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Year-Round Forage Production for Sustainable Goat Farming

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YEAR-ROUND FORAGE PRODUCTION FOR SUSTAINABLE GOAT FARMING

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Abstract

Goat farming in the U.S. is based on grazing lands. Forages available for grazing throughout most of the year are essential for supplying required nutrition for goats and minimizing production costs. Most goat farmers do not have pastures productive for an extended period. This situation results in poor performing animals and high production costs. Forage availability can improve by enhancing the productivity, quality, and production duration of pastures. The inclusion of browse species in grazing systems will also improve diet variety, minimize internal parasite problems, and better utilize the soil resources. Grazing opportunity can be extended by developing a woodland grazing system. Farmers can consider establishing a silvopasture system after the first and second thinning of forests or plantations by growing suitable forages and/or combinations in spaces between trees. Such operations diversify farmers' income opportunities and increase environmental quality and social acceptance of land resources.

Keywords: Year-Round Forage Production, Forage Production, Sustainable Goat Farming, Sustainable Farming, Grazing

Introduction

Goat production in the U.S. is based on pastures and other grazing lands. The availability of sufficient amount of quality vegetation (planted forages and browse, and spontaneous shrubs, vines, and trees) preferred by goats throughout or most of the year is the key to the success of grazing/browsing-based goat farming. Grazing is goats' consumption of vegetation that generally remains close to the ground surface and browsing is consumption of woody species, such as shrubs and tree branches, and vines that generally grow taller than the herbaceous vegetation. Grazing/browsing opportunity for goats can be increased substantially by improving the existing pastures or developing new pastures, cultivating desirable browse species, and developing silvopastures after the first and/or second thinning of woodlands or plantations. Silvopasture development is also possible in nut orchards and other tree production systems when all components of the system are managed well. Moreover, incorporation of existing woodlands into the grazing systems can be greatly helpful to supplement feed requirements for goats, increase variety in the diet, minimize the infestation of gastrointestinal parasites, and enhance the growth of target trees in the system. Furthermore, spontaneous shrubs, vines, trees, and other vegetation present in underutilized lands can be included for grazing goats with the provision of necessary grazing facilities, such as fencing, shelters, water, minerals, and predator control measures. In this paper, all these different possibilities for improving grazing/browsing opportunities for goats and minimizing production costs are briefly discussed.

Pasture Improvement

Pasture is a land area planted with forages for grazing. Pastures should contain facilities required for grazing animals, such as perimeter fencing to contain animals in the property and keep wild and other undesirable animals out, and cross fencing to divide the entire pasture into multiple sections (8 would be enough for most cases) for rotational grazing. Other facilities required for grazing goats are shelters to protect them from rain and other inclement weather conditions,

mineral feeders, water troughs with clean drinking water made available 24/7, concentrate and hay feeders (if supplementation is needed), and guardian animals (such as guard dogs) to protect goats from predators. Farmers should consider developing pastures before installing all these grazing facilities. There are several steps to pasture development or improvement. Each of these steps is presented below:

Site Selection and Soil Test

An area that is well-drained and has productive soil should be selected for developing pastures for goats. Goats do not like swampy or wet areas, and such areas would also harbor parasites and pathogens (disease-causing microbes). Disease and parasite problems, such as footrot, coccidiosis, barber-pole worms, and liver flukes commonly occur if pastures are swampy and wet. After suitable sites have been identified, soil samples should be collected from the sites at least three months before the planting date and tested at a state or local soil-testing laboratory. Soil pH should be corrected based on laboratory results and recommendations. The pH is the measure of how acidic or alkaline the soil is. The pH ranges from 0 to 14, with 7 being neutral, below 7 acidic, and above 7 alkaline.

Different types of forages require specific pH ranges to perform well. This is because the nutrients present in soil are more available to plant roots only at certain pH ranges as shown in Figure 1. In this Figure, the bandwidths of different nutrients indicate their availability for plants, with a broader band indicating higher availability and thinner bands indicating lower availability. When the pH is too low or too high, fertilizing pastures does not increase any forage production unless the pH is fixed. Therefore, it is very important to maintain the desirable soil pH to make the pasture productive. Farmers must take care of the soil pH first before planting or fertilizing.

