sample identification number with a dark colored waterproof marker. Do not use glass or galvanized containers for gases will expand and

may break the glass while the metal interferes with analysis.
2. Collect 10-20 sub-samples and sample in a grid pattern.
3. Avoid sampling large pieces or chunks of bedding. Mix all sub-samples thoroughly in a clean 5-gallon bucket.
4. Remove a large enough sample to fill composite container half way to three-quarters full. Place composite container within another sealable plastic bag so as to avoid potential leakage. If using a plastic bag, squeeze out air.
5. Freeze sample immediately to prevent microbial activity, in particular ammonia nitrogen loss.
6. Send for analysis, by placing frozen sample in a Styrofoam or plastic cooler with ice packs to keep the temperature down. It is advised to use a rapid transit courier and avoid sending on a weekend or holiday.

Sampling During Application

Keep track of the beginning, middle, and end portions of application, so that analyses can be correlated to appropriate land application reference.

A. Tarp Method

- Spread a tarp or plastic sheet that is about 10 – feet-by 10-feet or smaller, on the field before application. Hold down securely with rocks or stakes. Have a tarp for every parcel of land or for every load that is different, such as filled from varying storages.
- Drive manure spreader over desired land ensuring to cover tarp.
- Collect sub-samples and follow procedure as described above in “General Requirements for Sampling Solid Manure”.

B. Directly from Spreader

- Using a pitchfork, shovel, or long pole with a securely attached container, extract 10-20 subsamples from the spreader as it is being filled by the storage facility.
- Collect sub-samples and follow procedure as described above in “General Requirements for Sampling Solid Manure”.

Sampling from Solid Manure Storage Facilities

The optimal time to sample manure is during application, but if time and management practices do not permit, then samples may be collected from the storage facility. Always be cautious when sampling from the storage facilities wearing personal protective equipment such as gloves and mask, possibly even a self-contained breathing mask, if entering a confined manure space.

Sampling Dry Stacks

A dry stack of solid manure is manure that is stored outside in a facility such as a stacking shed or horizontal concrete silo above ground.

- Identify dispersed points on the stack that represent the average moisture content of the manure. Samples should be taken from a depth of at least 18 inches at various locations on the pile.
- From each point, remove the top crust layer, which is lower in nutrients, and collect 10-20 sub-samples. Once at 18 inches depth, use a shovel to take a small pile, and then take a cup full from the shovel, transferring contents into a 5-gallon bucket. Use a bucket loader to reach the center portions of the pile. Make sure to randomize sampling by performing in a zigzag pattern.
- Follow procedure as described above in “General Requirements for Sampling Solid Manure”.

Sampling from Barn Gutters

Many dairy operations collect accumulated manure from barns or housing facilities in gutters and remove from the gutter daily.

- Shovel a heap of manure from the gutter making sure to reach the bottom of gutter. The liquid, which sinks to the bottom, is a crucial component of the sample.
- Place the contents on barn floor and mix thoroughly, discarding any foreign objects and breaking up clumps of bedding. A pitchfork may be useful for breaking up clumps.
- Repeat above steps till you have taken from representative locations along the gutter. There should be numerous piles of mixed manure around the barn.
- Take subsamples from these small mixed manure piles following the above “General Guidelines” to comprise your composite sample.

Recommended Sampling Frequency

Dairy manure nutrient content is constantly changing. Therefore, to determine the best value for the nutrient content of a particular form of dairy manure, it is important to average as many analyses as possible. Remember that more subsamples will give you a better representation of manure composition.

Labs that Accept Manure Samples

University of Maine
Analytical Laboratory and Maine Soil Testing Service
5722 Deering Hall
Orono, ME 04469-5722

For further information call (207) 581-3591 or visit:
http://anlab.umesci.maine.edu/default.htm

Dairy One
730 Warren Road
Ithaca, NY 14850
(607) 257-1272
http://www.dairyone.com/

Resources

Bicudo, R. J. *Managing Liquid Dairy Manure*. AEN-91. University of Kentucky Cooperative Extension Service. www.ca.uky.edu/agc/pubs/aen/aen91/aen91.pdf

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Rieck-Hinz, A., et. al. 2003. *How to Sample Manure for Nutrient Analysis.* PM 1558. Iowa State University Cooperative Extension Service. www.extension.iastate.edu/publications/pm1558.pdf

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Dairy Manure Spreader Types and Calibration

Quick
Manure Conversions

1 ton= 2000 pounds

1 cubic foot = 7.5 gallons

1 bushel = 1.25 cubic feet

1 gallon = 8.3 pounds

1 cubic foot = 62 pounds (wet) to 55 pounds (dry)*

***Manure density (weight per cubic foot) See factsheet 11-34 for more details in calculating.**

Recalibrate the manure spreader after any adjustment so as to ensure desired rate.

Introduction

Spreaders need to be able to apply manure uniformly, effectively, and consistently from load to load and over time. The proper selection and calibration of a manure spreader ensures its optimal use and functionality of the manure as a major source of crop fertility while also avoiding over application of nutrients that can lead to environmental issues. There are several spreader systems, of which all have specific calibration methods. Manure application systems generally fall into one of the following three categories:

1. Solid manure systems that store, move and spread manure on soil surface.
2. Liquid manure systems that apply manure to the soil surface.
3. Liquid manure systems that inject manure into the soil, below the surface.

To manage manure on farms it is essential to know the quantity being spread. Knowing the amount of manure spread at the planned rate as well as plant nutrients available from the manure enables an adjustment to be made to the amount of fertilizer needed. It is important to spread the manure as evenly as possible to avoid part of the field getting excessive nutrients and another part not getting enough. Equally important is spreading the manure over the whole farm since the most of the nutrients in the manure came from the cropland. This will also avoid potential accumulation of excess nutrients in fields.

Solid Manure Systems

Solid manure is defined as manure that contains greater than 20% solids by weight. Solid manure and semi-solid manures are generally handled by tractor pulled or truck mounted box spreaders. The box spreaders vary in their capacities, ranging from two to twenty tons and manure is distributed with the help of a dispensary mechanism out the rear of the spreader. Some types of solid spreaders include, flail, side discharge and spinner spreaders. Flail spreaders are used for drier manures, and chain flails help to handle manures with varying moisture levels, by distributing it out the sides of the spreader. Side discharge spreaders have augers within the hoppers to move the manure toward a rotating panel or expeller where the manure is then distributed evenly as the tractor moves forward. Spinner spreaders have a similar design to the hopper spreaders except the spinning of disks at the rear of the auger brings about discharge of manure. Adjustments can be made by changing the disk speed or angle.

Liquid Manure Systems

Liquid manure is defined as manure that contains less than 10% solids. A tank wagon with splash plates is typically used to surface broadcast the manure. However, this method most often lends itself to non-uniform spreading, with much odor. There are several types of attachments that can be used to help improve uniformity and tanker performance. To deliver the manure slurry closer to the ground, booms can be added to the dispenser with nozzles and drop hoses, to help distribute the manure more evenly and minimize odor problems. Other types of liquid manure applicators include direct injection or immediate incorporation of manure into the soil. These types of spreaders are quickly gaining popularity in the dairy industry because they achieve greater manure use by reducing nutrient loss from volatilization, runoff, and odor.

Figure 1: Concave disks

This method can work several ways. The tank truck can have adaptors such as aerators (knives), cultivators, or concave disks. Areators, such as the AerWay, cut grooves into the soil and manure is then directly injected into those grooves. Culitvators and concave disks help to incorporate manure right after application.

Figure 2: Complete one pass spreader system with aeration attachment

Calibration

Depending on which manure spreader system is being used, varying calibration methods need to be applied to guarantee that each system is operating to its fullest potential. By calibrating, you ensure that the correct amount of nutrients is being delivered to the crops. If your spreader has not been calibrated, then chances are you are not applying nutrients effectively. Good management practices also include record keeping. Maintaining records of your calibrations and applications can help to improve the overall fertility of your farm operation and assist in trouble shooting problems.

How to Calibrate Manure Spreader:

Method 1 (solid or semi-solid manure)

Equipment required: Two to three plastic sheet 6 x 6ft or 10 x 10ft, scale, and a bucket for each sheet.

1. Weigh each sheet with its bucket on the scale.
2. Lay sheets in the field in the path of manure spreader, apart from one another and position them so the tractor will be at spreading speed before it reaches the sheet. Secure each sheet's position with heavy stones or stakes.
3. After spreading, weigh each sheet and manure in its respective bucket, being careful not to spill any manure. Repeat this step to get an average weight.
4. Subtract weight of the empty bucket and sheet in Step 1 from the weight in Step 3. This number tells the weight of the manure on each sheet.
5. To determine how much manure is applied per acre use the following formula:

(Wt. of collected manure (lb.) x 21.8) ÷ size of sheet (sq. ft.) = Tons manure/acre

Method 2 (liquid manure)

Equipment required: yard stick, rope.

1. Determine manure spreader capacity (see factsheet number 11-35).
2. Tie string around the top of the tractor tire. Mark the ground where the string falls directly below the tire. Move tractor forward until the string is back on top again. Mark the ground again, to where the string lies. Measure the distance between these two distances to determine the distance traveled by one revolution of the tire.
3. Spread manure load, and count wheel revolutions. To determine the distance traveled to spread the load, multiply the number of tire revolutions it took to spread the load by the number of feet the tractor moved in one revolution.
4. Measure the width of manure covered by the spreader.
5. Multiply the distance traveled (Step 3) by the width of manure covered (Step 4) and divide by 43,560 (the number of square feet in one acre) to determine area (in acres) covered by one load.
6. Divide spreader capacity (Step 1) by acres covered (Step 5) to determine tons or gallons applied per acre.

Once the spreading rate is determined, adjustments can be made to tractor speed or spreader settings to achieve the desired rate. It is crucial however, to recalibrate the spreader after any adjustment.

Resources

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Martin, Gerald. *Manure Spreader Calibration.* Agronomy Facts 68. Penn State University, Cooperative Extension Service. http://cropsoil.psu.edu/extension/facts/agfact68.pdf

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How to Measure Manure Spreader Capacity

Volume calculated in cubic feet can then be converted into pounds then into tons or gallons depending on the density of the manure.

The density of manure (weight per cubic foot) will vary depending on the moisture content.

Introduction

Manure is a valuable fertilizer resource and in order to utilize it to its fullest potential, in developing a strategy for land application, the manure spreaders capacity must first be determined. A spreader's capacity can be determined one of two ways, either by the manufacture's capacity rating, or by measuring the average volume of manure in one spreader load. Most often the latter method is used to obtain the most accurate and reliable measurement.

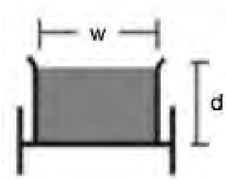
Rated Capacities

Each spreader's manufacture determines the rated capacity. For box-type solid or semisolid spreaders the rating specifications should indicate whether they are for "heaped or piled" or "level" loads. Make adjustments according to the fullness of the load. The rated capacity of liquid spreaders may be used only if the spreader is filled to that stated capacity. Most often, this is not the case and adjustments should be made. Should there be any uncertainty about the rated capacity, then an actual measurement of the volume of manure should be calculated.

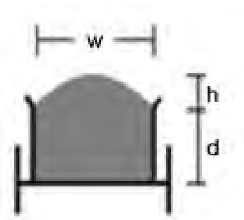
Measuring Volume of Spreaders

To determine the volume of the spreader, select the appropriate type below and follow the calculation. Note that all dimensions used in the formulas must be in feet so that volumes are in cubic feet. The volume calculated in cubic feet can then be converted into pounds then into tons or gallons depending on the density of the manure. See conversion factors in Table 1.

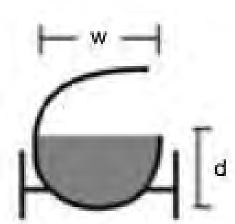
For solid or semisolid manure:



Box spreader (level load)
Volume = length (l) × width (w) × depth (d)



Box spreader (piled load)
Volume = length (l) × width (w) × depth (d) ÷ staking height × 0.8

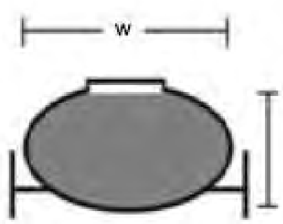


Flail-type barrel
Volume = length (l) × width (w) × depth (d) × 1.6

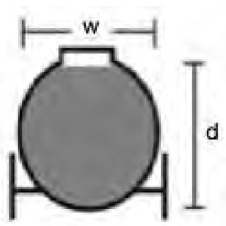
Example: You have measured your box spreader (level load) and found the inside dimensions to be 12 feet long and 5 feet wide. An average depth of load is 4 feet high:

Volume = 12 ft × 5 ft × 4 ft = 240 cu ft Your 5-gallon bucket weighed 3 pounds when empty and 42 pounds when filled with manure: Density = (42 lb - 3 lb) x 1.5 = 58.5 lb /ft^3 Tons/load = 240 (lb) × 58.5 (lb/ft^3) ÷ 2000 (lb/ton) = 7.02 ton

For liquid manure:
For **tank spreaders**, you assume that the tank is not completely filled because of foaming. Therefore, you measure the volume and then multiply it by 80%:



Round tank spreader
Volume = length (l) × tank diameter (d) × tank diameter (d) × 0.8



Noncircular tank spreader
Volume = length (l) × width (w) × depth (d) × 0.8

Example: How many gallons of manure do you haul to the field with your 3,000-gallon closed tank spreader?

The maximum rated capacity of your closed tank spreader is 3,000 gallons. You should assume that the tank is not completely filled because of foaming.

Hauled capacity = 3,000 gal x 0.8 = 2,400 gal

Manure Density

The density of manure (weight per cubic foot) will vary depending on the moisture content. Moisture content is affected by bedding material and water in manure. Bedding will decrease density, while water, more moisture, increases density. To calculate the density of manure:

1. Obtain at least 3 containers. (5-gallon buckets work well). This will allow you to calculate the average density of manure, which is more accurate.
2. Weigh container empty and record weight in pounds.
3. Add a typical sample of manure to container and weigh. Subtract weight of empty bucket (Step 2) from the weight of manure and container (Step 3). Record the manure weight in pounds.
4. Repeat (Steps 2 and 3) until all containers have been used and calculate the average manure weight. The average weight can be calculated by adding all manure weights together then divide by the number of times you recorded the manure weight. Record average manure weight in pounds.
5. Multiply the average manure weight (Step 4) by 1.5 to determine the estimated manure density in pounds per cubic foot.

Density = [wt. of 5-gal bucket full of manure – wt. of empty bucket] × 1.5

Table 1. Commonly used conversions for manure spreader volumes.

To convert from	To	Multiply by
Bushels	Cubic feet	1.24
Gallons	Cubic feet	0.134
Gallons	Pounds	8.3 (liquid)
Gallons	Tone	0.0041 (liquid)
Cubic feet	Gallons	7.48
Cubic feet	Tons	0.031 (liquid) or 0.0275 (solid)
Cubic feet	Pounds	62 (liquid) or 55 (solid)

Resources

Jokela, B. *Manure Spreader Calibration*. University of Vermont Cooperative Extension Service. www.uvm.edu/pss/vtcrops/articles/**Manure**Calibration.pdf

Natural Resources Conservation Services. *Calibrating a Manure Spreader.* http://wmc.ar.nrcs.usda.gov/technical/WQ/calibrating.html

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Manure Application on Hay Fields

Introduction

Manure is an excellent nutrient source for fertilizing hay fields, especially with current high fertilizer prices. Topdressing hay fields with manure can build soil fertility with on-farm resources and help expand acres for spreading. However, for efficient use of manure some considerations have to be made.

Grass Hay

Grass hay has a high demand for all manure nutrients and will make more efficient use of manure nutrients compared to legume based hay. If manure is not spread between hay cuttings it should be stored and spread in the fall when manure nutrient use efficiency is generally very low. Therefore application of manure on hay fields can increase the economic return from manure nutrients compared to late fall applications of the same manure for next year's crops.

