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Stakeholders Integration for Sustainable Use of Temperate Forage/Livestock Agriculture

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ABSTRACT

Forage/livestock production is complex, and best management options are often site-specific, but some concepts have broad application. The intent of this article is to provide an overview of research-based management approaches that the authors believe are necessary to ensure the sustainability of forage/livestock farms. This overview discussion is needed because livestock agriculture is changing, thus creating both challenges and opportunities for producers. In the last 30 years, beef numbers in the USA have declined by 20%, but production per cow has more than doubled, resulting in increased total production on less land with fewer animals. Similar statistics exist for the dairy industry. But in recent years, input costs (especially equipment, fertilizer, and fuel) have risen. Prices for livestock products have fluctuated, and grain costs are much higher, thus affecting the overall cost of traditional finishing programs. The result is that forage is more valuable than it has ever been, and improving forage management will pay bigger financial dividends than in the past. Producers who stay in business will need to increase their focus on a number of management areas. Examples include: (1) selection of the optimum species and varieties for the soils, climate, and enterprise; (2) forage crop fertility; (3) establishment; (4) use of forage legumes; (5) forage quality; (6) profit-robbing disorders such as fescue toxicity; (7) grazing management and (8) hay storage and feeding losses.

Keywords: Challenges, Costs, Forage, Livestock, Management, Opportunities, Pasture

Introduction

Forages typically account for over half the cost of production of forage-consuming animals and provides most of their nutrition. Thus, it has a major impact on both expenses and income. The basic commodity in forage and animals are the harvesters or consumers. Efficient forage production and utilization are essential to a profitable operation. Historically, the pace of change with regard to forages and livestock production has been relatively slow. However, that has changed in recent years. Input costs (especially equipment, fertilizer, and fuel) have risen, and the future is uncertain. Although prices for some livestock products are higher at present, we expect that from a financial standpoint, times will be hard for many livestock producers in the future unless they implement some changes in their operations. This paper provides a focus on management concepts that will be required for profitable and sustainable forage/livestock production in the future.

Judicious selection of species and varieties

It is an elementary, but highly important point that decisions regarding the forage species and varieties that will be planted and grown will have an enormous impact on productivity and profit potential (Vough *et al.*, 1995). If a forage crop is not well adapted to a given soil and site, planting it is likely to result in poor performance or even to stand failure.

Thus, it makes sense for a producer to refer to soils maps, study literature describing the adaptation of various forage crops, and to have discussions with knowledgeable persons such as governmental agency personnel, industry representatives, and neighbors to learn from their training and/or experience. The likelihood of optimizing one's forage program is greatly enhanced by knowing the forage species options for each field on the farm. The differing nutritional needs of various species and classes of livestock must be taken into consideration when deciding what forage crops to plant (Pearson and Ison, 1987).

Once forage species options are known, and decisions regarding species have been made, the important business of selecting the proper varieties should be given ample attention as well. For centuries humans have selected seed from the most vigorous and productive plants of a particular plant species. The result was that more productive strains were developed and food production was improved. However, the *science* of plant breeding is relatively young, with most of the advances having occurred within the past 50 years. Most economically important crop and forage plants have been improved through plant breeding, with hundreds of varieties of some crops having been developed. In various crops, forage yield, forage quality, disease or insect resistance, distribution of growth, seed production, and numerous other traits have been altered for the purpose of enhancing environmental fit and the likelihood of increased producer profits.

Seed of improved varieties, especially the best varieties, usually costs more than "common" seed or seed of less productive varieties. However, seed cost is usually no more than 10 to 15% of the cost of establishment of a forage crop, which is generally of relatively little consequence even with annual crops. With a perennial forage crop, where seed cost is prorated over a stand life of several years, the difference in seed cost between the best variety and the worst variety is usually miniscule on an annual basis, while the potential returns for better varieties is large. There are inherent differences among various forage species with regard to forage yield, forage quality, distribution of forage growth, and other factors. The species that is easiest to grow often does not provide the most economical production. Also, in some cases a particular *type* of forage plant within a given forage species may offer great advantages (for example, endophyte-free or novel endophyte tall fescue (*Festuca arundinacea* Shreb.) versus toxic-endophyte tall fescue).

