Sustainable Agriculture

II. The Contribution of Forage

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Photosynthesis

All food is derived from solar energy. Photosynthetic organisms transfer this energy into essential organic substances required for the life of animal herbivores. In turn, carnivores and omnivores tertiarily derive their food from the photosynthetic source.

The net process of photosynthesis is carbon fixation. Without the recycling of fixed carbon from organic materials back to carbon dioxide, from which it can, again, be converted to organic substances by photosynthesis, life on earth would cease. Stated another way, the conversion of organic carbon by non-photosynthetic organisms is necessary to maintain the carbon dioxide supply for continued photosynthesis. Similarly, non-photosynthetic aerobic organisms, like humans, receive their needed oxygen from this photosynthetic process.

Plants vs. Animals

Plants have developed protective systems to ensure their own continued existence and survival. Their physical and chemical structures offer resistance to ingestion or attack by heterotrophs, such as fungi, bacteria, and nonruminant animals. However, ruminants, like cattle, sheep, and goats, have evolved with a specific digestive system that can overcome some of these protective systems. For example, cellulose is an important part of plant structures. While nonruminants, like swine, poultry, and humans, cannot digest cellulose, ruminants can. This is why ruminant production systems, are built around pasture forage, hay, and silage while nonruminant systems depend on carbonaceous and proteinaceous concentrates. Although the abundance of cellulose in the world is great, its transformation into useful energy depends on the activity of microorganisms. Nowhere is this more evident than in the ruminant. Consequently, ruminant animal production will be sustained as long as humans survive.

As more and more pressure has been applied to ruminants to be more efficient in production of products consumed by humans, concentrates have replaced much of the dietary roughage (from pasture forage). But, what is often overlooked is that forages produce animal products from lands that cannot be used for grain production. In the future, if all the tillable land is used for production of products consumed by nonruminants, the grazing ruminant animals will still be able to produce because of their ability to utilize the forage cellulose. Furthermore, if the world's human population becomes entirely vegetarian, the major animal product from cellulose will be wasted and starvation will increase.

Forage Production

Pasture is a tremendous forage resource capable of intercepting and storing large

amounts of solar energy and, consequently, if managed correctly, supporting high levels of livestock production. Pasture needs to be managed to produce a high-quality, dependable, and uniform supply of forage at as low cost as possible to match the type and production stage of livestock consuming it. Pastures in the U.S. are almost exclusively complex mixed swards with variable plant growth characteristics. Manifestation of these characteristics depends on rainfall, temperature, light, and fertility. When plants are continually exposed to animal pressure, overgrazing usually occurs in early spring and mid to late summer. The same pastures are likely to be undergrazed in late spring, early summer, and fall. When excess forage is available, sheep selectively graze the more palatable plants, leaving the rest to mature, flower, set seed, and multiply. Sheep also tend to select leaf in preference to stem and young, green material in preference to older, dry material. The intake of any component depends on: (1) the potential rate at which it can be eaten (ease of fracture, particle size, water content, the shape of the animal's mouth, degree of satiation); (2) its accessibility (height, density, position of sward in relation to other components); and (3) its relative acceptability (taste, odor).

Pasture Management

Dry matter yield of temperate forages, like fescue, orchardgrass, and bluegrass, is inversely related to their nutritive values. Continuous stocking permits excessive consumption of low yielding, highly palatable forage in the spring, leaving the higher yielding, less palatable forage to mature and become low quality in summer. Overgrazing also allows encroachment of broadleaf weeds, legumes to be "shaded-out", decreases in soil nitrogen levels, and eventual total production decreases because the more palatable forages completely disappear. Even if animals are forced to consume the mature unpalatable forage in summer, utilization of this material for productive purposes is suboptimal. Eventually, the forage will be unable to provide the nutrients required for projected animal performance. Then, production will cease. On the other hand, rotational stocking rations pasture forages to grazing animals according to their needs while protecting the plants from overgrazing. Rotational stocking utilizes rest periods so forage regrowth accumulates without significant decreases in nutritive value. Rest periods can be short (i.e., 18 to 21 days) in spring, but much longer in summer (36 to 40 days). If rest periods are too short, overgrazing can occur. In contrast, if they are too long, accumulated forage contains excess fiber (cellulose) rendering the forage less digestible, lowering its nutritive value, and reducing the sustainability of animal production.

Growth is the best indicator of conditions of the plant. With adequate rest between grazings, pastures may be grazed for a longer part of the year than would otherwise be possible. Three example management schemes that can be used to extend the grazing season longer into the fall of the year are described below.

1) Set aside a portion of the area in the spring and harvest for hay. Rest the harvested area for 25 days, divide into paddocks and include in the grazing rotation. Harvest the highest quality forage as hay or pasture.

2) Increase the number of animals in the total area during May, June, and July. This may be the only way to graze the area if it is too rough for harvesting with machinery. Excess animals are removed by mid-July (sold or transferred to another area). Protect the plants from overgrazing.

