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Abstract

Grazing system management is for supplying inexpensive, adequate nutrition for the goat enterprise. This involves managing forages to facilitate dry matter production and managing grazing so forage quality is adequate and harvest efficiency is high while avoiding consuming internal parasites. Since nutrient costs are greatest for winter, the grazing system should be planned to provide some grazing during winter. The forage system should be managed to provide the greatest proportion of nutrients possible during kidding and lactation. The base forage species can be overseeded with cool-season or leguminous species to improve forage production, quality or the seasonal distribution of forage production. A well-managed rotational grazing system can improve forage harvest efficiency, reduce consumption of internal parasite larvae and improve animal tameness. Good pasture management requires gathering information, planning and compromising to attain forage production objectives and the flexibility to cope with changes in the weather.

Keywords: Grazing System, Grazing, Forages, Pasture, Goat Production

The goal for grazing system management is to provide as much of the nutrients required by the animal from economical forage sources. This implies that nutrients from forages under some conditions may not be the cheapest, depending on the forage system. Well managed pastures can be one of the cheapest sources of nutrients. It is difficult for small goat producers (<10 head which accounts for 52% of goat producers; USDA, 2011) to utilize the advantages of improved grazing systems because of the limitations of capital and scale. There is little information available in the literature on goat pasture management in contrast to beef cattle. We often can extrapolate from cattle realizing that goats have different dietary preferences, generally do not like Bermuda-grass and eat little of most clovers except for berseem clover. Also, managing the pasture for the avoidance of parasites is more important than managing pastures for maximal production. Generalized recommendations are given in this paper and local extension expertise should be consulted before application of principles outlined in this paper. This subject has been reviewed by Luginbuhl and Mosley (2015).

Nutrient Requirement of the Animal

We are most interested in supplying nutrients to the doe during the dry period, gestation and lactation as shown in Figure 1 (Appendix). Under some conditions, we are interested in supplying nutrients to stocker animals. Stocker animals would be expected to have an intake of 4.5% of body weight per day for animals under 50 lbs and 3.5% of their bodyweight for animals over 50 lbs. Forage quality is very important for stocker animal gains. For the former, the chief determinant of the nutrient requirement for the doe during the year is the day of kidding since nutrient requirements increase exponentially 6 weeks before kidding and are elevated during lactation after kidding and reduced abruptly at weaning. Although many kids are weaned at 90-100 days, kids may remain with the doe for 150 days until they are sold. Meat goats produce little milk after 80 days and a doe with kids at this time has nutrient requirements only slightly elevated above a dry

doe. Many factors affect choice of kidding date, such as weather, parasites, forage availability, tradition and market, but forage production is often not considered in the decision. Two-thirds of the total annual nutrient requirements of the doe occur from 6 weeks before kidding to 12 weeks after kidding due to the high nutrient requirements in late gestation and during lactation. Profitability can be increased by supplying more of these nutrients from grazed forage and less from stored or purchased feed.

Forage Production from Base Forage

A healthy forage stand requires sunlight, warmth, moisture and plant nutrients to produce forage. Warmth and under some conditions, sunlight may be limiting for growth. The producer can provide plant nutrients, but often moisture is limiting. There are several strategies for overcoming moisture (rain) limitations. Irrigation is the most obvious, but expensive and exacerbates parasite problems. Good fertility improves water use efficiency. Some forage species are more efficient at utilizing soil moisture and some forage species can extract more soil moisture than others. A pound of forage produced during the cool season is worth two pounds of warm-season forage because forage is much scarcer during the cool season and hay, the alternative, is more expensive. The relative production across the year is shown for cool and warm-season forages in Figure 2 (Appendix). The base forage is the forage in your pasture presently. It is generally not economic to change your base forage since it usually costs more than of $200. per acre to till and plant a new forage species due to the high cost of multiple tillage passes, high cost of seeds from improved varieties and high fertility costs necessary for seed establishment.