It makes sense to use products that offer the greatest value, not necessarily those that are lowest in price. In the case of forage crops, this means products that have been proven to result in economically favorable forage yields, forage quality, and animal performance. Saving a few dollars per acre in seed cost by purchasing a less-than-optimum variety, species, or type of forage plant is false economy. The successful livestock producers of the future will be those who plant forages that result in the most economical plant and animal performance.

Forage crop fertility

The trend toward increased cost of fertilizer is alarming. Budgets prepared by university agricultural economists in recent years have indicated that the expense of applying fertilizer according to soil test-recommendations can in some cases account for 50% or more of the cost of growing forage. Unfortunately, no significant decreases in the cost of commercial fertilizer are expected anytime soon. Soil testing is more valuable than ever. It allows a producer to determine soil pH, which is a critically important factor in stand density and forage production. Also, anyone who doesn't tests soil, t is guessing with regard to the amount of fertilizer to use. Applying too much fertilizer is a waste of money; applying too little will result in less-than-optimal forage growth. Soil testing can provide a huge payback in terms of forage crop productivity and animal production (Ball *et al.*, 2015; Chessmore, 1979). The higher fertilizer costs rise, the more important soil testing becomes.

Most livestock producers realize that forage is normally the least expensive source of nutrition for their animals, but when fertilizer costs are high, the idea of applying fertilizer in accordance with soil test recommendations may constitute a dilemma. On the one hand, fertilizer may seem unbearably expensive. On the other hand, failure to apply fertilizer will result in poor forage growth, with the result being that it may be necessary to purchase alternative sources of nutrition that will be even more expensive than applying fertilizer. High fertilizer prices often cause producers to decide to apply less fertilizer. While this lowers fertilizer costs, it also drastically reduces forage production. Nonetheless, in an economic crisis scenario, it makes sense to carefully assess stocking rate, expenses, and the risk of running out of pasture forage too soon (which would increase stored feed needs unless animals are sold). Undoubtedly, in such a situation some producers may reach the conclusion that to some extent they can substitute pasture acres for fertilizer, at least in the short run.

Careful attention to timing of fertilizer applications is worthwhile, because pasture forage is more valuable at some times or in some situations than others. As one example, tall fescue growth is greatest in spring, minimal in summer, and relatively good in autumn. Because there is more likely to be an adequate amount of tall fescue pasture forage available in spring, fertilizer applied in late summer or early autumn may stimulate fescue forage production that is particularly valuable. The higher fertilizer prices are, and the more expensive hay or alternative sources of feed become, the more important the timing of fertilizer application becomes. Furthermore, not all fields are equally productive. For example, a producer might have one pasture in a bottom field where the soil is good and where moisture is seldom a serious limiting factor, while another pasture is dominated by steep hills where the soil is poor and plants are vulnerable to drought. Obviously, the return in terms of forage production per dollar spent on fertilizer will be quite different in the two fields.

Organic waste materials can be a good option for providing nutrients to forage crops. Livestock manures, poultry litter, treated municipal wastes, and by-products from food processing may offer an opportunity for lowering costs. The keys to successful use of such materials are: (1) to make certain the cost per unit of nutrient applied is economical as compared to other sources of nutrients; (2) to verify that the product is safe to humans and animals; and (3) to know that the product will not harm the soil or the environment.

Establishment

Forage crop stand establishment is critical because good forage production depends on having a thick, healthy stand of forage plants. The consequences of taking short cuts or using imprecise or risky techniques during establishment can have long-lasting impacts that will hurt forage production from a field for a long period of time. Planning ahead is one of the keys to forage stand establishment success. This includes the previously mentioned concepts of determining what forage species and variety should be planted on a given field, and taking soil tests to determine lime and fertilizer needs. However, to help ensure establishment success, any of a number of other steps may need to be considered and accomplished including possibly killing troublesome perennial weeds before planting, locating source(s) of seed of the desired species and varieties, purchasing herbicide to use during the establishment process, and checking and adjusting planting equipment.