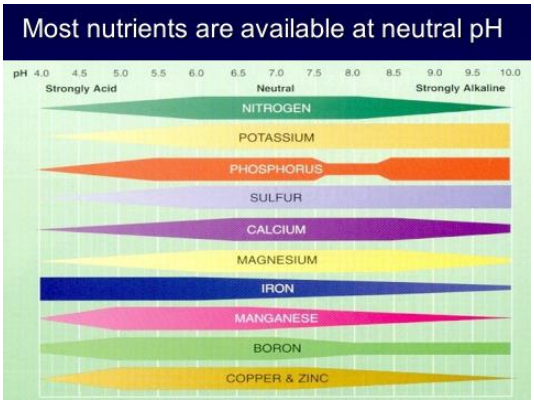

Figure 1. Availability of different nutrients to plants at different soil pH
Source: Adapted from http://articles.extension.org/pages/13064/soil-ph-modification

To prepare a representative soil sample for a soil test, collect 15-20 subsamples (take samples from 0-4-inch in depth from perennial pastures and 0-6-inch in depth from annual pastures with a soil auger or shovel and knife) from a uniform area of 20 acres or less that has similar soil type, topography, and vegetation (avoid collecting samples from high animal traffic areas and manure piles). Put all these samples in a bucket, mix well, and remove stones, debris, or any other non-soil materials, then take a pint of a well-mixed soil sample to send to the laboratory. If pasture size is more than 20 acres and/or the pasture is not uniform in terms of soil type, vegetation coverage, and topography, separate samples should be collected to represent each of those areas of the fields.

While collecting and preparing soil samples, one needs to be mindful that from the pint of soil sample sent to the lab, only a portion will be used to determine the pH and nutrient content of the soil. This means, if the soil sample is not representative of the entire field, for which the sample is prepared, the results would not be accurate in terms of calculating the needed lime and fertilizers for that field. So, it would be worth the time and effort walking the whole pasture area, taking random samples from the target field, mixing the samples well and removing the non-soil materials from the sample, and labeling the sample box with owner's name and address, field name, and forages to be grown or being grown (lime and fertilizer recommendations differ for different forages).

Weed Control

Any plants present in the pastureland that are not desirable to goats must be controlled before planting selected forages. Although goats eat numerous plants that are considered weeds in cattle pastures, there are many plants that goats do not consume much. Examples of such plants are mullein, copperweed, camphorweed, coffeeweed, small-flower morning glory, false nettle, horsenettle, cactus, broome snakeweed, yucca, and thistle. Depending on the type and severity of weeds, one can use various methods of weed control: mowing/bush-hogging, repeated tilling (if the land is not sloppy and there is not much risk of erosion), applying herbicide, or combination of two or more of these. If there is sparse distribution of weeds in pastures, one can either spot spray with the selected herbicide or uproot it if it is in an organic production system. Whichever method is used, weeds must be controlled before they flower and produce viable seeds. One weed plant is capable of producing thousands of seeds. If we wait too long, most weed seeds would drop to the ground, germinate, and take over pastures quickly. Farmers should be mindful that there may be thousands of seeds in the pastures accumulated from previous years, and these seeds can germinate when they get favorable conditions. More information about controlling weeds can be found from the county Extension agents or the weed specialists located near your area. A publication available at this link can also be very useful to be familiar with and control common pasture weeds found in the Southeast: https://www.tuskegee.edu/Content/Uploads/Tuskegee/files/CAENS/TUCEP/Livestock%20program/WeedProceedings.pdf

Soil pH Amendment

Follow recommendations from the soil-testing laboratory to apply lime to correct acidic soil (if the soil pH is below 5.8), or any of these products: sphagnum peat, elemental sulfur, aluminum sulfate, iron sulfate, acidifying nitrogen, and organic mulches to correct alkaline soil (if the pH is above 7.0). Application of any of these products must be done 3-6 months before the forage-plantation date, as soil pH changes slowly after the application of amendments.