Topdressing hay fields with manure can build soil fertility with on-farm resources and help expand acres for spreading.

When manure is used as the sole source of nitrogen for a grass hay crop, other nutrient levels in the soil, specifically phosphorous and potassium may increase over time.

The following management is recommended for application of manure on grass hay fields:

1. Follow regular soil testing to monitor soil nutrient level.
2. Manure should be applied as soon as possible after cutting to reduce potential injury to the regrowth.
3. Apply manure when soil is not wet. Driving heavy manure spreaders on wet soils causes soil compaction.
4. Nitrogen application rate should be based on the expected yield of the next growth. The actual rate should be 50 lb N/ton of expected hay yield.
5. On average, 1000 gallons of slurry contains 22-28 lb of N and one ton of solid manure contains 8-10 lb N. However, on average only 50% of N in manure is available for the current crop thus, you should expect only 40 lb of N/A if you are applying 3000 gals of liquid manure; (3000 gal/A x 26 lb N/1000 gal x 0.50 = 40).
6. Depending on the rate applied, supplemental fertilizer N may be needed for maximum hay production.
7. Liquid manure is probably best on hay fields because there is less chance of smothering and producers are less likely to gather up remnants of the manure in the next hay harvest.

When manure is used as the sole source of nitrogen for a grass hay crop, other nutrient levels in the soil, specifically phosphorous and potassium may increase over time.

Alfalfa Hay

Compared to grass hay, alfalfa requires high phosphorus and potassium levels making manure an excellent source of these nutrients as well is boron for alfalfa production. Some research in Wisconsin and Minnesota has shown manure can sometimes improve alfalfa yields when compared with commercial fertilizer sources. However, there are significant challenges in managing manure on alfalfa without damaging the productivity of the stand, particularly with solid manure and manure slurries.

Some caution is needed to prevent damage to establishing and established alfalfa fields from manure applications.

Established Alfalfa

1. Apply manure as soon as possible after harvest to avoid salt burn injury and wheel track damage to regrowing alfalfa.
2. Use equipment that applies uniformly and without clumps.
3. Apply to older and poorer stands.
4. Consider the potential for forage contamination with the Johne's disease.
5. Johne's bacterium is not absorbed by plants, but resides on manure and soil particles for a limited time. Allow more time between manure applications and forage harvest, minimize forage contact with soil and manure particles and use the forage as silage because fermentation kills the organism. Calves are more susceptible to the disease than mature animals.

Seeding Alfalfa

Applying manure before alfalfa seed is planted is excellent for alfalfa production while avoiding many problems associated with surface application on established stands.

1. Manure applied before planting must be incorporated into the soil.
2. The alfalfa seed should not be in direct contact with a manure layer during germination, and the seedling should not grow through a layer of manure at the soil surface.
3. The preplant application strategy is best suited for producers who have slurry or solid manure systems.
4. Producers should be prepared to manage the increased weed pressure with timely harvests or herbicides.

Resources

Applying Manure to Alfalfa, Pros, Cons, and Recommendations for Three Application Strategies. University of Wisconsin Cooperative Extension Service. http://www.soils.wisc.edu/extension

Applying Manure to Alfalfa. University of Wisconsin Cooperative Extension Service. University of Wisconsin Cooperative Extension Service. http://www.uwex.edu/ces/crops/teamforage

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Lory, J., et. al., 2002.*Managing Manure for Alfalfa Hay.* http://www.mbforagecouncil.mb.ca/Forage%20Manual%20Article/5-0%20Forage%20Fertility/5-15%20Manure%20on%20Alfalfa%20Hay-%20Missouri.pdf

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Prioritizing Fields for Manure Application

Based on soil test and state specifications, fields are required to be ranked for receiving manure.

Prioritization of fields for manure application saves money and protects the environment.

Introduction

Spreading livestock and poultry manure on crop and pastureland is an increasingly popular and recommended way to provide plant nutrients or to fertilize fields. This reduces the need to purchase feed and inorganic fertilizer. Managing manure to optimize its economic returns and at the same time minimize its potential environmental impact is critical.

In the past, manure spreading strategies have often been based on convenience. Usually those fields that are closest to the barn receive most manure. This strategy does not account for the economic value of nutrients in the manure and fails to protect the environment, especially air and water quality.

Every farm is unique with respect to site conditions, cropping patterns, and number and type of livestock. However, there are basic criteria that can be used for developing a manure application strategy. Based on soil and manure analysis, cropping system, and site limitations, fields can be ranked from highest to lowest priority for receiving manure.

What follows is a simple and flexible ranking method which farmers can use to quickly determine which fields should have priority for receiving manure. Fields with the highest accumulated points should be considered priority fields for manure application.

Category	Points*	Field # 1 2 3
1. Planned Crop (select one only)		
a. Continuous corn or corn not following legume:		
yield goal > 25 ton/acre	10	
yield goal 20-24 ton/acre	9	
yield goal <20 ton/acre	8	
b. Second-year corn following legume	8	
c. First-year corn following legume	1	
d. First-year corn following non legume	10	
e. Non-forage legume	2	
f. Small grains	6	
g. Prior to direct seeding legume forage	7	
h. Top dress (good legume stand)	1	
i. Top dress (fair legume stand)	2	
j. Top dress (poor legume stand)	3	
k. Hay grass	6	
2. Phosphorous and Potassium soil test level (select one for each category)		
A: Phosphorous (ppm)		
a. < 5 (Very low)	15	
b. 6-10 (Low)	12	

c.11-15 (Medium)	10
d. 16-20 (Optimum)	6
e. 21-25 (High)	4
f. 26-30 (Very high)	1
g. >30 (Excessive)	0

B: Potassium (ppm)

a. <70 (Low)	10
b. 71-120 (Medium)	8
c. 121-240 (High)	4
d. >240 (Very high)	0

3. Site / Soil conditions
(select one for each category)

A: Proximity to surface water or ground water

a. Manure applied and incorporated within frequently flooded plain or within <150 ft of surface water or ground water access	1
b. Manure applied and incorporated within frequently flooded plain or within 150-300 ft of surface water or ground water access	3
c. Application outside these restrictions	5

B: Slope (%)
(Do not apply in winter (Dec–Feb) if slope > 2 %)

a. <2	10
b. <6 (incorporated, contoured, or terraced)	8
c. <6 (no runoff reduction practices)	6
d. <12 (with runoff reduction practices)	4
e. <12 (no runoff reduction practices)	2
f. >12	1

C: Soil texture

a. Sands, sandy loams, loamy sands (fall app.)	1
b. Sands, sandy loams, loamy sands (spr. app.)	3
c. Other soils	5

D: Depth to bedrock (inches)

a. 0-10	0
b. 10-20	1
c. > 20	5

E: Years since manure applied

a. > 5 years	10
b. 2-5 years	5
c. applied manure last year	0

F: Distance to storage

a. <2 miles	10
b. 2-6 miles	5
c. 6-10 miles	0
d. >10 miles	-10

G: Odor and neighbor concerns -20

4.TOTAL POINTS

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Manure as a Nutrient Resource

The total available manure N for plant growth is derived from 3 sources:

- ammonium N from current application
- mineralized stable N from current application
- mineralized organic N from past applications

Introduction

Manure is rich in nutrients, including trace elements necessary for crop growth. Approximately 70-80% of nitrogen (N), 60-85% of phosphorus (P), and 80-90% of potassium (K) found in feeds is excreted in the manure. These nutrients can replace fertilizer needed for pasture or crop growth, eliminating the need to purchase fertilizers. Plants do not distinguish between sources of nutrients. However, compared to commercial fertilizer, manure contains organic carbon which is the key to maintaining soil health, including the characteristics of cation exchange capacity, soil tilth, and water holding capacity.

The nutrient value of manure depends on many factors. These include animal species, feed ration, the amount of bedding and water added or lost, the method of manure collection and storage, and the method of land application. The availability of nutrients and efficiency of utilization of these nutrients by a crop is also influenced determined by soil and climate conditions. These conditions affect the microbial activity responsible for decomposition of manure and other sources of organic matter within the soil.

Manure Nitrogen Credits and Availability

Manure contains unstable (inorganic) and stable (organic) forms of nitrogen. The inorganic N is initially present in urine and as urea in animal manure. It may account for up to 50% (70% in poultry) of the total N. Urea converts rapidly to ammonium then to ammonia gas as *p*H increases and manure begins to dry. If not lost, the ammonium from urea in manure is readily available for plant growth. However, ammonia is extremely volatile resulting in N loss. Nearly all the ammonium N can be lost from surface applied manure if it is not incorporated within a few hours.

Application Method	Ammonia-N Loss (%)
Injection	0
Surface application	100
Incorporated within 1 day	20
Incorporated within 2 day	50
Incorporated within 3 day	60
Incorporated within 4 day	70
Incorporated within 5 day	80

Liquid dairy manure contains, on average, 10-12 pounds of ammonium N per 1,000 gallons. Therefore, incorporation of 8,000 gallons of manure per acre on the same day can save up to 70 lbs of N fertilizer compared to surface application with no incorporation.

The stable organic N that occurs in the feces will be gradually released into the soil, providing a steady supply of nutrients which will be available to the crop throughout the growing season. Approximately 40-50% of the stable organic N in dairy manure will be available the first year, 12-15% the following year, 5% in the third year, and 2% in each subsequent year. The total available manure N for plant growth comes from 3 sources: Available N = (ammonium N from current application) + (mineralized stable N from current application) + (mineralized organic N from past applications).

Manure Phosphorus and Potassium Credits and Availability

Manure is an excellent source of P and K. When manure is applied at a rate to meet the N need of a crop, the P and K will likely be in excess of the crop requirement. Essentially all of the K is available for plant growth the year manure is applied. However, some of the P may be in the form of insoluble inorganic compounds or as organic P. Like stable organic N these compounds must be mineralized before they become available. Conserving N in manure increases the P efficiency for crop growth by reducing the total application of manure and therefore reducing excess P that can become a water pollutant.

The following table demonstrates the average manure nutrient content of varying stages of the dairy herd. Nutrient content of manure varies widely, so it is advisable to have a manure and soil sample tested before application to a field in order to determine specific nutrient needs for crop growth.

Animal Type	% Dry Matter	Analysis Unit	N	P_2O_5	K_2O
Dairy cattle					
milking cows, liq.	<5	lb/1000 gal	28	13	25
milking cows, sol.	12	lb/ton	10	4	8
Dry cow		lb/ton	9	3	7
Calf and heifer		lb/ton	7	2	7
Veal	4	lb/1000 gal	36	27	55

Adapted from the Penn State Agronomy Guide.

Application Considerations

Timing and method of manure application determine the efficiency of nutrient recycling. Also, manure must be spread uniformly to achieve consistent results. Proper calibration of a manure spreader will help insure the correct rate and uniform application. Applying and incorporating manure too early for the crop, in the fall or early winter, or in overly saturated soils could result in significant N leaching and groundwater contamination. Likewise, surface runoff and soil erosion must be controlled to protect surface waters. A cover crop, such as winter rye, planted early (late August to early September) can be effective in reducing nitrogen leaching through plant uptake, and can help with controlling surface erosion.

Resources

Cornell University Cooperative Extension. 2009. Cornell Guide for Integrated Field Crop Management. www.fieldcrops.org .

Manure Analysis Form for the University of Maine Analytical Lab: http://anlab.umesci.maine.edu/soillab_files/forms/Manure.pdf.

Pennsylvania State University. The Agronomy Guide 2011-2012. http://agguide.agronomy.psu.edu/.

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Vermicomposting on Dairy Farms

Introduction

Dairy farms face many challenges when it comes to managing manure. The use of earthworms to fully compost manure has been of increasing interest in the dairy industry. Earthworms, more specifically, the Red Wiggler (*Eisenia fetida*) and the Red Worm (*Lumbricus rebellus*) are found in areas rich in organic matter, like the topsoil layer or in manure piles. These two species of worms, due to their high tolerance of environmental factors such as temperature, moisture, and pH, and shallow feeding habits, are the desired species for degrading vast amounts of organic materials into vermicompost. Vermicompost is the end product of earthworms' consumption of organic materials in the form of nutrient rich "castings" and degraded bedding materials. Dairy producers are in an advantageous position to incorporate vermicomposting into their manure handling systems due to the vast amounts of resources available from the farm such as manure and crop residues that can be used as bedding and feedstock for the worms. Vermicomposting can provide a dairy farm with beneficial nutrient soil amendments while also giving the opportunity for added income if worms or castings are sold.

Vermicompost enhances overall plant growth, suppresses diseases, and increases microbial activity in the soil, while improving physical characteristics of the soil such as water holding capacity, aeration, and porosity, of which all benefit soil fertility.

Earthworm Production

There are several options for vermicomposting systems depending on the scale desired. The key to a productive and successful vermicomposting system is maintaining a healthy living environment that facilitates growth and reproduction of the worms. Several factors such as temperature, bedding materials, moisture, aeration, pH and food content effect productivity.

Temperature

Earthworms can tolerate conditions that are between 55° to 85° F. However, they best thrive in environments that maintain temperatures between 60° and 70° F. At either extreme, these temperatures will slow down worm production. Vermicomposting is not conducive to extreme temperatures. Temperature can be controlled by adjusting the amount of bedding, adding water (moisture), activating fans near the system or reducing feedstock. In Massachusetts, where weather can be variable from season to season it is advised to have protection from extreme temperatures. This can be achieved by building insulation around the system or using fans to cool.

Dairy producers are in an advantageous position to incorporate vermicomposting into their manure handling systems due to the vast amounts of compostable resources available from the farm like manure and crop residues that can be used as bedding and feedstock for the worms

Bedding Materials

Many organic residues such as plant wastes and solid composted manure can be utilized as bedding materials. In general, the bedding material should retain moisture, remain loose and aerated, and be low in protein and nitrogen due to their effect on increasing soil pH, which is detrimental to the worms. The bedding material should be varied in order to provide a range of nutrients for the earthworms and to produce richer compost.
Suitable bedding materials include:

- Semi-composted solid manure
- Shredded or mulched paper such as newspaper (non colored)
- Cardboard
- shredded fall leaves
- chopped up straw
- sawdust

Feedstocks and Feeding Rates

Worms will consume manures, compost, food scraps, paper, or almost any organic matter. The precise loading rate (at which raw feedstock can be added to a worm bed to encourage the worms to concentrate at or near the surface) will vary depending on the feedstock being used, temperature, moisture levels and the density of the worm population. Proper loading rates require that new feedstock is not added until the majority of the previously added feedstock has been decomposed.

Worms should be feed on a regular schedule. When most of the current feed has been consumed, then it is time to feed again. Just as any living creature, worms need protein to grow. If worms are not growing, add a high protein feedstock like grains, mashes, or cottonseed meal.

Pre-composting

Manure feedstocks and bedding should be pre-composted to prevent worm systems from experiencing too much heat. Fresh manures contain a lot of energy that transfers into extra heat when incorporated into the worm systems. High heat in the worm beds can be fatal. Therefore, before using manure as a bedding or feedstock material, it is recommended to semi-compost it for at least 10 to 14 days to retain sufficient nutrition for the worms.

Systems for Production

Beds and/or bins- are the most common small-scale system. Bins can be constructed out of several materials such as wood, plastic, or recycled containers like bathtubs and barrels. Bins should be 8 to 12 inches deep. The size will depend on the amount of feedstock and bedding available. As a rule of thumb, provide at least 1 square foot of surface area per pound of feedstock.

Windrows- are linear piles of feedstocks situated on the ground level that are either covered or uncovered. The windrow is started by spreading a layer of organic materials 12 to 18 inches deep. Next, redworms can be added at a rate of up to one pound per square foot. Add feedstock to windrow by layering 2 to 3 inches per week on top of current pile. Pile should not exceed height of 3 feet for the ease of management. Harvest worms with light method.