Doing a good job of establishment is largely associated with exercising attention to detail with regard to the establishment requirements of a particular forage species (Ball *et al*., 2015; Vough *et al*., 1995). This includes timing and method of lime and fertilizer application, planting at the right time of year, using a suitable seeding rate, planting the seed at the proper depth, getting good distribution of seed over the field, and planting in a manner that results in good seed/soil contact. Many techniques and types of equipment can be used in planting forage crops, some of which are superior to others with certain crops or in certain situations. However, the general rule is that if the requirements mentioned above are met, a good stand is likely. The results obtained, not the method used, is what is important.

Young stands should be closely monitored, because seedlings are much more vulnerable to adverse situations than are older, well-established plants. In some cases an insecticide or herbicide may need to be applied to protect against pests. In other situations, clipping or grazing to prevent shading of young plants may be advisable. On the other hand, grazing a young stand too quickly may result in seedlings being pulled up by the roots, or hoof damage to young plants, especially on a prepared seedbed.

Use of forage legumes

There are really only two ways to improve the economic viability of any enterprise/ agricultural : to increase income or reduce expenses. The fact that forage legumes such as clovers (*Trifolium spp*.), vetches (*Vicia spp*.), alfalfa (*Medicago sativa* L.), and lespedezas (*Lespedeza or Kummerowia* spp.) offer the possibility of doing both simultaneously, that is why they are of such great value in forage/ livestock production (Ball *et al*., 2015; Lacefield and Smith, 2009). A unique way that forage legumes can reduce expenses is via their ability to interact symbiotically with *Rhizobium* bacteria that take nitrogen (N) from the air and fix it in nodules attached to legume roots. Studies have shown that where a good legume stand is present, the amount of N fixed per acre per year will typically be in the range of 50 to 150 pounds for most annual legumes and 100 to 200 or more for a perennial legume. This means that, for example, if N is selling for $0.60 per pound, fixation of 100 pounds per acre per year is worth $60 per acre.

Another way that a forage legume can help reduce costs is that when it is grown in combination with forage grass(es), the grazing season will often be extended, thus helping reduce the need for stored feed. While this does not occur with every grass/legume combination, it certainly occurs with some. One example is that in many areas red clover (*Trifolium pretense* L.) seeded into tall fescue will increase the amount of summer pasture forage growth. Another is when crimson clover (*Trifolium incarnatum* L.), a winter annual that makes good late winter and early spring growth, is seeded into a warm season perennial grass such as bermuda grass (*Cynodon dactylon* [L.] Pers.) or bahia grass (*Paspalum notatum* Flugg.). As compared to growing grass alone, forage yield resulting from a legume/grass mixture is often higher. The more costly N fertilizer becomes, the more likely it is that a livestock producer will cut back on, or even eliminate, applications of N fertilizer. Yield is especially likely to be higher with a grass/legume mixture when compared to grass alone that receives little or no nitrogen fertilizer.

Most importantly, forage legumes offer a wonderful opportunity for increasing income as a result of higher levels of animal performance. Thousands of experiments, as well as wide producer experience, have shown that legumes usually produce higher quality forage than grasses. Weight gains, conception rates, and the overall health of grazing animals tend to be higher when the level of nutrition is improved. Forage legumes require more planting precision, they are less tolerant of herbicides, and they are more fickle than grasses. The possibility of legume bloat also looms large in the minds of some producers. However, nothing is perfect, and the benefits legumes offer greatly outweigh the disadvantages. Use of forage legumes has long been a forage/livestock profit factor, but the higher the cost of production inputs, the more economically important the use of legumes becomes.

Forage quality

In recent years, advances in plant and animal breeding, introduction of products that favor animal health, and development of new management approaches have made it possible to increase animal performance. However, for animal production potential to be realized there must be additional focus on forage quality. Good animal nutrition is essential for high rates of gain, ample milk production, efficient reproduction, and adequate profits (Ball *et al.*, 2015; Buxton and Mertens, 1995). However, inherent forage quality varies greatly among and within forage crops, and nutritional needs vary among and within animal species and classes. Producing suitable quality forage for a given situation requires knowing the factors that affect forage quality, then exercising management accordingly.

Analyzing stored forages for nutrient content can determine whether forage quality is adequate and can thus guide ration supplementation. If hay does not meet the nutritional requirements of the animals to which it is being fed, one of two things will happen: (1) weight gains and possibly reproductive efficiency will be less-than-optimum; or (2) supplemental feeds will need to be provided. Either of these scenarios is likely to be considerably more expensive than providing hay of adequate quality.