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3) Graze more than one species (sheep and cattle) on the same land area, either simultaneously or one after the other (depending on the production stage of each species). Animals with the highest nutrient requirements are grazed on the best forage. Follow with maintenance animals. The end result is greater animal output per acre because the plant variation fulfills the nutrient requirements of animals with different production functions.

In an intensive rotational stocking system, the sheep industry standard is not to exceed 6 days on the same paddock. Limiting ewes to 2 days or less, or 12 to 24 hours for growing lambs, may produce even greater forage utilization. Although these lengths of stay may not be the same in every situation, generally the longer animals stay in a paddock, the less palatable the forage becomes and the more time and energy they spend searching for palatable forage. Electric fencing technology has made intensive rotational stocking an efficient forage management tool by increasing plant solarization, photosynthesis, dry matter production, and biological output.

Energy from Forages

Forages are used by animals primarily as a source of energy. Of the total energy consumed, only the digestible portion (DE) is usable by the animal. Still, some of the DE is lost from the animal through digestion gas (methane, carbon dioxide), urine, and heat of digestion (heat increment). The energy remaining is net energy (NE) and is used to meet the animals' maintenance and production needs. The efficiency of NE use depends on whether it is channeled to maintenance, milk production, fiber production, or weight gain. The need to simply maintain weight may account for 50 to 100% of the animals' energy consumption. The amount remaining, after maintenance requirements are met, depends on the specific stage of animal production (gestation, lactation) and the quality of forages consumed (higher the quality, the more NE that can be used for milk production, fiber production, and/or weight gain).

Sheep use energy more efficiently for maintenance or milk production than for weight gain. For example, at 70% DE, forages, like vegetative bluegrass, orchardgrass, and fescue, are 65 to 70% as efficient as corn for meeting maintenance and production needs. Conversely, at 50% DE, these forages are only 50% as effective as corn in providing energy for maintenance and milk production. These same lower quality forages, at 50% DE, are less than 20% as efficient as corn for production of weight gain. Daily forage intake usually increases as DE increases – up to about 65% DE. If forages contain less than 50% DE, weight gain is impossible and milk production is possible only at the expense of body weight loss. Consequently, there are tremendous potential increases in animal production with modest increases in forage quality.

Sustaining Pasture Forage

Rotational stocking is recommended when the forage supply is short or when forage reserves need rebuilding for later use. Continuous stocking is recommended when the land is grazed at less than its full carrying capacity and intensive management is not required. **Production per animal may be greater with continuous stocking than with rotational stocking, but animal**

production per acre may be less. A significant advantage for rotational stocking that is often overlooked is weed control, especially with sheep.

If pastures are to be maintained and/or improved for maximum plant and animal yields, exogenous nitrogen (N), phosphorus (P), and potassium (K) must replace those elements removed by grazing animals. Although some believe excessive fertilization increases animal productivity, research shows neither animal intake nor digestibility is improved when forage crude protein levels (dry matter basis) are greater than 7%. Forage contains nonprotein N and protein N, both of which are rapidly degraded in the rumen by ruminal bacteria. Since sheep are probably dependent on ruminal microbial protein as their main source of N, fertilizer N that maximizes forage yield may be wasted because the resultant level of N in the forage may far exceed the requirements of the bacteria that live in the rumen of grazing sheep. Simply put, this says fertilize to optimize, not maximize, forage production. Then, viability and productivity of the forage plant is maintained as animal intake and digestibilities are maximized.

In view of fertilizer costs, incorporation of legumes into pastures for sheep is an economical alternative to maximize utilization of fixed forage N. Legumes are of greater nutrient value than grasses for high animal performance, even at equal intake and digestibility. Simultaneously, leguminous forages accumulate soil nutrients to enhance production of crops with high N requirements and serve as cover crops to reduce soil and water losses. However, legumes, like alfalfa, white clover, lespedeza, tend to be less competitive than grasses and need to be reseeded periodically with nodule-forming bacteria to make N fixation possible. Legumes may also require more P, K, and lime; their growth may be sporadic; rainfall is critical to maintaining productivity; and they require high stocking rates for efficient use. Too often, legumes are recommended and added to a pasture simply because "they are good for the soil", with little or no thought going to their management and ultimate utilization by animals.

Summary

As long as the sun shines, photosynthetic organisms will be able to transfer solar energy into organic plant substances required for herbivore survival. Although these same plants have developed innate characteristics that resist excessive consumption by grazing ruminants, their future survival will depend on plant/animal management schemes that complement each other. If ruminants, like sheep, are permitted to overconsume only forage, animal and plant productivity is likely to be reduced. In contrast, **maximum** forage productivity and **optimum** animal production can be realized when legumes are incorporated into pastures to match the production phase of the grazing animal. Rotational stocking needs to become routine and multi-species grazing will be practiced in order for the available forage nutrients to be used efficiently by the consuming animal. Therefore, if future agriculture is to be sustainable, forage, along with the consuming herbivore, must be contributors. However, both will rely on humans to manage them in concert so both can live in a symbiotic relationship.

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