Brush As A Base Forage

In some cases, brush and weeds may be the base forage for the goat enterprise. Goats will control many species of brush and weeds while returning a profit to the manager. Some major species of browse controlled are shown in Table 1. Goats will control many broadleaf weedy species but tend to do little for western ragweed (*Ambrosia psilostachya*), common mullein (*Verbascum thapsus*) and a few other weeds. It is difficult to predict what goats will eat because of soil and climate effects on brush and weed preferences. In addition, goats often prefer a plant only when it is at a certain growth stage. It may appear that goats are not controlling a weed and the weed will disappear when it reaches the proper growth stage for goat consumption. Goat grazing restores biodiversity and the consumption of small brush will reduce fine fuel load, reducing fire hazard. Goats are often set stocked for brush and weed control but could be rotated with cattle in a co-species grazing type of system. It is good to have an alternate pasture so that when goats have consumed most of the available biomass, they can be moved to another area. Goats generally do not consume more than 50% of their diet as browse due to the toxins that have to be detoxified. There should be other herbaceous forage available for consumption. Most browse species drop their leaves before or at frost and the goats will need other forage. Sometimes other species are green during the cool season such as honeysuckle and wild rye. A more extensive discussion of using goats for vegetation management is available (Hart and Kott, 2015).

Table 1. Browse Species Consumed by Goats

Common name	Scientific name
Blackberry	*Rubus oklahomus*
Smooth Sumac	*Rhus glabra*
Winged sumac	*Rhus capallinum*
Poison ivy	*Toxicondendron radicans*
Oak spp.	*Quercus spp.*
Hawshorne	*Crataegus viridis*
Greenbriar	*Smilax bona-nox*
Elm	*Ulmus Americana*
Winged elm	*Ulmus alata*
Honey locust	*Gleditisia tricanthos*
Black locust	*Robinia pseudoacacia*
Multiflora rose	*Rosa multiflora*
Dogwood	*Cornus drumumdii*
Privet	*Ligustrum spp.*
Mulberry	*Morus spp.*
Sweet gum	*Liquidambar styraciflua*
Poplar	*Populus spp.*
Eastern red cedar	*Juniperus virginiana*
Russian olive	*Elaegnus augustifolia*
Honey suckle	*Lonicera japonica*

Filling Forage Deficit Periods

Forage production of cool and warm-season grasses is graphed in Figure 2 (Appendix) and if Figure 1 (Appendix) is superimposed on it with your kidding date, the periods of forage deficiency should be evident. Forage deficit periods require supplemental nutrition to maintain animal productivity. Moving the kidding date will affect your forage deficit periods. The goal of forage management should be to provide as much forage as possible from grazing during the deficient times of the year. Ideas to help provide forage during these deficit periods are outlined below. An excellent reference on forages for pasture is Southern Forages by Ball et al. (2002).

The base forage can be overseeded to add forage production during times of the year when the base forage production is low. Cool season annuals could be overseeded into a warm-season perennial pasture to add grazing during the cool season time of the year, adding protein which is often limiting in the cool season as well as forage production. This may provide forage for early kidding. Cool-season annual species that are suitable include rye, ryegrass, wheat, oats, etc. Cool-season forages can reduce spring growth of a warm-season pasture substantially if not grazed off in the spring. Legumes may also be overseeded into warm-season perennial pastures with other annuals. Berseem clover, annual lespedeza and sericea lespedeza seem to be preferred by the goat to other clovers. Berseem clover grows at a time between cool season forages senescing and warm season forages initiating production and therefore fills a valuable gap. The lespedezas do have anthelmintic properties (Min et al., 2004 and Min et al., 2005) and would be a valuable addition to goat pastures. Also, they suppress coccidian (Burke et al., 2013), and would be useful at weaning when kids are most susceptible to coccidian. Lespedezas provide forage during the late summer when forage production and quality often decline. Cool-season forages have a period of limited

forage production during the mid and late summer period. Overseeding summer annuals such as sudangrass, sorghum x sudangrass, lespedezas and cowpeas may be desirable.

Overseeding Cool-Season Grasses

Many cool-season grasses can be overseeded into a base forage. The most common ones are rye, ryegrass, wheat, triticale and oats (may freeze in cold temperatures). A legume such as berseem clover (one clover that goats relish) may also be included. Local extension expertise can help in the selection of forages, establishment methods and production. Rye and triticale are the most cold tolerant species of this group. Nothing will produce more forage than well-fertilized ryegrass in the late spring when the temperature is warm enough for its growth. The forage is high quality and tolerates close, continuous grazing and it often reseeds itself. It is especially useful for kidding in the spring before warm-season grasses emerge. Some forages such as ryegrass do better than most other forages when broadcast whereas drilling with a no-till drill is the most reliable method to get a satisfactory stand. The base forage should be near dormancy and closely clipped or grazed prior to seeding. Do not fertilize until the base forage goes into winter dormancy and you have an adequate stand to respond to fertilizer addition.