Animal disorders

There are numerous animal disorders that can rob profits from forage/livestock producers. These include weeds, diseases, poisonous plants, and certain problems associated with animal nutrition. Due to space limitations, in this article we have chosen to address only one, which is fescue toxicosis.

Tall fescue is the most widely grown forage grass in the United States. Most acreage is the variety 'Kentucky 31,' and in most fields over 80 percent of the fescue plants are infected with an internal fungus or endophyte, (*Acremonium coenophialum* [Morgan-Jones and Gams] Glenn, Bacon, and Hamlin) that produces toxins that lower animal gains and reproductive levels (Ball *et al.,* 1993). This problem reduces income on livestock farms in the USA by as much as a billion dollars each year! Thus, during difficult economic conditions it is important for livestock producers to understand their options with regard to minimizing endophyte toxin-related losses. In broad terms they are as follows.

Avoidance: This is simply the idea of preventing consumption of toxic fescue by grazing animals, at least at certain times. Consider these facts: (1) grazing animals react more to endophyte toxins during hot weather; (2) toxin levels are typically highest in fescue in late spring; and (3) consequently, gains and conception rates of animals grazing toxic fescue in late spring are likely to be low. Thus, keeping away certain animals from grazing toxic fescue at certain times can reduce losses.

Dilution: If at least some of the toxic fescue in an animal's diet is replaced with another feed source, the amount of toxins consumed will be lower. One of the most effective ways to reduce the effects of a toxic endophyte pasture is to grow a legume such as white clover with the grass.

***Pasture height*:** Animal gains are not reduced as much on young, tender growth of toxic endophyte fescue as is the case when they graze older, more mature forage. Also, fescue seed heads contain more toxins than leaves and stems. Grazing management that keeps animals eating young grass minimizes the opportunity for them to selectively graze seed heads is desirable.

***Hay*:** Hay contains lower levels of endophyte toxins than green grass, but there are still adverse effects on animals. However, toxic hay fed during cool weather has less effect on animals than the same hay fed during warm weather. Treatment of toxic endophyte hay with anhydrous ammonia reduces toxin levels in hay.

Kill toxic endophyte fescue and establish another forage crop: Another option is to kill a stand of toxic endophyte fescue and replace it with some other perennial forage crop such as bermuda grass or orchard grass. Doing this is especially feasible when forage crops and row crops are grown in rotation. However, tall fescue has many excellent forage qualities, so the best option may be to replace toxic fescue with non-toxic fescue. Endophyte-free fescue is non-toxic, but is less stress tolerant and persistent than fescue that contains an endophyte. This is especially true in warm climates such as the southeastern USA.

***Kill toxic endophyte fescue and plant novel endophyte tall fescue*:** A major forage research development was the identification of endophyte strains that do not produce the toxins mentioned above, but that do produce the compounds that favor fescue persistence. "Novel endophyte" is the term scientists use for a fungus that was selected and subsequently inserted into a plant for the purpose of getting particular results. Novel endophyte fescue (NEF) has been a great success. Since 2000, hundreds of thousands of acres have been planted in the USA, plus a substantial quantity has been planted in other countries, especially New Zealand (novel endophyte perennial ryegrass is even more widely planted than NEF in that country).Gains of animals grazing NEF have been similar to those obtained with endophyte-free fescue (sometimes almost twice the gain obtained on toxic Kentucky 31). In addition, the reproductive rates of animals grazing NEF are often considerably better as well. Also, (in view of the stand loss problems that may occur with endophyte-free fescue under stressful conditions), NEF has proven to be tough and persistent. Several NEF's are now commercially available in the United States, and more are expected in the near future.It can be argued that in much of the USA, NEF represents one of our most promising opportunities for cost efficient livestock production. For example, gains of yearling beef animals grazing NEF can approach 2 lb/day, and calf weaning weights can be 50 or more pounds higher than with toxic -endophyte fescue. When clover is grown with NEF, gains are even better, while nitrogen expenses are reduced or eliminated. NEF can greatly improve the economics of livestock production on many farms where tall fescue is adapted.