Fertilizer Application

Recommendation for applying major nutrients (phosphorus, potassium, and nitrogen) required for desirable forage growth would be included in the soil-test report sent to you by the soil-testing laboratory. Phosphorus and potassium fertilizers can be applied a week prior to planting or at the time of planting, as these fertilizers are more stable than nitrogen fertilizer. Since nitrogen escapes from the soil very quickly, it should be applied when the forage plants can utilize it the most, or when the forages actually need it – that is when forages are actively growing. Apply the first dose

of nitrogen fertilizer once all forages are germinated well and the pasture field looks green. Subsequent doses can be applied after one or two rotational grazings if need be. If nitrogen fertilizers are added before forages are germinated well, weeds would grow fast and choke the growth of planted forages.

Application of nitrogen fertilizers may not be necessary if leguminous forages are planted alone, or mixed with grasses to one-third or more of the grass-legume mixture. This is because specific *Rhizobium* bacteria associated with leguminous forage roots fix atmospheric nitrogen (N) and make it available for plants, provided desirable soil conditions for N fixation exist. Such conditions include enough carbon and mineral nutrients (calcium, molybdenum, iron, sulphur, potassium, phosphorus, and copper); optimum pH (around neutral – 6.5-7.5), temperature (68-77^{o}F for temperate legumes), and soil moisture (25-75% of field capacity); and a high concentration of carbon dioxide but low oxygen level present in the soil.

Organic Matter for Building Pasture Soils

Other than applying commercial fertilizers, farmers must consider adding organic matter to their pastureland to improve productivity and long-term soil health. Organic matter is any animal or plant product, such as compost, crop residues, feed and forage byproducts or wastes, leaf litter, lawn clippings, wood chips, and many other similar products. Soil organic matter helps bind soil particles together into aggregates; maintains porous structure; holds air, nutrients, and water in the soil; and increases biodiversity and microbial activities. All these conditions promote the productive capacity of the soil. Adding organic matter into the soil is a long-term process, and farmers should continue this effort throughout the farming life and beyond. One can realize the difference once such practice is continued for many years.

Land Preparation

A well-prepared seedbed may be necessary to establish perennial pastures with small seeds, such as bahiagrass, bermudagrass, sericea lespedeza, white clover, and chicory (Tables 1 and 2, Appendix). Such beds can be prepared with disking and cultipacking. Farmers lacking needed equipment for preparing seedbeds may choose to do light harrowing without disking soil. Another option would be the use of a no-till drill that drills seeds into the soil without opening much of the ground and covers the drilled seeds right after drilling. No-till drill can be rented from local vendors (if they are in your local area) or may be available from the Natural Resources Conservation Service (NRCS) soil-district office near your location. One needs to be familiar with the proper use of this drill, such as adjusting the rate of seeding and planting depth for the type of forage seeds being planted before renting and using it.

Forage Selection

The selection of forages suitable to the pasture soil and climatic condition as well as desirable to goats is one of the most important decisions farmers need to make well in advance of the planting date. It will be wise to include the combination of warm- and cool-season annual and perennial grasses, legumes, and forbs in goat pastures for extended production and providing variety in goats' diet. Annual forages grow during their growing season and die at the end of the season. So, these forages need to be planted every year if they are desired to grow. Annual ryegrass, crimson clover, crabgrass, hairy vetch, and browntop millet are examples of annual forages (Tables 1 and 2, Appendix). Some of these forages, such as annual ryegrass, crimson clover, and crabgrass will

reseed well if grazing is managed to let these forages produce viable seeds. In such cases, annual planting would not be necessary. Perennial forages grow during their growing season, undergo dormancy when the growing season ends, and resume growth during their growing season for several years once established well and managed properly. Bahiagrass, bermudagrass, chicory, sericea lespedeza, and white clover are examples of perennial forages (Tables 1 and 2, Appendix).

Forages that grow during the cool portion of the year (late fall-spring) are known as cool-season forages. Examples are white clover, arrowleaf clover, rye, ryegrass, and chicory (Tables 1 and 2, Appendix). Warm-season forages grow during the warmer portion of the year (late spring-early/mid-fall). Examples are bahiagrass, bermudagrass, crabgrass, and sericea lespedeza (Tables 1 and 2, Appendix). Forages can be grasses, legumes, or forbs. Grasses have a fibrous root system, parallel leaf venation, and produce a single seed leaf (monocotyledons). Examples are rye, ryegrass, and bahiagrass. Legumes have a taproot system, reticulate leaf venation, and bear two seed leaves (dicotyledons). Forbs are broad-leaf herbaceous plants that are neither legumes nor grasses, e.g. chicory.