Overseeding Legumes

Choose legumes that goats will consume as well as providing forage. Goats tend to consume little clover except for Berseem clover although it may differ with different groups of goats. Birdsfoot trefoil may be consumed by goats. There are other cool-season legumes than clover, but little is known about their usefulness for the goat. It is worthwhile to ask your goat friends what their goats consume before you plant something your goats don't like. Annual lespedeza can often be broadcast or drilled. Soybeans or cowpeas are excellent for providing late summer grazing during the dry time of the year. Sun hemp is another warm-season legume that produces an abundance of forage. Soybeans, cowpeas and sun hemp produce better when grown on clean tillage alone instead of overseeded into a pasture. They grow tall enough that animals do not graze close to the ground and pick up infective parasite larvae.

Overseeding Woody Legumes

There is interest in utilizing woody legumes for goats since browse is beneficial to goats. Lucaena (*Leucaena leucocephala)* has been widely used in Australia, but for cattle. It is not frost tolerant. Potential species that could be used in the U.S. include mimosa (*Albizia julibrissin*), tagasaste (*Cytisus proliferus*; does not survive below 15^{o}F), bristly locust (*Robinia hispida*), shrub lespedeza (*Lespedeza bicolor* which is often used for deer food plots), false indigo bush clover (*Amorpha fructicosa*), Russian olive (*Elaegunus augustifolia*) and four-wing saltbush (*Atriplex canescens*). A little work has been done on several species in the US, including mimosa, shrub lespedeza, false indigo bush and honey locust (*Gleditsia triacanthos*). Luginbuhl and Mueller (2000) evaluated four trees fodder trees for goats. There were problems with persistence (and none were grazed) for some species and one species had poor DM production. Honey locust and black locust trees have been proposed as browse species, but due to the goat's high preference for the bark, persistence would likely be very poor. There is much research left yet to be done to identify suitable browse species to cultivate for goats.

Stockpiling Forage

Warm-season forages may be stockpiled for grazing in the winter and cool ool-season forages may also be stockpiled for grazing in the summer or winter when they are dormant. Stockpiling is intentional and requires specific management. Stockpiled forage is best utilized by strip grazing or much of the valuable forage can be lost due to trampling. To stockpile cool-season forages such as fescue, clip them in late summer to encourage new growth high in quality. Fertilize before Labor Day with 50-60 pounds of N. Fescue holds its quality well in winter as compared to other cool-season species (brome, orchardgrass and timothy) and can be grazed during winter dormancy in December through February. Other cool-season grasses can be stockpiled, but will weather more severely and should be utilized sooner than fescue. Weathering is increased by high rainfall and warm temperatures and stockpiled forages will deteriorate faster in those environments and therefore needs to be utilized quicker.

Native range can be effectively stockpiled by deferring grazing after July 1. It can be grazed after frost into early winter, but usually, a protein supplement is required. Native range weathers less than most other warm season grasses. Bermuda grass can be stockpiled for cool-season grazing. Pastures should be clipped to 2" height in August and 50 lbs of N per acre applied. Grazing should be deferred until after frost. Stockpiled Bermuda grass should be utilized early in the season because of its susceptibility to weathering.

Supplemental Pastures

Research has been done with supplemental pastures in the Southern Great Plains to provide forage when warm-season pastures are dormant or low in quality. Sims (1994) planted 12% of the native range to cool-season annuals (rye and wheat) which was double-cropped with hybrid pearl millet. This enabled stocking rate to be increased by 40% and net returns per acre were almost doubled (Gillen and Sims, 1998). A similar pasture system has been investigated by Dalrymple (1999) in which cool-season annuals are overseeded with crabgrass for high-quality summer forage. The crabgrass can be managed to reseed, eliminating seed and planting costs in subsequent years. These pasturing systems can have applicability to goats. Cool-season pasture use can be extended by limit grazing. Animals can acquire their supplemental protein needs in only two hours of grazing per day. This can be implemented as an alternate day grazing and removing animals when they get full and lie down 3-4 hours. Animals will become trained and come off the pasture when they get full, minimizing labor requirements.