Grazing management

Grazing management is a many-faceted topic that becomes increasingly important when economic conditions are difficult. Here are some (certainly not all) of the economically-important benefits that can result from proper grazing management (Ball, *et al.,.*, 2015; Smith *et al.*, 1986; Vallentine, 1990).

Higher percentage of pasture forage utilized: - The percentage of pasture forage produced that ends up being consumed by grazing animals increases as grazing management increases. With management-intensive grazing, utilization can be increased by as much as 20 to 30% in some cases.

More pasture forage produced: Leaves are the food production factory of forage plants. One of the goals of grazing management should be to manage grazing so that there is always enough young leaf tissue present to allow good interception of sunlight, but to minimize the number of old, marginally productive leaves. This favors more forage growth.

Better nutrient recycling: Good grazing management forces grazing animals to spend more nearly equal amounts of time in various parts of pastures. This results in more even distribution of urine and manure, which are major sources of nutrients for plant growth.

Higher quality pasture forage: The older and more mature forage becomes, the lower forage quality will be. Proper grazing management helps ensure that pastures are not under grazed and favors good pasture forage quality.

Fewer weeds: As grazing management becomes more intensive, animals have less opportunity to selectively graze. Many weed species are put at a severe disadvantage if defoliated on a regular basis.

Less "spot overgrazing" of desirable plants: Good grazing management allows a rest period for desirable forages. The result of this is a substantial increase in the competitiveness of desirable forage species.

Facilitates use of legumes: Legumes offer many benefits, but they require a higher level of management than grasses. Good grazing management can include use of strategies that favor establishment and persistence of legumes.

Facilitates crop rotations: In areas that are fenced, or that can easily be fenced, and where water for livestock can be provided, it is usually a simple matter to alternate row crops with forage crops. As compared to continual cropping of non-forage crops, rotations improve soil health and farm profit. This is especially true when both grasses and legumes are included in the rotation.

Larger plant root systems: Removal of leaves is a major stress factor for plants. When plants are grazed too closely, root growth stops or is severely reduced. Appropriate grazing management favors development of larger root systems that make plants more resistant to drought and other stresses, thus tending to lengthen the number of calendar days of grazing and reducing stored feed needs.

***Improved soil quality*:** Pastures that are never overgrazed and in which forage plants and their root systems are healthy and vigorous tend to have more soil organic matter, to be less compacted, and exhibit greater water infiltration. Such pastures are also much less vulnerable to erosion. Therefore, grazing management results in a livestock operation being much more environmentally friendly.

Hay storage and feeding

Most livestock producers need to have a supply of stored feed on hand to provide to their animals at times when pasture forage is inadequate to meet nutritional needs. In most situations in the USA, hay is the most logical type of stored feed to rely upon most of the time. However, hay is environmentally problematic, labor intensive, and expensive. Generally, the less hay required, the greater the cost effectiveness of a livestock operation. Several factors affect the extent of hay storage losses, but storage technique is of utmost importance (Ball *et al.*, 1998). Losses of dry hay stored inside a barn or otherwise protected from the elements are usually of little concern. However, even for barn stored hay, losses rise sharply as moisture levels increase above 20%, and losses from round bales stored outside under adverse conditions can be much larger. Hay can be subject to dry matter losses, as well as to losses of forage quality during storage.

In the eastern United States it is not unusual for 4 to 8 or more inches of spoilage to occur on large round bales stored outside with no protection from the elements. A weathered layer 6 inches in depth on a 5.6 foot × 5.6 foot bale contains about one-third of the package volume. The percentage of loss decreases as bale size increases because a smaller proportion of the bale volume is contained in the surface layer. In areas of high and/or frequent rainfall, or with hay that does not shed water readily, the method of storage can make the difference between less than 5%, or more than 50%, dry matter loss due to weathering! Furthermore, losses of more than 14% of the total crude protein and more than 25% of the total digestible nutrients can occur in the most highly weathered parts of a bale. An important associated factor is that weathering decreases the palatability of hay, which lowers animal intake and increases refusal. Space does not allow discussion of all important hay storage points in this paper, but here are a few that are worthy of consideration.