Individuals planning to start goat farming without any pre-established pastures have to develop a forage production plan prior to planting any forages. Such plans may include the number of paddocks to be developed, types of forages to be grown in each paddock, planting schedule, and grazing and harvesting (excess forage as hay) schedule. Farmers with existing pastures can overseed them with suitable companion forages to diversify the available vegetation and extend the grazing duration. Information presented in Tables 1 and 2 can be a guide for farmers, especially those located in the southeastern U.S., to select forages suitable for their pasturelands. Farmers from other regions may need to work with local county agents or livestock or forage specialists. One can devote a couple of paddocks (2-3) to establish cool-season perennial grasses/legumes, and the same number of other paddocks to establish perennial warm-season grasses/legumes at the beginning of pasture development. Once these perennial forages are established well, suitable annual grasses/legumes/forbs can be overseeded to provide forage production for an extended period.

Farmers need to consider including a paddock or two for growing tannin-containing forages, such as sericea lespedeza (AU Grazer type that is more suitable for grazing than other varieties) to minimize goats' gastrointestinal parasite problems. AU Grazer is a patented variety, and Sims Brothers, Inc. (Phone: 334-738-2619, Email: service@simsbrothers.com) located in Union Springs, Alabama is the sole producer and distributor for this seed. In the forage production and grazing plan, farmers should also account for potential woodland grazing, browse production plots, and any other areas with natural vegetation or crop residues that can be incorporated into the grazing system for goats.

Seed Procurement, Preparation, and Plantation

The recommended amount of seed should be planted during the suitable planting season appropriate for the selected forages (Tables 1 and 2, Appendix). Usually, cool-season forages are planted from September to November and warm-season forages from March (after the killing frost is over) to May. Some forages can be planted beyond these timeframes as presented in Tables 1 and 2, Appendix). If seed drills are used, seeds should be planted to the recommended depth (Tables 1 and 2, Appendix) to have good germination. Seeds planted too deep cannot germinate,

and this can be the number one cause of stand failure. If seeds are broadcast in the prepared seedbeds or harrowed field, consider using 20% more seeds than that recommended for drilling.

Legume (clovers, vetches, peas, beans, sericea lespedeza, alfalfa) seeds should be inoculated before planting to a new field to have N-fixing bacteria work for your crop. Check with the seed suppliers whether the legume seeds you have bought are pre-inoculated. If not, order the suitable inoculums while purchasing legume seeds, and inoculate (mix with seeds) immediately before planting. Follow the instructions on the inoculum packet for proper storage and inoculation. Detailed instruction on inoculation is found in "Forage Production and Grazing Browsing Management" YouTube video: https://www.youtube.com/watch?v=wq9wTE7-HkA. Seeds need good soil contact and moisture for germination and growth. Lack of good seed-soil contact is the second major reason for stand failure. To take advantage of moisture, it will be wise to schedule planting around rain forecast or soon after rain (after the excess rain has drained through the system) to avoid damage to soil and standing forages.

After Planting

Allow enough time for the planted forages to establish well by keeping grazing animals off the planted fields. In the case of limited soil moisture, irrigation of the newly established pastures will help better forage establishment and growth. Perennial forages require more time to establish compared to annual forages. When forages have developed a strong root system and shown good canopy density and height covering the pasture field well (Figure 2), then controlled grazing can begin to let animals harvest 50% of the leaf volume. Once 50% of the vegetation is eaten, move animals to the new paddock to maintain pasture productivity and persistence. Weeds can be a problem in the new planting; they can be controlled with grazing or chemicals depending on the type and severity.