Providing Hay or Preserved Forage

Hay may be utilized to provide forage for forage deficit periods, but the cost of forage is generally tripled as compared to grazing when the cost of cutting and baling, hauling, storage, feeding and harvest, storage and feeding losses (nearly 30%) are taken into consideration. Goats will generously waste hay depending on how it is fed. If feeding from a round bale on its side, 30-50% of the bale may be wasted. There is much less waste if the hay is fed in an elevated feeder that cradles the hay bale or if the round bale is rolled out on the ground. The latter is a good choice if cattle and goats are being fed together.

Grazing Management

Grazing management is how forage is utilized. Continuous grazing systems are the most common because they require little management. Forage distribution, production and utilization can be

improved with improved grazing management. Harvest efficiency (% of grazeable forage that is consumed and not trampled) is only 40-50% under continuous grazing, increases to 50-60% with a 4 paddock rotational grazing system, 60-70% with a 6-8 paddock rotational grazing system and 70-80% with strip grazing where animals graze an area for only one day.

Continuous Grazing

Continuous grazing is the simplest where animals are confined to one area during the grazing system. Although simple, it increases gastrointestinal nematode (GIN) problems, reduces forage production and has the lowest harvest efficiency (percent of forage grown that is consumed). It has deleterious effects to forage in that species that are most preferred are most heavily defoliated, reducing their persistence. Also, forages closer to a water source, mineral source or barn are defoliated more extensively. Continuous grazing is the least preferred grazing system for goats since it promotes internal parasites which are a great problem in goats. However, continuous grazing is the system of choice for controlling brush and weeds since the goal is to overgraze brush and weeds to reduce their persistence and thereby control them.

Rotational Grazing

Rotational grazing is a system where pasture is divided into multiple paddocks and each paddock is grazed for a period of time while the other paddocks are rested. The advantages of this are greater forage production (20%) in that plants are able to recover from defoliation, greater harvest efficiency due to less trampling, more uniform grazing in that animals are "forced" to consume less desirable plants before they are moved to the next pasture, and greater forage species diversity is maintained. Rotational grazing generally increases harvest efficiency from the 50% observed with continuous grazing to 70% with rotation grazing due to reduced trampling losses. Harvest efficiency is improved as days on a given pasture are decreased. The disadvantages are the extra cost of fencing and water points and an increased level of management required. Often forage quality is slightly reduced, seldom a significant factor. Also, if the rest period is long enough, infective larvae numbers are reduced.

Pomroy et al. (2002) demonstrated that Angora goats grazing native range with 5 days grazing interval and 65-day rest interval greatly reduced fecal egg counts and pasture contamination. Most likely, a 45-day rest period would have been adequate, but in more temperate areas, a longer rest period may be required. With long rest periods, forage quality is reduced, especially with introduced forages and baling or grazing cattle or horses halfway through the rest period may be useful. The forages could also be mowed to keep them in a vegetative state. Generally, pastures are grazed to a defined residue height, sufficient for regrowth and high enough (3-4" residue) to minimize animals consuming infective larvae. Moveable electric fencing can be used with goats, four strands equally spaced to .8 M height being adequate to confine goats. Providing water and mineral is another consideration. Shelter is another problem and moving the guard dog feeder can be another problem. During times of excessive forage growth, forage can be baled. However, many goat enterprises are so small that haying equipment could not be efficiently used in small paddocks. A minimum of 8 paddocks is necessary for rotational grazing and 12 would be preferable to allow for management flexibility. It is difficult to control GIN in grazing goats without a rotational grazing system.

Creep Grazing

Creep grazing is using a creep gate to allow kids to graze a pasture separate from their dams. Potential advantages include a high-quality pasture that may provide better gains and fewer parasite problems. Creep grazing kids on Mimosa enabled them to select a higher quality diet and have higher bodyweight gains. Does lost less weight, but similar results could be obtained by reducing the stocking rate (Yiakoulaki et al., 2007). Creep forward grazing has been utilized in cattle where a creep gate is utilized to allow calves to graze the higher quality pasture ahead of their dams. Such has potential with goats to aid with parasite control as well as providing improved quality of forage for the kids. This could be beneficial for weaning in that kids are already used to grazing and functioning independently.