*In general, the denser (more tightly) round bales that are to be stored outside are baled, the lower the amount of spoilage, assuming hay moisture at baling is 18 to 20% or lower.

*Studies have shown net wrap to be more effective than twine wrap in preventing losses.

*If hay must be stored outside, the location should be a well-drained area. Hay/soil contact should be prevented.

*The flat ends of bales should be firmly butted against one another. If possible, rows should run north and south. At least 3 feet should be left between bale rows to allow air movement.

*Providing barn storage or some type of cover to prevent penetration of rain water is highly desirable, especially on loosely baled or large-stemmed hay.

Hay storage and hay feeding are intertwined, as both operations greatly influence the amount of hay wasted (and therefore needed) in a livestock operation. In fact, hay storage conditions can affect feeding losses, because animals are more reluctant to consume weathered hay, and will therefore waste more. Feeding losses occur mainly from trampling, refusal, and leaf shatter. Some feeding loss is inevitable, but it can vary from as little as 2 or 3 percent to well over 50 percent. The more hay presented to animals at a time, the higher feeding losses will be. Recognition of the potentially higher losses from feeding large hay packages has led to development of various strategies to minimize losses. Placing a barrier between animals and the hay, such as a hay ring, has been shown to be quite helpful. A cone, trailer, or cradle feeder design is even more effective due to reduced amounts of hay falling on the ground. Some producers unroll hay on sod, which can also greatly lower feeding losses while reducing pasture damage.

If hay is fed on sod, the feeding areas should be rotated. This minimizes soil compaction and damage, and also helps result in more even distribution of dung and urine. It is desirable to select less fertile fields or areas within fields for feeding hay on sod, as this will aid in building soil fertility in these locations. Losses of hay during storage and feeding are real, and not just potential, losses. When hay losses occur, the time, thought, labor, and monetary inputs involved in producing or procuring the hay are lost along with the hay. Clearly, any livestock producer who is seriously interested in maximizing cost effectiveness in his or her operation needs to focus on all aspects of hay. Losses that occur during storage and feeding are expensive, but relatively easy to prevent or minimize.

Hay production versus hay purchase

There are several valid reasons why people may opt to produce, rather than purchase hay. However, anyone who is truly serious about improving the cost effectiveness of their operation would do well to consider whether buying or producing hay will be most economically favorable. Because of the expense of owning and operating hay equipment, it is quite difficult for a producer who has only a relatively small number of animals to economically justify producing hay. Most Land Grant universities in the USA provide annually prepared budgets that provide much insight regarding the economics of producing, versus purchasing, hay.

Stored feed needs

Feeding animals during times when pasture forage is not available is typically the greatest expense associated with livestock production. While most livestock producers know that hay is costly, it seems that many may not fully realize and appreciate just how expensive it really is. As suggested in the previous paragraph, anyone who would like additional enlightenment regarding the cost of hay production should take a close look at up-to-date forage budgets that are applicable to their geographical area. An inescapable conclusion that results from a careful evaluation of the cost of hay production is that it is usually desirable for a cattle producer to minimize the amount of hay fed. A recent nationally-oriented publication titled, “Extending Grazing and Reducing Stored Feed Needs,” which summarizes approaches that can be used to accomplish this objective, is online at several forage web sites and can be located via a quick web search. For most livestock producers, extending the grazing season for their animals, or otherwise filling gaps in pasture forage availability to reduce stored feed needs, should be a high priority objective.

Conclusion

Forage crops have always been important in production of grazing animals, but they may be more important than ever in the future. Over half of the cost of producing most livestock is the expense of providing pasture and hay. In addition, the level of performance of grazing animals depends largely on the nutritional value of what they eat, which is mainly forage. Thus, a livestock producer's forage program is of major economic importance. It appears that economic realities may result in unprecedented changes in forage/livestock production. Livestock producers who are concerned about profitability of their operations may be compelled to consider making substantial changes in their management approaches. Focus on the general management categories mentioned in this paper provide the key to profitability and sustainability in the future. Fortunately, there is much research-based technology associated with these concepts that is not being widely utilized at present, so there is much room for improvement. Furthermore, there is emerging technology that promises to be of much future benefit (Volenec and Nelson, 1995).

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