The wedge system- this system is a modification of the windrow system by adding feedstock to existing windrow at a 45 degree angle. By creating a "wedge" next to the current windrow being used, the redworms will migrate toward the "fresh" pile. Add organic materials to this new pile till it reaches a height of 3 feet then begin a new wedge. Worms will move laterally through the piles. Eventually after 2-6 months, you will be able to harvest the first pile and subsequent piles after.

Continuous-flow reactors are systems with raised beds that have side walls and mesh bottoms with openings that are either 2 inches by 4 inches, or 2 inches by 2 inches. Lay material such as newspaper on the mesh so as to prevent bedding from falling through. Spread about 12 inches of bedding on top of the newspaper. Place redworms on top of the bedding at a rate of ½ to 1 pound per square foot of surface area. Feedstocks are then added in layers on top of the bedding. Vermicompost can be harvested by scraping a thin layer just above the mesh to allow contents to fall into catchment chamber. These systems work best under cover.

Harvesting

Systems should be harvested on average every 30 days to maximize production. There are several options available for harvesting the worms depending on the system utilized. The most commonly used technique for small-scale systems is called the "light method". Shine a bright light or place the bin near bright sunlight. The light will drive the worms down into the materials so that you can now harvest the top layers carefully. Repeat this process until you have a harvested most all of the worms.

Vermicompost and Its Value

Worms' excrements are in the form of casts which consist of granules, surrounded by mucus that quickly hardens when exposed to air. These casts are them mixed with the composted worm bedding to create Vermicompost. In ideal growing conditions, worms can consume their own weight in organic matter in one day. Therefore, one ton of worms can consume one ton of organic waste per day. The nutrient content of vermicompost will depend on the type of feedstock and bedding provided for the worms. Vermicompost enhances overall plant growth, suppresses diseases, and increases microbial activity in the soil, while improving physical characteristics of the soil such as water holding capacity, aeration, and porosity, of which all benefit soil fertility.

Table 1. Chemical characteristics of garden compost and vermicompost, 1994.

Parameter*	Garden Compost[1]	Vermicompost[2]
pH	7.80	6.80
EC (mmhos/cm)**	3.60	11.70
Total Kjeldahl nitrogen(%)***	0.80	1.94
Nitrate nitrogen (ppm)****	156.50	902.20
Phosphorous (%)	0.35	0.47
Potassium (%)	0.48	0.70
Calcium (%)	2.27	4.40
Sodium (%)	< .01	0.02
Magnesium (%)	0.57	0.46
Iron (ppm)	11690.00	7563.00
Zinc (ppm)	128.00	278.00
Manganese (ppm)	414.00	475.00
Copper (ppm)	17.00	27.00
Boron (ppm)	25.00	34.00
Aluminum (ppm)	7380.00	7012.00

[1]Albuquerque sample
[2]Tijeras sample
*Units, ppm=parts per million m mhos/cm=millimhos per centimeter
** EC, electrical conductivity is a measure (millimhos per centimeter) of the relative salinity of soil or the amount of soluble salts it contains.
*** Kjeldahl nitrogen is a measure of the total percentage of nitrogen in the sample including that in the organic matter.
**** Nitrate nitrogen that nitrogen in the sample that is immediately available for plant uptake by the roots.

Adapted from Dickerson, Geroge W. 2004. Vermicomposting. www.aces.**nmsu**.edu/desertblooms/**nmsu**gardening/docs/chap_1/chap1.h.pdf

Considerations

If you are considering setting up an operation, there are a few important questions that you may want to consider:

- What are your intentions for starting?
- For on farm nutrient management?
- To produce and sell into a market?
- How much time and money are you willing to invest?
- How will you produce the product(s)?
- How can you market the product(s)?

Check with local and state agencies for zoning or regulations that may need to be addressed such as permits or the need of a business or resale license if you plan to sell vermicompost.

Potential Markets

Vermicomposting offers the potential sale of both vermicompost and earthworms. Vermicompost can be sold directly from the farm to gardeners, or wholesaled to garden centers and interested agricultural businesses. Earthworms can be sold to a variety of recipients, such as home vermicomposters, garden centers, fish hatcheries, the bait market, pet stores, poultry producers, educational facilities, and private labs.

Resources

Dickerson, George W. 2004. Vermicomposting. H-164. New Mexico State University Cooperative Extension Service. www.aces.**nmsu**.edu/desertblooms/**nmsu**gardening/docs/chap_1/chap1.h.pdf

Munroe, Glenn. Manual of On-Farm Vermicomposting and Vermiculture. Organic Agriculture Centre of Canada. www.organicagcentre.ca/docs/vermiculture_farmersmanual_gm.pdf

Sherman, Rhonda. 2003. Raising Earthworms Successfully. EBAE 103-83. North Carolina State University Cooperative Extension Service. www.bae.ncsu.edu/topic/vermicomposting/pubs/earthworms.pdf

For more information visit www.umass.edu/cdl

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UMass Extension

Runoff Control from Barnyards and Feedlots

Proper runoff management can result in:

- **Avoidance of stream pollution by phosphorus and other potential pollutants.**
- **Reduced manure storage.**
- **Reduced costs related to manure handling and land application.**
- **Improved animal health through reducing food disease and other ailments.**

Roof gutters, surface water diversions and drip trenches can keep water clean, and away from the barnyard.

Introduction

Runoff management allows dairy farmers to direct rainwater and/or other runoff water away from their manure storage facilities and confined animal feeding areas. Benefits from runoff control include but are not limited to:

- Avoidance of stream pollution by phosphorus and other potential pollutants
- Reduced manure storage
- Reduced costs related to manure handling and land application
- Improved animal health through reducing food disease and other ailments

Managing Runoff

Careful planning, to determine the location and size of the barnyard/feedlot, helps to minimize the risk of water entering the barnyard/feedlot as well as the amount of water running off from a precipitation event and the potential for pollution. The barnyard/feedlot needs to be on a surface that can be cleaned so that manure may be removed. This limits the quantity of manure that could potentially be washed off. Providing a hard surface allows the cleaning operation to be done without forming pockets that can collect leachate or change the runoff flow.

The runoff water should be collected so that it can be stored or treated. If it is to be stored, gravity flow to an appropriately sized waste storage facility is preferred. If the runoff will be treated, pretreatment, by settling to remove most of the solids, and topography are suitable for improved barnyard/feedlot construction.

Various management practices are available to collect and/or treat the runoff from barnyards and feedlots. Water that comes in contact with animal manure must be handled as waste.

The following examples can keep water clean and prevent it from entering the barnyard/feedlot:

- Roof gutters
- Surface water diversions
- Drip trenches

The following management practices can be used to divert runoff from roof gutters and paved areas away from animal areas:

- Grass filter buffers
- Sediment basins
- Diversions
- Subsurface drainage
- Evaporative or shallow holding ponds in drier conditions.

A constructed wetland can trap any solids or other pollutants carried by runoff before being allowed to enter streams or other sensitive areas. Less water in the barnyard/feedlot decreases the velocity and carrying capacity of flows in the area, resulting in less detachment of manure particles.

Runoff settling basin

Less flow also slows the water, which can allow manure particles to settle where a sediment trap is designed into the runoff management system.
As a result of installing BMPs to reduce runoff, the feedlots and loafing areas will be drier, allowing farmers to manage their daily operations more easily. Animal health can improve due to reduced foot disease and other ailments.

Resources

Wright, P. *Barnyard/Feedlot Runoff Management*. Natural Resources Conservation Service. http://www.sera17.ext.vt.edu/Documents/BMP_barnyard_feedlot.pdf

USGS. 1998. *Effectiveness of Barnyard Best Management Practices in Wisconsin*. USGS Fact Sheet FS-051-98 http://wi.water.usgs.gov/pubs/FS-051-98/

Conservation Practices Minnesota Conservation Funding Guide. *Feedlot Runoff Control System.* http://www.mda.state.mn.us/protecting/conservation/practices/feedlotrunoff.aspx

Conservation Practices Minnesota Conservation Funding Guide . *Roof Runoff Management*. http://www.mda.state.mn.us/protecting/conservation/practices/roofrunoff.aspx

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Dairy Waste Management and Composting

Make sure C: N ratio is adequate.

A Carbon: Nitrogen (C: N) ratio of 30:1 is considered ideal for composting.

A compost thermometer with a long probe for reaching the interior of the pile is useful for monitoring temperature.

Introduction

Waste management is all about how to dispose of all the things you don't want on the farm. Composting is a sustainable waste management practice that converts a large volume of accumulated organic waste into a usable product. When organic wastes are broken down by microorganisms in a heat-generating process, waste volume is reduced by almost 50%, many harmful organisms including pathogens and weed seeds are destroyed, and a useful, potentially marketable product is produced. In a dairy operation, the majority of organic wastes will likely be manure combined with spoiled hay and feed, and animal bedding. Adding compost to soil increases organic matter content. This, in turn, increases the population and diversity of the beneficial microorganisms and earthworms in the soil and therefore improving many soil characteristics and allows for the slow release of nutrients for crop use in subsequent years.

How to Compost

Materials for successful composting are many. In order to facilitate composting, a suitable environment must exist. The microorganisms which degrade organic wastes use carbon for energy, and nitrogen for protein. Organic matter contains carbon and nitrogen in varying amounts and ratios. A Carbon: Nitrogen (C: N) ratio of 25-30:1 is considered ideal for finished compost. Too much carbon (woody materials) or very large particle size slows the process down. When too much N is present, the compost may become too hot, killing the composting organisms. The C: N ratio will depend on the type of bedding used and the manure: bedding ratio. Table 1 below shows C: N ratios of some materials.

When making compost, size of operation determines how the system will be managed. Very small scale composting can be done in a small plastic bucket. Large scale composting requires long rows of waste, turned by tractors using "windrowing" equipment. In between are piles can be managed with a manure fork or a bucket loader attached to a tractor.

Attaining composting temperatures is the key to successful composting. The composting microorganisms i.e. bacteria and fungi, operate best in a warm, damp, well aerated environment. This condition will not likely exist on the very outside of a pile of organic wastes. Thus it is important to:

a) have enough volume of composting material to create a warm interior
b) mix up or turn the pile frequently. Large volumes can be handled in windrows which can be turned using a tractor mounted bucket

Frequency of turning will be a function of materials being composted, water, aeration, weather conditions, and microorganisms present. Water is necessary for the microorganisms to live and work, but too much water can create anaerobic conditions which are not conducive to the composting process. Water can be controlled by either watering the pile if too dry (<40% moisture = crumbly), or covering the pile loosely if too rainy. Heat is very important in the killing of weed seeds and other harmful organisms. Heat generation also indicates that the composting process is working. A final temperature of 150-160^{o} F is ideal. Higher temperatures may kill the composting organisms. When the temperature reaches 160^{o} F, turn the pile. When the compost texture is uniform, and turning the pile no longer results in a temperature rise, the compost is considered finished! A compost thermometer with a long probe for reaching the interior of the pile is useful for practical and easy monitoring.

Table 1. Carbon to Nitrogen Ratios for Selected Materials (by weight)

Materials with high N	C:N Ratio
Grass clippings	12-25:1
Cow manure	20:1
Horse manure	25:1
Poultry litter	13-18:1
Materials with high C	
Leaves	30-80:1
Corn stalks	60:1
Straw	40-100:1
Bark	100-130:1
Paper	150-200:
Wood chips and sawdust	100-500:1

The above table is an excerpt taken from the publication, FSA-6036, http://www.uaex.edu/Other_Areas/publications/pdf/FSA-6036.pdf , of the University of Arkansas, Division of Agriculture, Cooperative Extension Service

Note that the C:N ratios given for cow and horse manure do not include bedding. Addition of sawdust bedding will raise C:N ratios significantly. Addition of sand bedding will not affect C:N ratio, but will increase the density of the finished compost. Look for a mix of materials which will result in an overall 30:1 C:N ratio.

What not to Compost (and what do with it)

Many hazardous materials are not suitable for composting. A small amount of an unsuitable product can destroy a large amount of compost.

When grass clippings are added to the compost for increasing N content (decreasing C: N) the lawn should be chemical free, otherwise plants receiving the compost may be seriously damaged. Plants with especially damaging diseases, such as late blight of tomato and potato, which is caused by the fungus Phytopthera, should not be composted, because if the disease is not killed in the composting process, the spread of the disease can be devastating. Materials such as pressure treated lumber contain heavy metals (arsenic) and should not be composted. Proper disposal in Massachusetts is described in following link: http://www.mass.gov/dep/toxics/ptwoodqa.htm "Small amounts" of such materials may be taken to landfills.

Pesticides can only be composted if it is clear from the label that the material in question will break down into harmless components in the composting process and will not kill the composting microorganisms. Pesticide labels should list proper disposal methods.

Inorganic materials cannot be composted. Plastics must be recycled or disposed of in a landfill. Retailers in Massachusetts are required to accept used motor oil in the quantity you purchased from them, but only if you have the receipt. Tires, metals items which cannot be separated according to specific content (aluminum, steel, etc.), and plastics are difficult to dispose of, but hard to manage without. It is possible using Internet searches to find reasonably local businesses which will recycle tires and sorted metals.

Animals and animal products may be composted in some situations. In a large scale system, even large livestock carcasses may be composted (see www.umass.edu/cdl/BMPs/DisposalofDeadLivestockandEquine08-14.pdf). Caution should be taken when composting animal products, as the short-term odors may attract compost-disrupting wildlife and dogs.

Resources

Frederick C. Michel, Jr., et al. Effects of Straw, Sawdust and Sand Bedding on Dairy Manure Composting. Department of Food, Agricultural, and Biological Engineering, Ohio Agricultural Research and Development Center, Ohio State University, Wooster, Ohio. www.cals.ncsu.edu/waste_mgt/natlcenter/sanantonio/Michel.pdf

Hirrel, Suzanne Smith, et al. *Composting.* University of Arkansas Cooperative Extension Service. http://www.uaex.edu/Other_Areas/publications/PDF/FSA-2087.pdf

Massachusetts Department of Agricultural Resources:

Composting Program Informatio: http://www.mass.gov/agr/programs/compost/index.htm

Guide to Agricultural Composting. Revised 2010.http://www.mass.gov/agr/programs/compost/docs/Guide_to_Ag_Composting2010.pdf

Washington State University has a web publication explaining the composting process very well. There are five separate sections of Compost Fundamentals as follow:

- http://whatcom.wsu.edu/ag/compost/fundamentals/consideration_destruction.htm
- http://whatcom.wsu.edu/ag/compost/fundamentals/consideration_pesticides.htm
- http://whatcom.wsu.edu/ag/compost/fundamentals/consideration_fly_control.htm
- http://whatcom.wsu.edu/ag/compost/fundamentals/consideration_reclamation.htm
- http://whatcom.wsu.edu/ag/compost/fundamentals/consideration_time.htm

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Dairy Cow Welfare Issues

Major welfare issues associated with dairy cattle include:

1) castration

2) disbudding and dehorning

3) tail docking

Introduction

The American Veterinary medical Association (AVMA) recognizes that **castration and dehorning** of cattle are important for human and animal safety when cattle are used for agricultural purposes. Because castration and dehorning cause pain and discomfort, the AVMA recommends the use of procedures and practices that reduce or eliminate these effects, including the use of approved and clinically effective medications whenever possible. Studies indicate that preoperative use of non-steroidal anti-inflammatory agents and local anesthetics reduces pain and distress associated with castration and dehorning. Both dehorning and castration should be done at the earliest age practicable. Disbudding is the preferred method of dehorning calves. Local anesthetic should be used for other dehorning procedures. Elastrator rubber banding techniques have been associated with increased chronic pain and should be discouraged. High tension-banding systems may be used with appropriate veterinary supervision and/or training in those situations where surgical castration may predispose to postsurgical complications. There are a number of acceptable castration techniques utilized by the cattle industry. The castration method used should take into account the animal's age, weight, skill level of the technician, environmental conditions, and facilities available, as well as human and animal safety. Research leading to new or improved techniques that reduce or eliminate pain and distress associated with castration and dehorning, or development of viable alternates to castration and dehorning, is encouraged.