Co-Species Grazing

Co-species grazing is grazing goats with another species such as cattle, sheep or horses. Goats work very well with cattle in a co-species grazing system in that they will control most types of brush and weeds (sericea lespedeza, multiflora rose, kudzu and many others). Co-species grazing is a win-win practice since the producer not only makes money from his goats converting unwanted brush and weeds to meat to sell at a profit but has the additional money saved by not having to spray or apply some other method of weed control. Goats can be run in front of cattle, with cattle or behind cattle. It is probably easier management-wise to run goats with cattle, but the electric fence needs to be modified to control the goats. See Hart and Potraz (2015) for further details on fencing options. Goats generally graze in their group and cattle keep to themselves. There is no significant risk of disease crossing between cattle and goats. Waterers must be modified for goats to drink from and goats will often use cattle mineral feeders. Cattle are often rough on goat mineral feeders which could be placed in a creep area where the cattle are excluded. When grazing with sheep, the goats require copper levels that are toxic to sheep. One solution is to feed a sheep mineral to all animals and give goats 6 grams of Copasure capsules per year. Another solution is to mount the goat mineral feeder on a platform such as a wooden wire spool that goats have to jump on to access the mineral and this will usually exclude sheep from the goat mineral.

Managing for Brushy Species

Brush has many advantages for goats. Because animals are grazing away from the ground, they pick up very few infective parasite larvae, and some browse plants have antiparasitic qualities. The protein content of browse is high, but availability of protein may be affected by tannins in the browse. Energy levels are moderate and will not support a high level of goat production, but usually adequate for does with twins. Calcium is adequate, phosphorus deficient and trace minerals unknown, so it is best to keep a high phosphorus mineral available. It is possible with rotational grazing to utilize brush as a renewable resource as done in South Africa. Delay grazing in the spring until plants are fully leafed out, graze one week and rest a minimum of 8 weeks between grazings and allow the plants to recover fully before frost. In this way, brush can be maintained indefinitely.

Pastures for Parasite Control

When permanent pastures get heavily contaminated and there is a crisis, goats can be fed in confinement until pasture can be produced which has a low level of contamination and high nutrient quality and/or high level of antiparasitic tannins. Some pastures reduce parasites by avoidance ie. grazing high away from the ground so as not to pick up infective larvae, such as

cowpeas and other forages suppress parasites by being toxic to larvae and worms in the animal, usually by tannins such as with the lespedezas. Kentucky State University Extension developed a system to prevent parasites in goats utilizing forage sorghums or hybrid sudangrasses that were planted in clean till (buried infective larvae) and animals grazed on plants grazed at such a height as to not get close to picking up infective larvae. Another crop that is good for this is sun hemp, a legume that produces a generous amount of high-quality forage that grows at such a height that goats are not grazing near the ground. Annual lespedeza has tannins that reduce parasitism and can be overseeded into pastures and reseed itself. Sericia lespedeza is a perennial legume that is well documented to control parasites. Animal production may be impaired if animals are grazed on sericea lespedeza for an extended period (8 weeks or more).

Stocking Rate

A mature 100 lb goat will eat about 2500 lbs. of forage in a year. To arrive at a stocking rate, if you know the annual hay production of your forage, multiply it by .60 for harvest efficiency and divide it by the portion of year's nutrients you expect the goat to harvest from pasture (1500 lbs is a good estimate; 60% of nutrients from pasture) to arrive at an initial stocking rate. After the first year, the producer should be able to observe forage sufficiency and make the necessary stocking adjustments. If native range is the pasture, range production estimates are available in the Natural Resource Conservation Service web soil survey (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) or Google web soil survey. First, you define your area of interest (where your farm is and borders). Then select the Soil Data Explorer tab and then select Vegetative Productivity on the left side. Select Range Production normal year from the drop-down menu and then click view rating button lbs. per year. Scroll down below the map to view predicted yield for each soil type. The yield data can be multiplied by .60 for native range or .50 for brush to obtain harvestable forage yield and then divide by 1500 lbs or what you have selected above to arrive at the stocking rate. Stocking rate can be adjusted the next year based on current year observations. Also, it is best not to stock more animals than you can carry in a dry year. Another method is to find the recommended cattle stocking rate and considering 5-6 goats /hd cattle, multiply by 5-6 to arrive at the number of goats.