Tail docking

Tail docking is a management practice used within the dairy industry. The dairy industry in New Zealand developed the process during the early 1900s as an attempt to reduce the incidence of leptospirosis in milking personnel. The stated goals of tail docking include improved comfort for milking personnel, enhanced udder cleanliness, reduced incidence of mastitis, and improved milk quality and milk hygiene. In the USA, California has passed legislation banning routine tail docking in dairy cattle and similar actions have been proposed in other states. Current AVMA policy opposes routine tail docking of cattle. The current position of the American Association of Bovine Practitioners (AABP) states that: "The AABP is not aware of sufficient scientific evidence in the literature to support tail docking in cattle. If it is deemed necessary for proper care and management of production animals in certain conditions, veterinarians should counsel clients on proper procedures, benefits, and risks."

Figure 1: Castration equipment.

Castration of Male Cattle

Castration is common practice throughout the world. Although castration inflicts pain on the animal and causes a period of slow growth rate and poorer feed efficiency there are benefits as well. Castration reduces aggressiveness and sexual activity by lowering testosterone levels, and modifies carcass characterictics in animals sold for beef. There are several different methods of castration; they can be classified into three major groups:

physical, chemical, and hormonal. These groups can be divided further by technique but overall castration is achieved by removing the testicles surgically, damaging them irreparably, or causing them to atrophy by stricture of the blood supply.

All physical methods of castration cause pain. Animals exhibit pain responses during and after castration; these responses include struggling, kicking the hind legs, tail swishing, foot stamping, head turning, restlessness, stilted gait, reduced activity, increased recumbency, abnormal standing posture, reduced interest in dams and each other, and reduced grazing and feed intake.

Pain associated with the surgical and Burdizzo clamp methods is relatively immediate, whereas pain resulting from elastrator ring/band placement is delayed due to interruption of the blood supply by the band/ring. Three-to 4-week-old calves castrated using rubber rings exhibited no signs of pain at the time of ring placement. In contrast, Burdizzo-castrated calves demonstrated marked signs of pain if not anesthetized, and mild to moderate pain if anesthetized prior to castration. Potential complications associated with castration include hemorrhage, excessive swelling or edema, infection, poor wound healing, and failure. Use of the Burdizzo clamp may be associated with a higher failure rate, most likely caused by operator error.

Risk of hemorrhage is greater after surgical castration and is associated with higher complication rates including bleeding, swelling, infection, and death. Application of local anesthesia prior to castration is mandated in some countries, and significantly reduces the pain response to castration. Castration is considered to be a necessary management practice for cattle. Although younger cattle exhibit less pain, stress, and distress in response to the procedure, all methods of castration induce pain and physiologic stress in animals of all ages. Pain and physiologic stress resulting from castration should be minimized to provide for the overall welfare of the animal. Research results suggest that application of local anesthesia and the administration of analgesics have the potential to minimize or eliminate pain and stress associated with castration. For a visual of equipment used for castration, see Figure 2.

Disbudding and Dehorning

Disbudding involves destroying the horn-producing cells of the horn bud.Horn buds are removed without opening the frontal sinus. Chemical and hot-iron disbudding methods destroy the horn-producing cells, whereas physical methods of disbudding excise them. Hot-iron disbudding is commonly performed and is reliable, but it is considered to be quite painful and local anesthetic should always be used with this procedure.

Figure 2: Dehorning equipment.

Dehorning is removal of the horns after they have formed from the horn bud. Physical methods of dehorning (gouge dehorning) include the use of embryotomy wire, guillotine shears, or dehorning knives, saws, spoons, cups, or tubes. The Barnes-type scoop dehorner is commonly used for physical dehorning. The presence of the cornual diverticulum of the frontal sinus causes surgical dehorning of adult cattle to be more invasive.

Dehorning of adult cattle is associated with increased risks of sinusitis, bleeding, prolonged wound healing, and infection, and should be avoided. Dehorning cattle conveys some advantages. Dehorned cattle require less feeding trough space; are easier and less dangerous to handle and transport; present a lower risk of interference from dominant animals at feeding time; pose a reduced risk of injury to udders, flanks, and eyes of other cattle; present a lower injury risk for handlers; and exhibit fewer aggressive behaviors associated with individual dominance. Minimizing pain associated with disbudding and dehorning is important to limiting the pain-stress-distress cascade that creates altered behavioral and physiologic states.Pre-emptive analgesia can be accomplished with sedation, general anesthesia, local anesthesia, and pre- and postoperative administration of nonsteroidal anti-inflammatory drugs.

Tail Docking

Reports of the benefits of tail docking are not currently supported by data in the scientific literature. Tail docking has been experimentally shown to cause minimal adverse physiologic effects; however, fly avoidance behaviors are more frequent in docked cattle, suggesting potential long-term adverse behavioral effects. Increased temperature sensitivity and the presence of neuromas in the tail stub suggest that chronic pain may be associated with the procedure.

Holstein calves have been observed to exhibit increased walking or running behavior, increased head-to-tail movement and licking, and less tail swinging and lying behavior following application of a rubber ring for tail docking. These actions have been interpreted as indicators of distress. The use of local anesthetic at the time of ring application provided no detectable benefit in reducing physiologic signs of stress. Necrotic tissue, such as the distal tail after banding, is prone to infection with pathogens. Clostridial organisms, ubiquitous in soil, may colonize the wound and result in local or systemic infection. Tetanus and gangrene have been reported after tail docking.

The role of the tail in communication between cattle has not been documented, but it has been speculated that tail docking limits the ability of cattle to exhibit normal signaling behavior. In addition, the tail is widely believed to play a role in fly control; shaking the tail and brushing the body and limbs can dislodge biting flies.

Resources

American Veterinary Medical Association (www.avma.org):

Welfare implications of castration of cattle. June 26, 2009. http://www.avma.org/reference/backgrounders/castration_cattle_bgnd.asp

Welfare implications of dehorning and disbudding cattle. January 28, 2010. http://www.avma.org/reference/backgrounders/dehorning_cattle_bgnd.asp

Welfare implications of dairy cow tail docking (January 28, 2010). http://www.avma.org/reference/backgrounders/tail_docking_cattle_bgnd.asp

Figure Reference
http://www.usask.ca/wcvm/herdmed/applied-ethology/articles/manitoba.html
Painful Procedures and Misconceptions
Joseph M. Stookey, Large Animal Clinical Sciences
Western College of Veterinary Medicine
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52 Campus Drive
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Improving Reproductive Performance in Dairy Cows

Introduction

Most cow operations would benefit economically by reducing the number of operational days, decreasing culling rates due to non-pregnant females, and shortening their calving interval. Several factors influence reproductive performance, but none require more visual attention than heat or estrus detection.

The primary sign of heat occurs when the female stands immobile and allows other animals to mount her. Each stand lasts only 4 to 6 seconds.

Cows come into estrus at all times of the day and remain in heat for only 12-18 hours making it difficult to observe especially in hot weather. Keeping cows in groups of three to five with two to three visual observations per day for heat, will increase the chances of detecting cycling animals. The use of synchronization and heat-detection aids can greatly shorten the time spent observing heat but will not benefit non-cycling cows or Anestrous Cows - a condition where the cow does not cycle due to insufficient natural hormonal stimuli. This is different than apparent anestrous due to failure to observe estrus (missed heats). Cycling cows require management that pays attention to details, supplies high-quality nutrition, and provides exceptional cow comfort, including hoof health.

There are primary and secondary indicators of heat. The primary sign of heat occurs when the female stands immobile and allows other animals to mount her. Each stand lasts only 4 to 6 seconds.

Secondary indicators may signal that a cow is in heat, coming into heat or going out of heat. These include:

- mounting other cows
- clear mucous discharge
- chin resting and rubbing
- swollen red vulva, frequent urination
- muddy flanks and ruffled tailhead
- bawling, restlessness, sniffing behavior
- decreased milk production and off feed

The decision to inseminate a cow should be based on standing heat, not on secondary signs of heat.

The decision to inseminate a cow should be based on standing heat, not on secondary signs of heat.

There May be Inaccurate Heat Detection if…

- More that 20% of the cows bred on natural heat are inseminated based on secondary signs of heat. This does not apply to estrous synchronization (timed breeding programs where cows are bred at a prescribed time)
- Cattle inseminated on natural heats are bred within 12 hours of the onset of heat (this does not apply to timed breeding programs)

Effective Heat Detection Should Consider These Questions:

- Is there a high priority for heat detection?
- Do personnel understand the true signs of heat?

- Is there enough time allotted for heat detection?
- Are protocols for heat detection followed?
- Is there one person responsible for insuring that heat detection is performed?
- Are specific individuals responsible for observing estrous behavior?
- How many of the last 10 cows were bred on the basis of true standing heat?
- How often is the herd observed for heat?
- If estrous detection aids are used to supplement heat detection are they used properly?
- Are reproductive events, specifically heats, recorded and posted so other employees know
- Which cows to anticipate in heat?
- What is the voluntary waiting period?
- Does the herd manager intentionally delay the interval to first service beyond 85 days?
- Is the average interval between services greater than 42 days? (this is a diagnostic indicator of the post-breeding heat detection rate)

Resources

Drill-Down Tools. Penn State University, Dairy and Animal Science. http://www.das.psu.edu/research-extension/dairy/pa-tool/drill-down-tool.

Graves, M. W., 2009. *Heat Detection Strategies for Dairy Cattle.* University of Georgia. http://www.caes.uga.edu/Publications/displayHTML.cfm?pk_id=6304.

Pennington, A. J., *Heat Detection in Dairy Cattle.* FSA4004. University of Arkansas, Division of Agriculture. Web. http://www.uaex.edu/Other_Areas/publications/PDF/FSA-4004.pdf.

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Nutritional Management of Dairy Cows

Introduction

Nutritional management requires that dairy cows and their replacements be considered in three distinct groups of animals; a.) mature, non-lactating or dry cows, b.) lactating or milking cows, and c.) growing replacement animals. Each of these groups can in turn be subdivided into two or more groups to more closely match nutritional requirements with the appropriate ration. Meeting, but not exceeding dietary requirements maximizes production and hence profit potential and minimizes soil, water, and atmospheric impacts. It is more desirable to have fewer high producing cows than it is to have many low producing cows. This is due to the dilution effect of maintenance requirements and to lowered environmental impacts. Nutrient requirements for dairy cattle in all stages of growth and production are listed in the Nutrient Requirement of Dairy Cattle (NRC 2001), a book published by the National Research Council. Some nutrients that could have adverse environmental and production impacts are listed in the table below (http://www.fass.org/facts/dairyfact.htm). For specific information regarding other breeds, bodyweights, and levels of production refer to NRC (2001).

Meeting, but not exceeding dietary requirements maximizes production and hence profit potential and minimizes soil, water, and atmospheric impacts.

Table 1. Selected nutrient requirements of dairy cows as determined using sample diets[1]

Holstein, 1500 lb., average body condition, 65 mo. age	90 Days in Milk				Early Lactation		Dry, Pregnant 270 Days in Gestation BW 1656 lb.
Milk yield, lb/d	55	77	99	120	55	77	
Dry matter intake, lb/d	44.7	51.9	59.2	66	29.7	34.3	30.1
Net energy, Mcal/lb	0.62	0.67	0.7	0.73	0.94	1.01	.48
Diet % RDP	9.5	9.7	9.8	9.8	10.5	10.5	8.7
Diet % RUP	4.6	5.5	6.2	6.9	7	9	2.1
Crude Protein,[a] %	14.1	15.2	16.0	16.7	17.5	19.5	10.8
Calcium, %	0.62	0.61	0.67	0.60	0.74	0.79	0.45
Phosphorus, %	0.32	0.35	0.36	0.38	0.38	0.42	0.23
Potassium[b], %	1.00	1.04	1.06	1.07	1.19	1.24	0.52
Sodium, %	0.22	0.23	0.22	0.22	0.34	0.34	0.10
Copper[c], ppm	11	11	11	11	16	16	13
Zinc, ppm	43	48	52	55	65	73	22

[a] Equivalent to the sum of rumen degradable protein (RDP) and rumen undegradable protein (RUP) only when they are perfectly balanced.
[b] Heat stress may increase the need for potassium.
[c] High dietary molybdenum, sulfur, and iron can interfere with copper absorption increasing the requirement.
[1] Adapted from Table 14-7, 14-8 and 14-9, Nutrient Requirements of Dairy Cattle. 7th Revised Edition, 2001. National Research Council, National Academy of Sciences, National Academy Press, 2101 Constitution Ave, Washington, DC 20418 (J. H. Clark, Chair, Subcommittee on Dairy Cattle Nutrition).

Nutrients

Water

The importance of access to clean fresh water for animals of all ages cannot be overemphasized. Vital metabolic reactions occur within the "universal solvent", water. Failure to provide readily accessible clean water will result in depressed growth and production.

Energy

Energy is often limiting particularly in animals in the first half of lactation. The requirement for energy is satisfied by a combination of forages, concentrates, and a limited amount of supplemental fat. Dairy cattle have a specific requirement for forages, which are fermented by rumen bacteria to volatile fatty acids (VFAs). These VFAs supply a majority of the required energy to support maintenance, growth, and lactation.

Poor quality forages are poorly digested and result in lower production levels and higher volumes of manure. Feeding high quality forages decreases the need to supplement with concentrates. Rations with inadequate amounts of forages, forages that are chopped too finely, or excessive "sorting" of the ration by cows will have adverse effects on the beneficial rumen microbial populations and will result in decreases in quantity and quality (% fat and protein) of the milk. Concentrates and supplemental fats (not to exceed 8% of the ration) are fed to provide additional energy. Over or under supplementation can have profound effects on the production and health of dairy cattle.

Protein

The protein requirement for dairy cows is divided into two groups, the rumen degradable protein (RDP) and rumen undegradable protein (RUP). The RDP is utilized by the rumen microbial population for the production of microbial crude protein (MCP) which includes the microbes themselves as well as all of the proteins that they secrete. Eventually all MCP will flow down to the lower gastrointestinal tract where it will be digested and absorbed at the level of the small intestine. The RUP escapes rumen degradation and flows to the small intestine where it too is digested and absorbed. Excesses of protein, either RDP or RUP, will be excreted in the urine as urea. Milk urea nitrogen (MUN) levels can provide producers information regarding over or underfeeding of protein. The desirable range for MUN is between 9 to 14 mg/dl. Because protein is usually the most expensive component in the ration dietary excesses are not desirable in either an economic and environmental sense.

Phosphorous

Phosphorous (P) in feedstuffs is not utilized efficiently in ruminants. This, coupled with higher than needed requirements (due to misplaced concerns over reproductive and production performance) has led to overfeeding of P in dairy rations. A significant amount of dietary P is excreted in the manure, which has led to accumulating levels of soil P. The current dietary P recommendation for dairy cattle has been reduced (below the 2001 NRC recommendations) to 0.32-0.38%. It is recommended that mineral analysis on feeds be done using wet chemistry instead of NIR.

Resources

Federation of Animal Science Society. 2001. *Feed and Animal Management for Dairy Cattle*. http://www.fass.org/facts/dairyfact.htm

Nutrient Requirement of Dairy Cattle; 2001 Seventh revised edition; National Research Council; National Academy Press; Washington, D.C.

Van Soest, Peter, 1994; Nutritional Ecology of the Ruminant; Second Edition; Cornell University Press, Ithaca, NY.

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Air Quality Issues for Dairy Operations

Sources of gas emission include barns, feedlot surfaces, manure storage, silage piles, composting structures, and other smaller sources, but air emissions come mostly from the microbial breakdown of manure stored in pits or lagoons and spread on fields.

Emission control during land application is best done by direct injection of liquid manure below the soil surface.

Introduction

Dairy operations can affect air quality through emissions of gases such as ammonia and hydrogen sulfide as well as particulate matter, volatile organic compounds, hazardous air pollutants, and odor. These pollutants and compounds have a number of environmental and human health effects. They also produce carbon dioxide, methane, and oxides of nitrogen that have been associated with climate change.

Odorous compounds generally contain either nitrogen (i.e., ammonia) or sulfur (i.e., hydrogen sulfide, the odor of rotten eggs). While not strictly an environmental concern, odor emission from farms may be the most common complaint producers hear. Odors used to be considered simply part of farming, but with increasing intensity in animal agriculture and increasing population of formerly rural areas, odor is becoming a serious point of contention between farmers and their neighbors.

Sources of gas emission include barns, feedlot surfaces, manure storage, silage piles, composting structures, and other smaller sources, but air emissions come mostly from the microbial breakdown of manure stored in pits or lagoons and spread on fields. Each emission source will have a different profile of substances emitted, with rates that fluctuate through the day and the year. The following are some examples of hazardous air pollutants.

Ammonia has a direct, toxic effect on vegetation. When returned to the soil and water by rainfall, it disrupts ecosystems causing algae bloom in water bodies and acidification of soils. It is estimated that emissions from animal waste account for about one-half of the ammonia emitted in the United States annually.

Hydrogen sulfide is a colorless gas with a strong and generally objectionable rotten egg odor. It is produced in anaerobic (oxygen-deprived) environments by microbial decomposition of sulfur-containing organic matter in manure.

Methane and **nitrous oxide** are greenhouse gases that are known to contribute to global warming. EPA estimates that more than 30% of the nation's methane emissions come from livestock operations. Similar to sulfur, agricultural methane, is emitted during microbial degradation of organic matter under anaerobic conditions. Nitrous oxide forms via the microbial processes of nitrification and denitrification.

Many of the complaints about dairy and other livestock operations are generated by odor. Odor is not caused by a single substance, but is rather the result of a large number of contributing compounds, including ammonia and hydrogen sulfide.

BMPs to control Air Quality

Emissions of odors and gases from livestock production facilities arise from buildings, manure storage, and land application. Eliminating emissions from one of these sources will likely not eliminate emissions entirely, as control technologies often address only one of the three sources. Many of the available technologies reduce emissions; none eliminate them. There are various BMPs that can be implemented to reduce gas emissions and odor from dairy operations

Land application has been and remains to be the predominant method for disposing of manure and recycling its nutrient and organic content. In general, designed objectives for managing manure do not include minimization of emissions of ammonia, methane or other gaseous compounds, but rather focus on odor and avoidance of direct discharge to surface water, and also land application rates that are beneficial to growing crops.

Emission control during land application is best done by direct injection of liquid manure below the soil surface. Solid manure is generally less odorous than liquid, but because it cannot be injected, rapid incorporation into the soil by disking or similar techniques is the best method to minimize odors.

Farmers should consult with non-farm neighbors before land applying manure to fields. Every effort should be made to avoid manure application on weekends, holidays, or during picnics and other gatherings. Also, prevailing wind direction should be considered.

Emissions from buildings can be reduced by inhibiting contaminant generation, or by capturing and treating the air as it leaves the building (e.g., by using biofilters). Frequent manure removal is an efficient way of reducing contaminant generation within the building. Other methods that can be used inside buildings include using bedded solid manure (i.e., manure mixed with bedding that creates a solid stack of material), chemical additives on animal litter, and diet manipulation. Other examples of BMPs to minimize odors and emissions from animal housing include setback distances from neighbors, trees planted around animal housing with attention paid to prevailing wind direction.

Manure storages include outdoor slurry storage, deep pits, anaerobic lagoons, and solid stacks. Outdoor open storage is the most apparent source of odors. Some control methods that have been shown to be effective when managed properly include:

1) covers (permeable and impermeable, natural such as barley straw or cornstalks, and synthetic)
2) biological control of lagoon (both anaerobic and aerobic)
3) composting.

Aerobic lagoons are continuously agitated in order to keep an appropriate amount of oxygen in the system. Anaerobic lagoons, when allowed to fully process waste, host micro-organisms that thrive without oxygen and will reduce odors when the digestion process is complete.

Composting is an aerobic biological process that turns animal waste into rich organic matter. Biological control and composting must be properly managed in order to be effective at controlling odors and emissions from manure storages.

Techniques to manipulate the manure to minimize emissions also exist but have certain limitations. For example, separating solids from liquid manure reduces the load on anaerobic lagoons, but also creates a second waste stream to manage unless the removed solids are composted. Anaerobic digesters reduce odors, but they also may not be economically feasible.

Resources

Copeland, C. May 2010. "Air Quality Issues and Animal Agriculture:A Primer". Congressional Research Service. www.ncseonline.org/NLE/CRSreports/10Jun/RL32948.pdf

Dairy Cattle Nutrient Management. 2010. United States Cooperative Extension Service. http://www.extension.org/pages/15602/dairy-cattle-nutrient-management

Powell, J. M, L Slatter, and T. Misselbrook. 2005. *Dairy Manure and Air Quality.* www.soils.wisc.edu/extension/wcmc/2005/pap/Powell1.pdf.

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Feeding to Reduce Phosphorus Excretion in Dairy Cows

Introduction

Dairy cows (and the rest of us, as well) require phosphorus in our diets. Phosphorus is a key element in energy transfer, as well as an important component of bones and teeth. In an effort to avoid phosphorus deficiency, dairy cows are often given more phosphorus than they need. This excess is excreted in the feces, and to a much lesser extent, in the urine. The excreted phosphorus becomes part of the dairy operation's waste stream. Phosphorus will build up on the farm (or in the groundwater) if more P is brought in, in the form of feed, fertilizer, or bedding, than leaves the farm in the form of milk, compost, crops, or animals sold.

Phosphorus is important in energy transfer and as a component of bones and teeth.

Benefits of Phosphorus

Because phosphorus is essential to energy transfer, it is important in all aspects of an animal's functioning. Reproduction and milk production are the measures of success in dairying, and these will be influenced by P availability, but all aspects of the animal's health will be affected. Strong bones and teeth are clearly important to animal health. Fortunately it is not difficult to supply the phosphorus needs of dairy cattle.

Too much phosphorus is expensive and potentially polluting.

Drawbacks of Excessive Phosphorus

Phosphorus is expensive, whether as feed or as fertilizer. It makes no sense to purchase extra phosphorus if the addition does not promote improvement in a cow's health, reproductive system, or milk production. Pollution is another consideration. Phosphorus is important in plant, as well as animal systems. As with animals, sufficient P is required for plant life. Too much P, however, can have negative effects. For example, ponds in areas of excessive P runoff will develop excessive plant growth, depleting oxygen in the water and threatening animal life in the pond.

How to Adjust Phosphorus in the Dairy Cows' Diet

Balance phosphorus content of feed according to dietary needs of cattle, avoiding excess P excretion.

Find out how much phosphorus is being excreted. There are many ways to sample manure. At the end of this document is a list of manure sampling laboratories. Their sampling recommendations reflect the assumption that manure is being sampled for its fertilizer value, so they suggest including bedding, and sampling as close as possible to the time of field application. To estimate fecal phosphorus, however, it is best to sample only feces, and that as soon as possible after leaving the cow. It is difficult to get a herd-wide sample without including material other than feces. Wear gloves. Scoop a cupful of fresh feces into a clean 5 gallon bucket. Collect a number of samples; the more you collect, the more representative the result will be. Mix well, and send to the lab as directed. Estimate per cow P output as either 150 lb manure per day for a lactating Holstein dairy cow or 80 lbs manure per 1000 lbs body weight. Note that the latter will likely give a lower manure estimate.

Determine phosphorus intake in feed. This is fairly straightforward when using purchased grain with nutrient content printed on the label. Baled hay can be sampled using a hay probe. Hay, grain, and silage samples can be tested by the same labs that test manure, as well as additional labs (see below). Pasture fed cows' intake is a bit trickier to estimate. However, pasture samples can be taken and analyzed as hay samples. Phosphorus intake can be estimated by multiplying percent P in the different feeds and adding the estimated intake of each feed.

Adjust feed to balance needs of cows vs need to avoid excess P excretion. Dairy cows not being fed excessive amounts of P should excrete approximately 73% of dietary P intake, with 27% going to milk (Harrison). For Holstein cows producing 55 to 120 lbs milk containing 3.5% fat and 3.0% true protein per day, dietary recommendation is from 0.32 to 0.38% P (Powell and Satter). P absorption increases when P is in short supply. Phosphorus coming from different sources may differ in absorption by cows, with concentrates having higher absorption coefficients than forages. However, research in this area has not shown consistent results. Because values for both fed P and excreted P are estimates, it is wise to consider both values when making changes to rations.

Manure Testing in the Northeast

University of Maine
Analytical Laboratory and Maine Soil Testing Service
5722 Deering Hall
Orono, ME 04469
http://anlab.umesci.maine.edu/default.htm

Penn State University
Agricultural Analytical Services Laboratory
University Park, PA 16802
http://www.aasl.psu.edu/manureprgSTD.html

Dairy One Cooperative Inc.
730 Warren Rd
Ithaca, NY 14850
http://www.dairyone.com/Forage/services/Manure/manure.htm

University of Minnesota lists nationally certified manure analysis laboratories for 2011:
http://www2.mda.state.mn.us/webapp/lis/manurelabs.jsp

University of Massachusetts does not test manure, but does test plant tissue and soil:
Soil and Plant Tissue Testing Lab
West Experiment Station
682 North Pleasant Street
University of Massachusetts
Amherst, MA 01003
http://www.umass.edu/soiltest/index.htm

Resources

Harrison, Joe. Western Integrated Nutrition and Nutrient Management: Feed Management Education for the Agri-Professional.
http://www.puyallup.wsu.edu/dairy/nutrient-management/data/publications/SARE101-%20WholeFarmDairyPExample.pdf

Powell, J. Mark, and Larry D. Satter. Dietary Phosphorus Levels for Dairy Cows.
http://www.sera17.ext.vt.edu/Documents/BMP_dietary_phosphorus.pdf

Wu, Z., L. D. Satter, A. J. Blohowiak, R. H. Stauffacher, and J. H. Wilson. 2001. Milk Production, Estimated Phosphorus Excretion, and Bone Characteristics of Dairy Cows Fed Different Amounts of Phosphorus for Two or Three Years. J. Dairy Sci. 84:1738–1748

Wu, Z., S. K. Tallam, V. A. Ishler, and D. D. Archibald. 2003. Utilization of Phosphorus in Lactating Cows Fed Varying Amounts of Phosphorus and Forage. J. Dairy Sci. 86:3300-3308

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UMass Extension

Biosecurity Guidelines for Dairy Farms

Biosecurity is defined as a system of management practices that prevent or greatly reduces the risk of introducing new diseases to a farm or stable.

Be aware of routes of transmission, preventative steps, animal-to-animal contact, and current health records of your animals to ensure that your facility remains disease free.

Introduction

Biosecurity is defined as a system of management practices that prevent or greatly reduces the risk of introducing new diseases to a farm or stable. A good biosecurity program should address the prevention of disease entry and spread on a farm.
As with any biosecurity plan, dairy farm owners should contact their regular veterinarian to discuss what appropriate measures should be implemented on their specific operation. Since some animals may not exhibit obvious signs of disease it is important to understand how diseases are transmitted.

Spread of Disease Agents

Animal to animal
Animal to human

Different Routes of Transmission

- **Aerosol** – Disease agents are contained in droplets which can pass through the air.
- **Direct contact** - Disease agent in animals or the environment are transferred from one to the other.
  Examples: Open wounds, mucous membranes, skin, blood, saliva, nose to nose, rubbing, and biting.
- **Reproductive transmission** - breeding or dam to offspring.
- **Fomite -** Contaminated inanimate object carries agents to other animals.
  Examples: Brushes, needles, shovels, trailers, and humans.
- **Oral -** Consumption of contaminated feed or water, licking or chewing environments containing feces, urine, or saliva
- **Vector-borne** - Insect acquires pathogen from one animal and transmits to other animal(s). Living organisms that carry disease agents from one host to another are called vectors

  Mechanical vectors: A vector that simply carries a microorganism with no replication from host to host
  Some examples: flies and cockroaches

  Biological vectors: In contrast, microbes must propagate within a biological vector before the biological vector can transmit the microbes.
  Some examples: fleas, ticks, and mosquitoes
- **Zoonotic –** Infectious agents that can be transmitted between (or are shared by) animals and humans.
  Examples: Brucellosis, Tuberculosis, West Nile Virus, and the Plague.

General Steps for Prevention

Purchasing and Introduction of New Animals to the Herd

- Buy from a reliable source.
- Make sure health records on the new animals are up-to-date.
- Have a reliable veterinarian in the area inspect the animal(s) prior to purchase.
- Isolate animals once on your property (30 days is the recommended for cattle).
- Provide a pen or stall that has adequate ventilation and is not located near other livestock.
- Do not cross use shovels, feed buckets, brushes or other equipment between the isolated animal and other livestock.
- Ensure workers clean their hands and boots and change clothes prior to entering other areas.

Returning From Shows or Exhibits

- Isolate animals once on your property (see above recommendations).
- Use your own trailer to transport your animals. If you do not have your own transportation, it is crucial to disinfect all returning animal's hooves prior to entering your barn or stable.

Limit Contact With Animals

- Neighbor's livestock
- Wildlife and birds
- Roaming cats and dogs

Maintain Secure Areas and Locked Gates

- Establish biosecurity protocols for delivery vehicles and personnel
- Know who is entering your milk room. Milk tank can be vulnerable to outsiders.

Keep Up-To-Date Health Records on Every Animal

- Review vaccination and treatment programs Annually, bi-annually
- Protocol versus actual
- Investigate unusual signs and unresponsive cases
- Neurologic, downers, or sudden death
- Train farm or stable personnel to report sick animals
- Inspect animals daily
- Clean equipment, boots, and clothing
- Euthanize terminally ill animals promptly and appropriately
- Removed and rendered
- Necropsy animals that died from unknown causes

Key Points

- Biological risk management is important
- All diseases are transmitted by a few common transmission routes (described above).
- Disease risk can be managed efficiently and effectively.
- Awareness education is essential.
- Work with your regular veterinarian.
- You play a critical role!

Resources

American Veterinary Medical Association
http://www.avma.org/pubhlth/biosecurity/
Resources (geared toward veterinarians) include biosecurity resources, updates, information on disaster preparedness, and resources on select public health topics.

Dairy Facility Biosecurity:
http://www.state.ma.us/dfa/animalhealth/dairy_facility_biosecurity.htm

Farm and Ranch Biosecurity:
http://www.farmandranchbiosecurity.com

Livestock Biosecurity (Penn State website):
http://www.vetsci.psu.edu/Ext/Biosecurity/BioMain.htm

Massachusetts Department of Agricultural Resources
http://www.mass.gov/agr/animalhealth/index.htm

National Biosecurity Resource Center for Animal Health Emergencies (primarily focuses on pigs):
http://www.biosecuritycenter.org/

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Composting Dead Dairy Cows

Always check with you local environmental agency to see what types of permits are required in your area in order to compost.

An adult carcass will compost in around six months. Stirring the composting mixture can help to accelerate time.

Introduction

Methods and processes of dealing with dead dairy cattle have always been and continue to be a concern in all animal production operations, slaughter plants, and other facilities that have animals. Proper disposal methods/systems are especially important due to the potential for disease transfer to humans and other animals, and the pollution of soil, air and ground water. Properly composting animal carcasses may be less of a threat to groundwater than burial or unattended surface dumping.
Composting has been shown as a viable means of disposing of dead livestock. (This method is not recommended for whole herd disposal).