Plant Nutrients

Plant nutrients are critically important in forage production, especially for improved pasture species and annual plants. Soil pH is especially important for clover establishment and persistence as well as maintaining an earthworm population. A soil test is very important for determining the plant nutrients available to the forage and recommendations for the application of plant nutrients. Generally, yield goals are required for soil tests to give fertility recommendations. The soil type in itself may be a limitation on yield as well as rainfall. Local extension expertise should be consulted for plant nutrient recommendations. Nitrogen may be provided by legumes if they are productive. Phosphorus is often limiting and in certain areas potassium is limiting. Generally, fertilizer is applied when pasture is seeded, overseeded, or interseeded such as with a no-till drill. When pastures are overseeded with cool-season annuals, plant nutrients are applied, usually after the base forage goes dormant. For permanent pastures after the initial soil test, pastures are sampled every 3 years and fertilized as necessary. Many of the plant nutrients are recycled by grazing ruminants in their excreta, but often half the nitrogen is lost while phosphorus and potassium are more efficiently recycled.

Poisonous Plants

Some producers are concerned about toxic plants in their pasture, but every plant is poisonous at some stage in its lifecycle and animals manage to avoid toxicity. Goats graze many toxic species without encountering toxicity. This is due to goats consuming a diversity of species on any given day. The goats never consume a toxic dose of any one species, their greater size of liver as a % of body weight gives them the extra capability to detoxify toxins. Also, some plant species may counteract the toxicity of other plant species. If goats have adequate quantity and an array of forage species to choose from they will seldom get toxicity. Goats learn from their mothers what plants to eat and what plants to avoid. If goats are moved to an area with very different forage species, they may not know to select against toxic plants. Also, in plants that are normally non-toxic that goats are used to eating, if there is occasional toxicity such as due to environmental factors, animals may not be able to identify the plant as being toxic and avoid it. Generally, toxicity is rare in goats.

Conclusion

Managing the forage system to provide as much of the nutrients required for animal production from pasture can greatly reduce production expenses, increasing enterprise profitability. The quantity and quality of nutrients should be calculated at monthly or weekly intervals and the quantities of nutrients provided by the existing forage base calculated. The periods that have a forage deficit, can be supplied by overseeding annual forages, establishing new species or stockpiling forage for deficit periods. Harvested forage should be utilized as little as possible since it usually costs several times what grazed forage does. This requires a forage management plan that should be written out with help from available expertise and technical resources.