On-farm composting of dead animals generated on the same farm as the composting facility is exempt from having a permit if operated in compliance with the Massachusetts Department of Agriculture regulations. (Refer to MDAR 330 CMR 25:00).

Burial

Burial must be no greater than 6 feet deep with a minimum of 30 inches of soil cover. Burial must be in well drained soils and be at least 2 feet above the highest groundwater elevation. Burial must be at least 100 feet from a private well, 200 feet from a public well, 50 feet from an adjacent property line, 500 feet from a residence and more than 100 feet from a stream, lake or pond. Burial cannot be in a wetland, floodplain or shoreline area.

Composting

1. Check with your state's environmental agency or state veterinarian before you begin composting dead animals. The Massachusetts Department of Environmental Protection, for instance, does not require a permit.

2. As an underlying layer, or substrate, use a mixture of hay, manure and bedding with moisture content between 40 to 50 %. Odor can be kept to a minimum as long as the pile is turned to aerate it and the covering material has enough carbon sources, such as straw, sawdust or hay, to provide a 25:1 ratio of carbon to nitrogen.

3. Construct a windrow 10 feet wide by 4 feet deep of the dry manure and bedding mixture. Locate it on a solid spot where the ground slopes 1 to 2%. Site it lengthwise with the slope of the land so runoff and snow can't puddle against the windrow. If possible, orient the windrow north to south so that only one end faces a cold exposure. Choose an area where tractors can maneuver in all weather.

4. Once you've placed a carcass, cover it with at least 2 feet of the same manure and bedding mixture that is underneath the carcass. Maintain a stockpile of the material for covering. Carcasses can be added anytime but should be spaced about 4 feet apart.

5. The pile must heat up for proper composting. Use a compost-style dial thermometer, ideally with a 30-inch long probe, to monitor the temperature. Temperatures around the carcass will rise to 150 to 160 degrees. Monitor temperatures every two to three weeks. When temperatures fall to 110 to 125 degrees, stir the material with a bucket loader, allowing oxygen to re-activate the composting.

6. Left untouched, an adult carcass will compost in five to six months. Stirring the mix and covering the carcass again can accelerate the time.
Colder temperatures slow the compost process. When the air temperature is above 50 degrees and the pile is turned when its temperature drops below 120 degrees, the soft tissue in a 1,500-pound cow will finish composting as quickly as two to three months.
There will be less bony residue with younger carcasses. Calves, for instance, may compost in three to four weeks under summer conditions. In areas with heavy rainfall, the process can be slowed if there's too much moisture, preventing aeration.. Anchor a tarp over the windrow or mix some very dry sawdust or shavings into the substrate.

7. When you see no more soft animal parts, you can spread the compost or leave it in place. Bones, which degrade very little, can be pulverized to spread on fields, creating good fertilizer. Or they can be left in the pile.

Resources

Glanville, Thomas, 1999. *Composting Dead Livestock – A New Solution to an Old Problem.* Iowa State University Cooperative Extension Service.
www.**extension**.ia**state**.edu/publications/SA8.pdf

Massachusetts Department of Agriculture Resources. 251 Causeway Street. Suite 500. Boston. MA 02114. Phone (617) 626-1700. Website: www.mass.gov/agr

Rynk, Robert, et.al 1992. On-Farm Composting Handbook. Northeast Regional Agricultural Engineering Service. 152 Riley-Robb Hall. Cooperative Extension.
www.nraes.org/publications/nraes54.html

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Bedding Options for Dairy Cows

Introduction

Some type of bedding is needed in almost every dairying operation. The best bedding choice will depend on the type of housing used, as well as local cost and availability of different bedding products. The best bedding material for combating lameness may not be best for udder cleanliness. Relative concerns regarding such different problem areas will also influence bedding material recommendations.

Desirable Characteristics of Bedding

Cost and labor efficiency as well as cow comfort are of utmost importance in bedding selection.

There are two driving factors behind good bedding choices. One is cow comfort, and the other is farmer comfort. The two have some common areas and some diverging areas. Cow comfort is critical because of the importance to both cow and farmer of the cow spending most of the day lying down processing feed into milk. Therefore bedding must be comfortable to lie on. Because cows are large animals, bedding must offer uniform support. Coolness in summer and warmth in winter will promote cow comfort. Dry bedding is critical at all times both for comfort and for reduction in pathogen growth. Good footing is important for injury prevention. Nonabrasive bedding promotes both comfort and injury reduction. Farmer comfort requires in addition that bedding be cost efficient, labor efficient, and that the bedding drain well to keep cows dry and limit growth of pathogens.

Barn Design Affects Bedding Options

Barn design influences bedding alternatives

- **Tie stall**
- **Free stall**
- **Open style**

There are several formats in dairy barn alignment. There are open style barns in which cows are free to move around at will and lie down wherever they choose. These barns have separate feeding and watering areas, typically on concrete. There are also barns with individual stalls. These may be tie stalls in which an individual cow is restrained within a stall, or they may be free stalls in which cows are allowed to move about the barn, but the barn is subdivided into individual stalls in which a cow may stand or lie down. In tie stall barns, feed and water are provided to individuals, while in free stall barns, cows move to feed and water stations. Pros and cons of different beddings will depend on barn design.

Specific Bedding Choices (in alphabetical order)

Compost, or actually composting material, is used as bedding in open style barns. Approximately 12-18 inches of a material such as wood shavings or sawdust is initially spread in the barn. Manure builds up gradually. The barn must be aerated to a depth of 8-12 inches twice daily during milking. Shavings or sawdust are added weekly as needed. The pack can rise to as much as 4 ft, and is removed once or twice a year to be spread on fields. This system requires very good ventilation (tall hoop structures predominate), as well as excellent teat cleaning at milking. Feed and water are maintained in separate alleys, generally on a concrete floor. This system has been found very comfortable to cows, and foot and leg health are reported as positives of using this bedding system. Up to 100 ft sq per cow is recommended.

Geotextile Mattresses manufactured from a variety of materials are commercially available. These may be used in either tie stall or free stall barns. These have waterproof exteriors, and are filled with a variety of materials including rubber crumbs, polyethylene foam, and water. They are marketed as requiring no bedding, but research has shown (see Bernard, et al. and Tucker and Weary) that added bedding makes the mattresses much more attractive to cows. Mattresses are generally installed in rows, attached to one another, and come in a variety of sizes to fit typical stall sizes.

Paper may be available inexpensively in the vicinity of paper mills. Chopped recycled newsprint has also been used for dairy bedding. Both can be effectively mixed with other bedding materials. Fineness of chop will influence bedding characteristics.

Sand can be a good choice of bedding. Depth of 6-8 inches in a tie stall or free stall barn is recommended. Because sand is an inert material, it will not tend to promote growth of pathogens, though when mixed with manure, the manure will support pathogen growth. Particle size is of great importance. Too small a particle size (or too much organic matter mixed in) will hold water too well. Large particles (> 3mm) will not be comfortable to lie on. Sand which is naturally occurring will have more rounded edges and be more comfortable as bedding than manufactured sand which comes from crushing rock. Refer to the Gooch and Inglis paper cited below for more information on the importance of particle size and sand quality. The potentially negative side of using sand as bedding comes in the disposal. In a liquid manure handling facility, sand must be settled out and disposed of. If this could be done in such a way as to reuse the cleaned sand, however, it would become a benefit.

Sawdust and Wood shavings are probably the most commonly used bedding products for dairy cows. They have the advantage over sand of being broken down by microorganisms in the disposal system, but they have the disadvantage of allowing growth of microorganisms (pathogens). Addition of lime to bedding may reduce growth of pathogens. The smaller particle size of sawdust makes it more absorbent than wood shavings and quicker to break down. However, small particle size is also associated with rapid growth of bacteria and other harmful pathogens. Cost and availability tend to be deciding factors in choice of material.

Straw composts well and reduces in volume when composted, better than sawdust or wood shavings. It is important when using straw as bedding that the particle size be small, preferably fitting through a ¾ inch screen, both to increase animal comfort and to shorten breakdown time. Bedding absorbency as well as comfort to animals varies according to the species as well as to the chop size. Straw is an attractive bedding alternative when it is produced on the farm.

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For more information visit www.umass.edu/cdl

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Small Scale Dairy Calf and Cattle Housing

Introduction

Several different designs for housing and handling facilities are suitable for small scale dairy operations taking into consideration the weather, topography, and the availability of feed and pasture. It is important to know all the rules and regulations with respect to location, design, and type of operation. Check with your local Building Inspector to obtain the required permits prior to building or renovating your existing facility. You should also talk to an experienced builder or contractor to ensure the cost of the facility is within the objectives of the operation

As a rule, cattle can stay on pasture during the warm weather months.

It is important to choose a location for buildings and handling facilities that is on well-drained soil with properly designed surface water drainage situated away from streams, other bodies of water and is not close to population centers. The barn should be served by a good all-weather driveway, or border on a high, well-drained service yard. Check with your county Natural Resources and Conservation Service (NRCS) office for recommended guidelines.

Calf Housing

A one or two-sided structure with a roof can provide shelter to heifers during periods of intense cold. Structures should be built with the open sides facing the south or east (depending upon prevailing winds) to maximize effects of solar radiation during the winter.

Hutches - Calves can be raised in individual hutches that afford them the opportunity to move around, be fed individually, and allow for good ventilation and ease of cleaning. The key is to have the hutches placed about 2 feet apart to avoid contact (spread of disease). They should be positioned facing south, and placed on a well-draining material, such as a layer of sand, gravel, or stone for proper drainage. The hutches should also be well bedded. Straw and/or shavings as a top layer make a dry and comfortable bed. Fencing can be placed around the hutch (Figure 1.) to give the calf the opportunity to exercise. Hutches may also be placed in greenhouses or barns during harsh winter weather, but it is not always necessary since the hutch affords them warmth. At weaning, or about 8 weeks of age, calves outgrow hutches and need to be moved to alternative housing.

Figure1. A calf hutch with wire fencing placed around for more available room.

Another option, which may be more cost effective, is to have the calves in individual pens under a greenhouse structure (Figure 2). If housed in groups, calves should have 30 square feet per animal. Avoid housing systems that place calves on cold concrete, rubber mats or slatted floors.

Figure 2. Individual calf pens in a greenhouse facility.

Cattle on average can consume 1 gallon of water per 100 pounds live weight per day.

Weaning to 6 months of Age

Transitional housing for weaned calves up to 6 months of age can be a shed with pasture, or group housing in a hoop shelter or shed. Heifers in group housing need at least 35 square feet per animal.

Over 6 months to Bred Heifers:

Figure 1. Group housing with headlocks.

Most producers use loose housing to minimize work. It is best to separate the large heifers from the small. If you are able, leave liberal amounts of feeding space so that smaller animals will not be crowded out. Heifers 6 to 24 months old should each have 35-40 square feet.

As heifers grow, there are considerable changes in their needs for resting area and feeding space. Facilities for older heifers should be designed to meet an animal's requirements and labor ease. The housing structure for older heifers should allow for convenience of:

- Feeding
- Cleaning and bedding
- Moving and restraining animals

Hoop barns – One of the least expensive structures for housing cattle is the hoop barn (Figure 4). Disadvantages are heat and ventilation problems during the summer months, but this should not be an issue if you are planning on grazing your cattle during the warmer months.

Figure 2. A hoop barn is one of the least expensive structures for housing.

Open sided, single slope roof shed - This type of housing is the most typical kind of structure used and is suitable for all cattle on the farm (Figure 5). They are the least expensive of new structures and very easy to build. Open sheds should face the south for winter sun and block the prevailing winds. Pole barns of this design can be partitioned for groups of animals without complicated interior construction. The installations of headgates are recommended when working with loose housing operations. Headgates come in four basic types; self-catching, scissors-stanchion, positive-control and fully opening stanchion. The self-catching headgate closes automatically due to the movement of the animal. The scissors-stanchion type has bi-parting halves that pivot at the bottom. The positive-control type locks firmly around the animal's neck. The fully opening stanchion consists of two bi-parting halves that work like a pair of sliding doors. The self-catching, scissor-stanchion and the fully opening stanchion are available with either straight or curved stanchion bars. The straight-bar stanchion is extremely safe and will rarely choke an animal. The disadvantage of a straight-bar is that animals cannot move their heads up and down unless a nose bar is used. The curved-bar stanchion offers more control of the animal's head but is more likely to choke the animal than the straight-bar type. Both types are safer than the positive-control headgate. No matter which type of headgate is selected, proper adjustment for the type of cattle being worked is necessary to prevent injury to the animals.

Figure 3. Open sided, single slope roof shed is one of the most common housing structures.

Milking Herd

Milking cattle may be housed in tie stalls, freestalls, or bedded-pack barns.

Cows typically rest 9 to 14 hours per day in intervals of five or more hours. Cows should be turned outside, for a minimum of one hour, at least once per day, for exercise (weather permitting), during the non-grazing season or when appropriate conditions for grazing do not exist. This is especially important for cows in tie stall barns.

Figure 4. Tie stall housing allows for individual cow monitoring especially for animal health.

Tie stall housing allows the farmer greater interaction with the herd. This type of system is good for small herds with fewer than 100 cattle. Good ventilation is critical in this type of housing. Table 1 shows the recommended dimensions for tie stalls based on cow size. The stall should be large enough to allow the largest cow in the herd to freely enter the stall, lie down, rest comfortably and easily get to her feet and exit the stall.

Table 1. Dimensions for Tie Stalls

COW SIZE		PLATFORM WIDTH		PLATFORM LENGTH*	
kg	lbs	mm	in.	mm	in.
400	880	1050	41	1450	57
500	1100	1150	45	1550	61
600	1320	1250	49	1650	65
700	1540	1350	53	1750	69
800	1760	1450	57	1850	73

*Length is with use of cow trainers. If no trainers are used decrease stall length by 100 mm (4 in.).
Ontario Department of Agriculture.
http://www.fao.org/prods/gap/database/gap/files/1328_designing_for_cow_comfort_in_tie_stall_barns.htm.

Figure 7. A freestall barn with proper ventilation and fans for air movement.

Freestalls that are well designed can reduce excessive standing, and minimize injuries. Many freestall barns start out as bedded-pack barns until enough capital is saved to add freestalls and freestall alleys. Freestall barns evolved from bedded-pack barns to reduce bedding costs and the amount of labor spent on bedding management.

Figure 8. Bedded-pack barns provide a comfortable resting place; however, consistent daily management is needed.

Bedded-pack barns are a low cost alternative to freestall barns (Figure 9). However, the lower initial investment for bedded-pack barns may be offset by higher annual costs. Bedded-pack barns require careful and consistent daily management to create a healthy and comfortable cow environment. Poorly managed bedded packs can quickly turn into a sloppy, wet manure mess if not cleaned daily.

Summary

While improving your ability to handle cattle efficiently and safely does cost both time and money, it is an investment that provides an excellent and often immediate return. A number of options are available if you want to install a new facility or improve an existing one, enabling you to shape your facility so that it meets your needs without exceeding your resources.

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246 Agricultural Engineering Bldg.
University Park, PA 16802.
Ph:(814)865-7685 FAX:(814)863-1031
www.abe.psu.edu
(Fact sheets and Idea Plans are listed under "Our Publications")

Graves, R., McGarland, D., Tyson, J. *Designing and Building Dairy Cattle Freestalls*. G-76. Penn State, Agricultural and Biological Engineering Department.
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Converting to a Seasonal Grazing Dairy Operation

With current energy and grain costs, converting to a seasonal grazing dairy operation may be more economically suitable.

Introduction

Converting to a smaller seasonal grazing dairy operation can be profitable if managed properly. With the high cost of grain and energy, a seasonal dairy operation can result in savings in both of these areas. Generally, the cost of product in a seasonal dairy is lower than average because you depend more on pasture than harvested forages. Grass-based producers ensure that forages provide the bulk of the energy and protein required to produce milk by providing high quality pasture during the grazing season and stored forages in the dormant season.

Figure 1. Seasonal breeding involves a 12-month calving interval, estrus detection, light culling and manipulation of day length and endocrine functions.

What is Seasonal Production?

Seasonal production is based on a 12-month pattern where all cows are bred to calve in a 60-day window and then the whole herd is dried off at the same time. Cows are dried off for 30-60 days before they calve in the following year. The major challenge for any seasonal operation is the herd's reproductive management by getting the maximum number of cows to freshen in a short calving window. Cows that are outside of this interval will need to be sold as either culls or replacement animals since this is a cost to the operation.

Seasonal production is based on a 12-month pattern where all cows are bred to calve in a 60-day window and then the whole herd is dried off at the same time.

Importance of Genetics

Selection of the genetics is very important in a grass-based seasonal operation. In the U.S., ninety percent of the cattle genetics are Holsteins. This is based on the fact that they have been bred for a conventional farm operation and the ability to produce in excess of 20,000 pounds of milk per year. In grass-based operations, they are looking for a smaller framed animal similar to the Jersey, Guernsey or Ayrshire body type. These breeds can also be cross-bred to add hybrid vigor.

Forage Quality

Pasture quality is also extremely important in a grass-based operation. Producing and managing quality pastureland can have a major impact on herd performance and return. By establishing the type of pasture needed to meet a herd's nutritional requirements, producers not only protect animal health, but also reduce or eliminate the cost of purchasing alternate feed sources which can add up quickly.

To determine whether your pasture should be improved, ask yourself, "Are there more weeds than consumable grass?" If weeds have the upper hand, you probably have lower-quality forage, since the desirable grass is competing with weeds for nutrients and moisture. Also, check for signs of plant disease, which can cause forage quality to decline.

When animals graze, the food choices they make is another forage quality indicator. They naturally tend to choose the highest quality forage available. When they would rather eat the hay you put out than grass growing in the pasture, it's a sign forage quality is low.

Body condition is another criteria to use in measuring forage quality. If you see changes like weight loss or deteriorated body condition, it's a sign of poor nutrition. Unfortunately, at that point it requires a great effort to help those animals recover.

Some Tips When Converting

When exploring conversion to a grazing operation, Darrell Emmick, a grazing specialist with New York National Resources Conservation Service, has suggested some steps to evaluate resources:

- First, identify your goals. What do you expect to get out of grazing the cows?
- Next, identify problems to overcome and opportunities in which you can take advantage.
- List your on-farm assets as they are now, such as land, livestock, forages, water, lanes, buildings, machinery and wildlife (NRAES, 2006a).
- Once you complete your inventory, compare your grazing goals to the resources that you have to determine the feasibility of converting to a grass-based seasonal operation.

Conventional, grain-based dairies are often skeptical of switching to grass for fear of lost production and profits which isn't necessarily true. The record grain prices make it increasingly difficult to make money on a grain-based dairy. And, grazing is sustainable. What the cows eat, they later drop as fertilizer. The key is to do your research and be prepared to not expect the high herd average that you did with a conventional grain-based operation.

Resources

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UMass Extension

Milkhouse Wastewater Management

A minimum of two months of daily flow data will provide adequate information for estimating a design of wastewater flows.

The primary tank should have a capacity of at least 1,000 gallons.

Introduction

Milkhouse wastewater (water used to clean milking equipment and cows) can contaminate both groundwater and surface water if the disposal system is inadequately performing or poorly managed.

Milkhouse wastewater can contain:

- Residual milk (i.e. milk that remains in the pipeline and milking units)
- Wash water for cleaning (pipelines, milking units, and the milk house floor).
- Cleaning chemicals, detergents, and acid rinse
- Manure and other organic matter
- Bedding material
- Nutrients especially nitrogen and phosphorus
- Bacteria
- Soil particles

Milk runoff is especially detrimental to streams due to its high biological oxygen demand. If allowed into water bodies, milk, manure, and detergents can cause an ecological imbalance, which will result in algae blooms, fish die-offs, abundant foam, and strong odors.

The amount of milkhouse wastewater varies from farm to farm as well as with the number of animals. An estimate of wastewater produced is necessary for designing an efficient milkhouse wastewater treatment system. Typically, the majority of water used in the milkhouse will pass through a water softener, making this the best location to install a flow meter. A minimum of two months of daily flow data will provide adequate information for estimating a design of wastewater flows. Continued flow monitoring should remain a part of the system operation and maintenance plan. With no flow meter data, a good estimate of wastewater is 5 gal/cow/day. This estimate is for milkhouse wastewater only and does not include any parlor washing or other wastewater.

Options for Handling Milkhouse Wastewater

(Check with local agencies to ensure legality of the any milkhouse wastewater system)

- Collect in combination with solid manure
- Store in a liquid manure storage unit (settling tanks-to separate dense fibers)
- Bark beds
- Grass filter strip
- Constructed Wetlands
- Treatment followed by soil infiltration (septic system and bark beds)
- Temporary storage followed by land application through spray irrigation

Settling Tanks

Settling tanks are used to separate solids and light fibers from the wastewater. This type of system is particularly useful if one is planning to use wastewater for irrigation. It is also a good precaution to take because solids will eventually clump and clog pipes and leach fields, blocking entry to a holding tank or septic tank and causing backup. Tanks that have compartments or multiple tanks in a series perform best because they are able to separate floating debris from the wastewater more effectively and the second tank acts as storage of the waste water for later use.

Bark Beds

This system is quite similar to a septic system in that wastewater is collected and piped to a tank before being sent to a leach field. The leach field area should be located in a place with zero slope, non-compacted soil, and minimum of 2 feet from a water table. The bark bed is enclosed in several foot-thick layers consisting of wood and bark which gives it a unique ability to function all year round due to the insulation of the leach field pipes by the bark preventing them from freezing. This system also allows the wastewater to evaporate during the summer months. The bark aids in reducing decomposition odors and moderates the level of nutrients being absorbed by the soil. Due to the decomposition of the organic materials, additional layers will be needed every 2 to 3 years.

Grass Filter Strips

Milkhouse wastewater can be directed to a properly sized grass area for filtering. Grass filter strips can absorb nutrients efficiently while preventing organic particles from being transported into water bodies. Filter strips can only function effectively if temperatures allow plants to grow actively. During the cold months, when grasses are not growing actively or are covered with snow and ice, nutrients in wastewater cannot be absorbed by plant roots. Therefore, the system will not work efficiently. For maximum filtering capacity, wastewater should be applied in rotations to prevent nutrients from runoff, over-application, or leaching into groundwater. Grass strips should be grazed or mowed on a regular schedule to function properly and maintain productivity.

Constructed Wetlands

Constructed wetlands can generally handle loads of nutrients than compared to aerobic lagoons and therefore need less land. Settling tanks are still recommended to remove solids prior to wetland application. These systems treat wastewater aerobically in surface waters and anaerobically in the sediment layer. They do not produce much odor and can provide a scenic resource and area for wildlife habitat. These systems *do* require careful operation and maintenance for optimum treatment and performance.

Treatment Followed by Soil Infiltration

Septic System

Milkhouse wastewater may be pumped or drained from a settling tank to a septic system (leach field) similar to a household septic system. Soils with extremely low or extremely high permeability must be avoided to minimize groundwater contamination. Septic systems have limited will not last forever and should be replaced when they plug up.

Bark Beds: (see above article)

Temporary Storage Followed by Land Application

Milkhouse wastewater can be pre-treated in a primary septic tank and then used for irrigating croplands and pastures. A minimum of 3-day Hydraulic Retention Time (HRT) is required to remove large particles and some of the fats and oils. The primary tank should have a capacity of at least 1,000 gallons. Effluent (liquid waste) from the primary retention tank flows into a dozing tank with a minimum of 1,000 gallons which is used when irrigation must be suspended for crop harvesting or grazing. Irrigation systems are used to distribute treated milkhouse wastewater on pasture or cropland, and consist of a pump, piping, and irrigation heads.

Resources

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Snieckus, Robert E. Ed. 2002. Dairy Environmental Handbook; Best Management Practices for Dairy Producers . National Milk Producers Federation. Arlington,VA. 175p. http://www.nmpf.org/publications/dairy_handbook

Assessing the Risk of Groundwater Contamination from Milkhouse Wastewater Treatment. Worksheet #10. Vermont Farm*A*Syst*. United States Environmental Protection Agency. http://efotg.sc.egov.usda.gov/references/public/VT/Worksheet10-Milkhouse_Wastewater_Treatment.pdf

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UMass Extension

Considerations When Selling Unpasteurized (Raw) Milk

Introduction

The demand for unpasteurized (raw) milk, in particular from pastured and grass-fed cow, is increasing in both the Commonwealth and across the country. At this point in time, raw milk sales in Massachusetts are legal only through the direct sale from the farm in which it was produced. Farms selling raw milk must also first comply with state regulations. The Massachusetts Department of Agricultural Resources (MDAR) is the main regulatory agency that governs the sales and distribution of raw milk. However, on the local level, towns and cities have the authority to enforce the policy.

The farmer shall label the product "Raw cow's milk" and the label shall include the name, address, and zip code of the producing farm.

All farmers selling raw milk must register with MDAR, regardless of the quantity sold. A "Dairy Farm Certificate of Registration" will be given to the farm as validation of compliance. Farms selling retail raw milk must also obtain a vendor's license from the nearest appointed milk inspector just like in the case of any dairy selling raw milk to pasteurization plants. MDAR keeps a close watch on the raw milk licensees, regularly inspecting the operations.

Regulations

Prior to starting the sale of raw milk, it is advised to review the following Massachusetts' Regulations at www.mass.gov/agr/legal/regs/

- **330 CMR 27.00** Standards and Sanitation Requirements for Grade A Raw Milk
- **330 CMR 28.00**Milk and Milk Products
- **331 CMR 7.00**Determination of Milk Fat Content in Milk or Cream
- **330 CMR 21.00** Supervision of Milk Pricing and Supply

Because towns and cities may establish, amend, or repeal rules and regulations for the handling and sale of milk, it is suggested that farmers work with their local Board of Health to ensure that they are complying with the most current regulations. A list of Board of Health's contacts can be found through the Massachusetts Health Officers Association.

Once you decide to sell raw milk to the public, you need to consider the following:

Have customers sign a legal waiver agreeing to not hold the farm accountable for any illness caused by drinking your raw milk.

- Cleanliness is of utmost importance. Always properly sanitize milking equipment. It is advised to use an automatic milking machine since it is considered a safer handling process as compared to hand milking.
- Storage of milk should be below 40 degree F. Transport should also be below 40 degrees F.
- On-farm testing of milk on a daily basis. There are test kits available to test somatic cell counts and also for antibiotic drug residues. This data should be recorded and always available for the consumer to examine.
- Send milk samples to an independent milk lab to compare readings to your on-farm test results.
- Investigate your market audience to determine your use of rBGH or other hormones in your herd. If you plan on selling your milk as organic or hormone free, you may want to explore alternative herd health treatments instead of the use of antibiotics and do not use Bovine Growth Hormone (rBGH).

- Test your herd for tuberculosis, brucellosis, Johnes and Bovine Leukemia Virus (BVD),also In particular, test all new animals coming into the herd. Herd records should also be available to the consumer at any time.
- Check with your legal adviser to see if you should have customers sign a legal waiver agreeing to hold the farm harmless for any illness caused by drinking your raw milk.
- Farmers complying with MDAR regulations must have a label on all of their bottles reading *""Raw milk is not pasteurized. Pasteurization destroys organisms that may be harmful to human health."* A sign with this language must also be posted in the area where the milk is being sold. The FDA's position is that "Raw milk, no matter how carefully produced, may be unsafe." http://www.foodsafety.gov/keep/types/milk/
- The farmer shall label the product "Raw cow's milk" or "Raw goat's milk" and the label shall include the name, address, and zip code of the producing farm.

Remember that you are the face of agriculture. Consumers need to be comfortable with farmers and their practices.

Resources

Kleinschmit, G. and T. Martin. 2007. *Raw Milk Use and Safety Fact Sheet.*" Northeast Organic Farming Association. http://www.nofamass.org/programs/organicdairy/pdfs/Raw%20Milk%20Use%20and%20Safety%20Fact%20Sheet.pdf.

Massachusetts Department of Agricultural Resources. 251 Causeway Street. Boston, MA 02114.
Tel: (617) 626-1700. http://www.mass.gov/agr/

Northeast Organic Farming Association Massachusetts Chapter. (NOFA)
http://www.nofamass.org/programs/organicdairy/info.php

The NOFA/Mass Raw Milk Network
If you are a consumer or dairy producer wanting to be part of The Raw Milk Network to help make safely-produced raw milk available throughout Massachusetts, contact Winton Pitcoff, Raw Milk Network Coordinator, at winton@nofamass.org, or at (413) 634-5728.

Raw Milk Facts:
http://www.raw-milk-facts.com/index.html

Raw Milk Truth: http://www.rawmilktruth.com/

Real Raw Milk Facts: http://www.realrawmilkfacts.com/

Weston A. Price Foundation's Real Milk website promotes raw milk from a nutritional viewpoint and lists producers in different states, as well as local Weston Price chapter heads who can provide a good source of raw milk information in your area.

http://www.realmilk.com/

For more information visit www.umass.edu/cdl

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Value-Added Dairy Products

Introduction

Value-added describes what happens when you take a basic product and increase the value of that product and usually the price by adding extras in the manufacturing process, or by tacking on extra products and/or services.

As a dairy producer, you can add extra value to your milk by processing and marketing your own products, such as cheeses, bottled milk, yogurt, ice cream or butter. The Commonwealth consumer will pay a premium to purchase products that are locally produced. Certifications such as *Organic* or *Animal Welfare Approved* also enhance the market appeal of your product. Many consumers are very interested in what happens on the farm.

Massachusetts is a national leader in the growing local foods movement.

Key Points

When considering the production and marketing of value-added dairy products, you have to take into consideration the capital outlay, time commitment, market share and the fact that your business may not make a profit in the first five years. Some important questions to ask yourself:

- What product do you intend to sell?
- Who is your target audience and how will I market the product?
- Are my location(s) convenient to the consumer?
- What is the profit potential of the product?
- How much will the consumer pay for the product?
- How will I demonstrate the quality of the product?

Massachusetts ranks first in the nation for the average value of direct market sales per farm. The state has over 120 farmers markets, up from approximately 85 in 1990, and more than any other New England state.

Value-added products can help your farm become more viable, more visible to the public and open up new markets but there are more risks involved when selling value-added versus marketing directly to your local milk cooperative.

Farmers can take classes, or attend seminars on making the products that they are interested in marketing. Food technologists can also offer guidance on the processes and production of milk products.

The Massachusetts Department of Agriculture http://www.mass.gov/agr/ offers *Agricultural Business Training Workshops* from January through March that addresses start-up concepts, such as marketing, financing and grant sources.

The key to the success of value-added products is to market a high quality product that is reasonably priced and available in a convenient location for the consumer to purchase. You must deliver your product consistently and have sufficient supplies to meet the demand. Remember that the consumer will react negatively to your product if you do not maintain your quality standards and/or timely deliver sufficient supplies.

A new certification being offered to growers, producers, harvesters and processors is the *Commonwealth Quality* brand. This brand was designed by the Massachusetts Department of Agricultural Resources and serves to identify locally sourced products that are grown, harvested and processed right here in Massachusetts using practices that are safe, sustainable and don't harm the environment. Only Massachusetts producers can participate in this program. Further information on this program can be found at: http://www.mass.gov/agr/cqp/

Regulations are a critical piece in the planning stages of processing your own product. Contact your state regulatory agencies early in the planning process to help insure that your facility and products meet health and safety requirements.