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Appendix

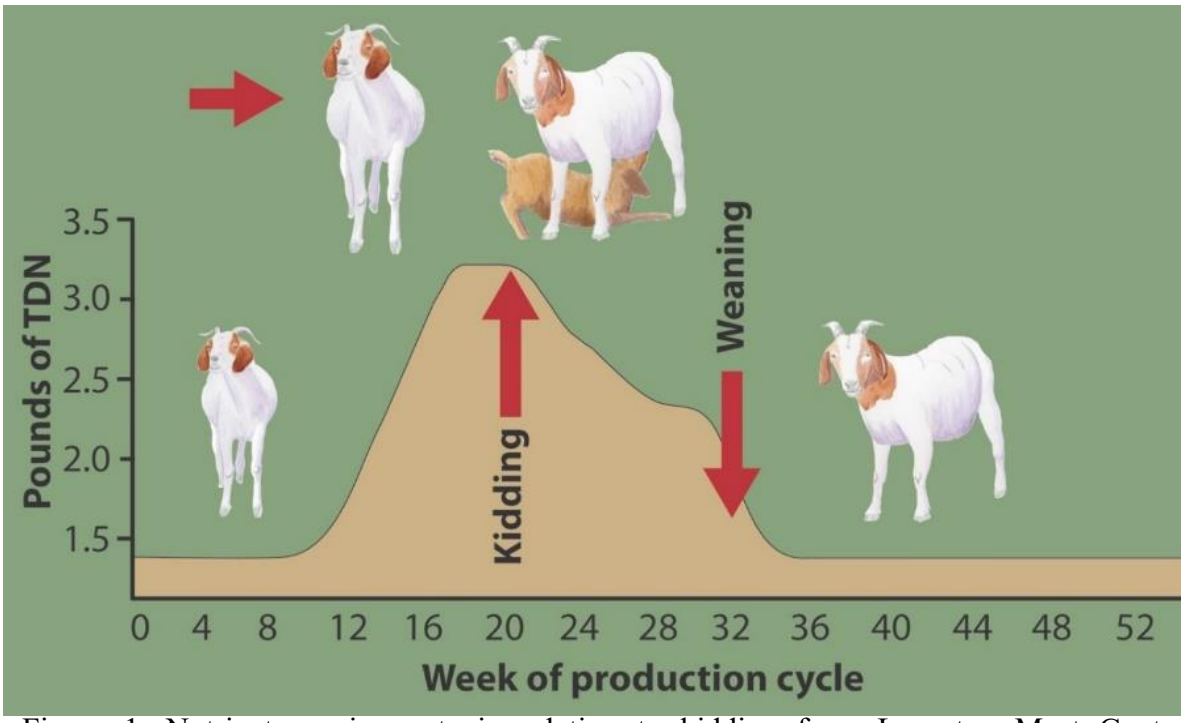

Figure 1. Nutrient requirements in relation to kidding from Langston Meat Goat Production Handbook.

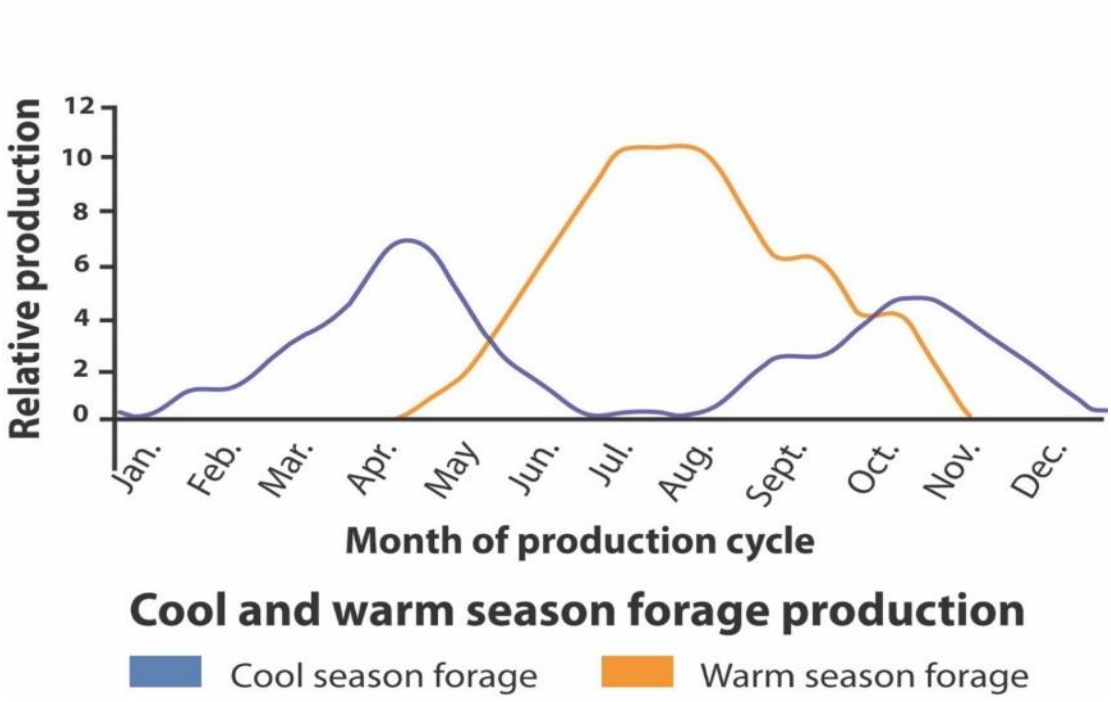

Figure 2. Seasonal production patterns of cool-season and warm-season grasses.