Summary

Through the addition of value-added products to your farm this can be a good way to increase your farm income, give your farm more visibility and help to expand to new markets. Careful business planning and adhering to state and federal regulations will also ensure the success of your new venture.

Resources

Workshops/Certifications

Massachusetts Department of Agricultural Resources
http://www.mass.gov/agr/programs/abtp/index.htm

Commonwealth Quality Certification
Massachusetts Department of Agricultural Resources
http://www.mass.gov/agr/cqp/

Animal Welfare Approved
1007 Queen Street
Alexandria, VA 22314
(202) 546-5292
www.AnimalWelfareApproved.org

Cheese Information:

http://www.cheesesociety.org
The American Cheese Society website listing conferences, articles, and their latest newsletter.
http://www.cheesereporter.com

New England Cheesemaking Supply Company
P.O. Box 85
Ashfield, MA 01330
(413) 628–3808; Fax: (413) 628–4061
http://www.cheesemaking.com

Regulations:

Massachusetts Department of Agricultural Resources
Regulations on Farm Products
http://www.mass.gov/agr/legal/regs/index.htm

Massachusetts Department of Public Health Food Protection Program
Food & Food Processing Regulations
http://www.mass.gov/?pageID=eohhs2agencylanding&L=4&L0=Home&L1=Government&L2=Departments+and+Divisions&L3=Department+of+Public+Health&sid=Eeohhs2

Consumer Affairs
Chapter 93A
http://www.malegislature.gov/Laws/GeneralLaws/PartI/TitleXV/Chapter93a

Reference:

Gegner, E. L. *Value-Added Dairy Options.* National Sustainable Agriculture Information Service. http://attra.ncat.org/attrapub/PDF/valueaddeddairy.pdf

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UMass Extension

Renewable Energy Production on Dairy Farms

Introduction

Rising energy cost is a significant factor in increasing the cost of agricultural production. Rising energy costs drive up prices for fuel and electricity directly, and costs for feed, fertilizer, and transport indirectly. The economic feasibility of growing oilseed crops or implementing biogas digesters or solar panels will depend on current and future costs and the availability of alternative sources to fossil fuels like oil, coal, natural gas, and nuclear power, on which we currently depend heavily. The fossil fuel costs will most likely increase, however, the rate is unknown, and so there is flexibility for personal assessment of the economic viability of some these renewable energy options.

Consider labor, tractor-time, fertilizer, herbicide, and pesticide costs, as well as pressing costs when assessing feasibility of growing fuel.

Grow Your Own Fuel

Oilseed crops such as sunflower, canola, and soybean can be grown for the pressed oil which can be burned in diesel engines. This only makes sense if the energy required to grow the crop and press the oil is significantly less than the energy value of the fuel output. Consider labor, tractor-time, fertilizer, herbicide, and pesticide costs, as well as pressing costs when assessing the feasibility of growing fuel. In Massachusetts, where farms are relatively small, cooperative purchase of a press may make growing your own fuel more affordable.

Crops that can be burned without processing, such as switchgrass and grain corn, can fit into some dairy operations. Switchgrass is a perennial crop which has minimal fertility requirements, so after establishment there is little growing cost. It may be grown on marginal land which would be unsuitable for row crops and too remote for pasture. Pelletizing switchgrass may have significant associated costs, but as with the oil press, the cost of a pelletizer may be shared among several cooperative owners. For a dairy farmer, growing grain corn to burn may require little additional work or expense if corn is already being grown for grain feed. Corn driers burn a small amount of corn in comparison to the more traditional propane used dry a lot of corn.

Oilseed crops such as sunflower, canola, and soybean can be grown for the pressed oil which can be burned in diesel engines.

Biogas Digesters for Producing Burnable Gas

Biogas digesters, taking in manure and turning out electricity, serve multiple purposes. Firstly, they produce gases which can be burned to generate heat and/or electricity. Secondly, biogas digesters capture methane and precursors to methane which would otherwise contribute to greenhouse gas emissions. Thirdly, biogas digesters leave a spreadable fertilizer as a byproduct. The technology and design of the units is changing as more are being built. Generally, the units require a large enough volume of material that they are built by farmers with help from government grants.

Solar Panels for Water Heating

State and federal incentives for solar hot water production come and go. Check current policies when in the early planning stages of a project. Solar hot water systems are relatively uncomplicated, and may be used to boost water temperature for both forced hot water space heating systems and for domestic/farm hot water systems.

Solar Panels for Producing Electricity

Solar systems for electricity generation are much more complex and expensive than those used for hot water. They may be an economically viable alternative, though, as opportunities to sell electricity sent into the power grid increase. It may even be possible to site panels in such a manner as cows can graze beneath them. There is a photovoltaic system currently under construction at the Crops and Animal Research and Education Center (CAREC) in South Deerfield, MA. The effects of shading the panels on pasture quality beneath the panels are a focus of study. Cows will be grazed under the raised panels.

Resources

Massachusetts alternative energy incentives:
http://www.mass.gov/?pageID=eoeeasubtopic&L=3&L0=Home&L1=Energy%2c+Utilities+%26+Clean+Technologies&L2=Renewable+Energy&sid=Eoeea

State and federal incentives for energy efficiency and alternative energy production:
http://www.mass.gov/?pageID=eoeeaterminal&L=4&L0=Home&L1=Energy%2c+Utilities+%26+Clean+Technologies&L2=Energy+Efficiency&L3=Energy+Efficiency+for+Businesses+%26+Institutions&sid=Eoeea&b=terminalcontent&f=doer_Energy_Efficiency_Federal_and_State_Incentives&csid=Eoeea

Federal grant opportunities to aid in construction of alternative energy projects:
http://www.epa.gov/agstar/tools/funding/incentive/USvalueaddedproducergrants.html

Solar Rating and Certification Corporation rates manufactured products. www.solar-rating.org/

For more information visit www.umass.edu/cdl

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Reducing Energy Use on the Dairy Farm

Introduction

As energy prices continue to rise, farmers must reduce electricity and fuel use on the farm in order to reduce operation costs. Many energy conservation measures are free, low-cost, or have a cost-effective payback. This publication provides an overview of energy conservation across the many operations of the average dairy farm in Massachusetts. After reading this, the next step is to use a farm energy calculator as a self assessment tool to determine where energy inefficiencies are occurring on your farm and where improvements can be made. Next, conduct an energy audit of your farm. Many utility companies can recommend an auditor or audit information can be found through the Massachusetts Farm Energy Program (MFEP)or the USDA Rural Energy for America Program (REAP). Finally, take advantage of state and federal tax breaks, grants, and incentive programs for reducing energy use on your farm (Additional information below).

Steps to Energy Efficiency:

1. **Read this publication**
2. **Use an energy calculator to determine current energy use.**
3. **Conduct an Energy Audit.**
4. **Target energy saving projects and practices to implement on the farm.**
5. **Seek Funding.**
6. **Implement your energy conservation plan.**
7. **Perform regular maintenance on machinery to ensure efficient and long lasting performance.**

Tips for Reducing Energy Use

Tractors, field work, grain driers, buildings, watering systems, fences, and other farm equipment are all part of daily operations on a modern dairy farm and can incur high costs in energy use. The two main types of energy use on farms are electricity from the local utility company and fuel such as heating oil or diesel for running farm equipment. The following pages offer simple ways to improve energy efficiency on the farm.

Tractors and Vehicles

Equipment driven on fields is one of the largest uses of energy on the farm, so careful maintenance and use of tractors will improve energy efficiency greatly. Ultra low sulfur diesel (ULSD) fuel has been phased in over the past few years. Reducing sulfur has allowed for reduction in emissions. However, as with the removal of lead from gasoline many years ago, problems can surface in older equipment. Whether or not additives improve lubrication is disputed. The other problem that occurs is gasket leakage as a result of a change in fuel. Replacing gaskets will solve the problem. Keeping engines running well in the winter with electric warmers is cheaper than using fuel to heat the engine. Idling vehicles can use up to 20% of total fuel use, so turn off machinery when not in use. If there are fuel tanks on the farm, keep them cool to reduce evaporation of fuels, and regularly inspect for leaks.

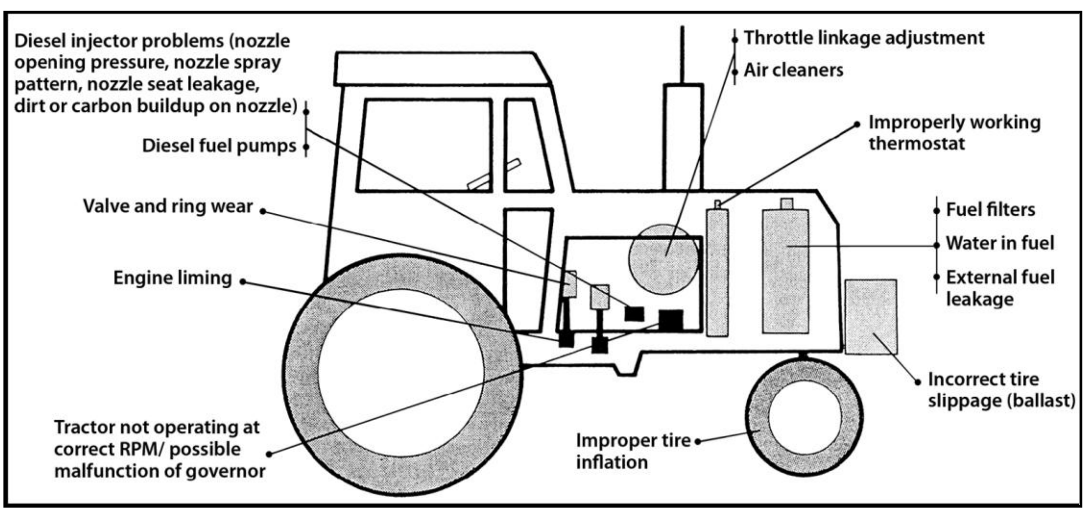

Figure 1. Factors reducing fuel efficiency on a diesel tractor (http://attra.ncat.org/attra-pub/PDF/consfuelfarm.pdf)

Regular maintenance of farm machinery including tune-ups, replacing filters, changing oil, and keeping tires inflated and balanced will help machinery last longer and save fuel. Remove unnecessary weight from vehicles to reduce fuel use. Use an appropriately sized tool or machine for the job so as not to waste fuel. Too much or too little horsepower will reduce fuel efficiency. Drive tractors in higher gears and at lower rpm or throttle setting to reduce fuel use but not so slow as to produce black smoke or a sluggish response. Sharpen ground tillage implements to work the soil with less resistance. Consider purchasing an ATV so as not to use a full sized truck for some smaller on-farm tasks.

Field Practices: Switching to no-till or minimum tillage can reduce fuel use by 86% but may increase the farmer's dependency on herbicides to control weeds. Several conservation tillage methods exist such as zone or strip tillage where only the seeding area is plowed, or ridge and mulch till which require fewer trips across the field. Combining field tasks such as spreading manure and planting simultaneously can reduce the number of passes over a field. Manage manure to reduce dependence on costly fossil fuel based fertilizers.

Average Fuel Use of Farm Activities in Gallons per Acre*

Activity	Gasoline	Diesel
Plow 8 inches deep	2.35	1.68
Chisel plow	1.54	1.10
Cultivate field	0.84	0.60
Planting row crops	0.70	0.50
No-till planter	0.49	0.35
Combine	2.24	1.60
Baler	0.63	0.45
Sprayer	0.14	0.10
Grain drying	8.4	6.4

*****Estimates from Colorado State University Extension

Grain Drying: In some situations, more energy is used to dry a crop then to grow it. Planting early maturing corn varieties allows for more time to field-dry the crop. When using a moisture meter to ensure dryness of grain, make sure it is reading correctly by comparing the reading with another meter. If mechanical drying is necessary, use a natural air or low temperature drying system.

Buildings: Improve housing facilities by insulating and using natural ventilation when possible to reduce energy needs for heating and cooling. Another way to save energy in buildings is to plant a shelter belt of trees along the north side of buildings to reduce the impact of cold winter winds and therefore reduce heating costs. When constructing farm buildings place large doorways facing south so as not to lose too much heat during the winter months. An alternative heating source for farm buildings is a waste oil heater that burns used oil from farm machinery. Keep ventilation fans in livestock housing clear of dust so they will run efficiently and last longer. Large diameter fans are more efficient than small ones. Designing buildings to use natural ventilation is the best case scenario because this requires no energy. Compact fluorescent lighting can be installed in barns and in other areas of the farm to reduce the electric bill. For lighting large areas, a high intensity discharge lamp or metal halide lamp is most efficient. Keep in mind that compact fluorescent bulbs used in livestock housing areas must have a covering. Implementing timers, daylight sensors, or motion sensors will insure that lights are only on when they need to be.

Watering Systems: Irrigation and livestock watering systems can be designed to use less energy. Avoid using center-pivot sprinklers because they require a high flow rate of water and a large electric motor to operate. Using evapotranspiration (ET) based irrigation scheduling will result in the appropriate amount of water applied for crop growth.Make sure that livestock waterers are properly insulated and the right size for the number of animals on the farm. Unplug them when the heater is no longer needed.

Electric Fencing: Where appropriate, solar electric fence chargers hooked up to a battery can be used to keep fences charged 24hrs a day, year-round. Like any electric fence, brush and grasses must be mowed so as not to ground the bottom wire.

Other Equipment: Dairy farms have several options for improving the efficiency of refrigeration and vacuum pumps used for milking. One option is the use of a plate cooler which captures heat from milk and transfers it to cold water, partially cooling the milk before it reaches the storage tank. This can reduce cooling time by as much as 15 to30 minutes, and the warmed water preheats hot water for other uses. A refrigeration heat exchanger is another energy saving device that transfers the excess heat from the milk cooler to preheat water for use in the barn. One more option for use on dairy farms is a variable frequency pump or drive which adjusts the pump's energy use to meet the milking need, resulting in energy savings of 50-80%. It is recommended that variable frequency drives be used for varying loads such as milk pumps, vacuum pumps and ventilation fans. Consult with an energy auditor before making any new 'energy saving' purchases to make sure they will be appropriate for your needs.

Funding Energy Improvements

Improving energy efficiency generally requires minimal investment compared to installing new on-farm energy production systems, therefore many funding opportunities require an audit showing that the farm is currently undertaking energy efficient practices as mentioned in this publication before financing new infrastructure. Since funding opportunities change depending on the political atmosphere, and with your location, be sure to check with an organization such as the Center for Ecological Technology (CET) (cetonline.org) to find out what your farm may qualify for.

Tax Incentives or financial incentives from your local utility company can help offset the costs of installing energy efficient alternatives on your farm.

Summary

Energy conservation and efficiency on farms is a broad topic and farmers will need to find information from other sources regarding the implementation of specific practices. A list of such sources can be found in the 'Additional Information' section of this BMP guide. As a general guideline follow these steps for improving energy efficiency on the farm.

1. Use an energy calculator to determine current energy use on the farm.
2. Conduct an Energy Audit to assess need and viability of energy improvements.
3. Target energy saving projects and practices to implement on the farm.
4. Seek Funding (see above and 'Resources').
5. Implement your energy conservation plan.
6. Make sure to conduct energy audits or perform regular maintenance on machinery to ensure efficient and long lasting performance.

Resources

'25 Quick On-Farm Energy Saving Tips', University of Ontario:
http://www.omafra.gov.on.ca/english/engineer/facts/energy_tips.htm

Massachusetts Farm Energy Program (MFEP)
http://www.berkshirepioneerrcd.org/mfep/energy.php

National Sustainable Agriculture Information Service
http://attra.ncat.org/energy_calculators.html

NRCS/USDA Farm Energy Tools
http://energytools.sc.egov.usda.gov/

USDA Rural Energy for America Program
http://www.rurdev.usda.gov/rbs/farmbill/index.html

U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE)
http://apps1.eere.energy.gov

For more information visit www.umass.edu/cdl

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