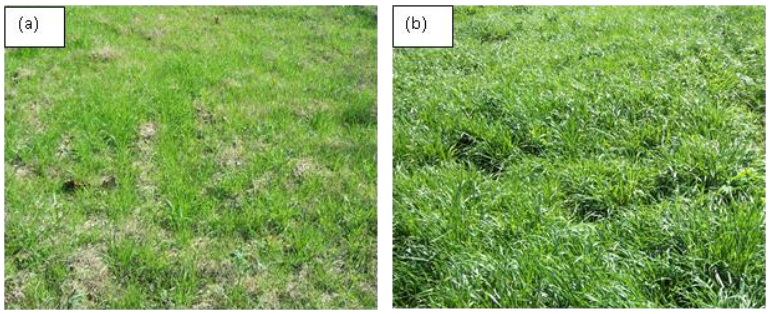

Figure 2. Marshall ryegrass pasture too early to begin grazing (a) and the right time to begin grazing (b)
Source: Karki (2013)

Subsequent Soil Test, Amendments, and Overseeding

Repeat soil tests annually for cultivated or annual pastures and hayfields, and once in 2-3 years for permanent pastures. Apply lime and fertilizers as recommended. Overseed the pasture the following season if required (if the land cover with desirable forages is between 40-75%).

Additional Resources

Sustainable year-round forage production and grazing/browsing management for goats in the Southern Region

https://www.tuskegee.edu/Content/Uploads/Tuskegee/files/CAENS/TUCEP/Livestock%20program/Year-RoundPasture_Handbook(1).pdf
Year-round pasture production and management https://www.tuskegee.edu/Content/Uploads/Tuskegee/files/CAENS/TUCEP/Livestock%20program/YearRoundPasture_ProductionManagement.pdf
Cool-season forages for sustainable goat production: Research highlights https://www.tuskegee.edu/Content/Uploads/Tuskegee/files/CAENS/TUCEP/Livestock%20program/Winter_Forage.pdf
Year-round pasture and grazing calendar https://www.tuskegee.edu/Content/Uploads/Tuskegee/files/CAENS/TUCEP/Livestock%20program/Year-round%20Pasture%20Calendar.pdf

Inclusion of Browse Species

Goats are good browsers. They consume significant quantities of shrubs, vines, and tree leaves and twigs when such vegetations are available in their grazing systems. Several studies have shown that goats spend a substantial amount of time browsing (32-90% depending on the season, wetness, plant community present in the grazing system, and time of the day) (Bhattrai et al., 2017; Papachristou, 1997; Sharma et al., 1998; Wallis de Vries and Schippers, 1994; Yayneshet et al., 2008). In several countries around the world, where goat raising has been a tradition for hundreds of years, browse species are widely used to feed goats either through the cut and carry system or through grazing. However, such practices are not common in the U.S. Most pastures developed for goats are like those for cattle or sheep, although goats have quite different vegetation preferences than other ruminants. When goats graze close to the ground surface, they often suffer from gastrointestinal parasite problems, especially during warm, humid, and wet pasture conditions. To minimize health problems and improve the performance of goats, the inclusion of a good amount of browse (50-60%) in the grazing system is necessary. Farmers may want to devote separate paddocks to cultivate browse species, such as bush indigo, wild plum, mulberry, mimosa, groundsel, blackgum, winged elm, beautyberry, and many other shrubs that are locally adapted and consumed well by goats. Such species will take a year or two to establish well and produce biomass for goats' browsing.

Most of the browse species will produce biomass during the warm portion of the year (May-September/October). Goats can be rotationally stocked in the browse plots to let them harvest fifty percent of the canopy and moved out to allow the regrowth of the vegetation and bring animals into the plots again when plants attain a full canopy. Browse plants may require six to eight weeks or more of rest to resume full canopy. Alternatively, limited stocking can be practiced by allowing goats into the browse plots for a couple of hours each day or every couple of days depending on the available vegetation. Moreover, if open pasture and browse plots are adjacent or located nearby, goats may be allowed to have access to both types of plots and let them choose where to eat from. Whichever method is used, it should be some kind of controlled grazing, where animals can be moved in and out of the browse plots as appropriate. A continuous grazing system should never be used in managing the system containing browse. Additionally, farmers must be watchful of animals' behavior while they are in the system containing browse plants, as animals may damage these plants by debarking and/or breaking branches and main stems. If such behavior occurs, animals' access to browse plants must be stopped immediately.

Coppicing (cutting browse plants to the ground level) or pollarding (cutting browse plants to a certain height) of browse to around two to three feet from the ground level may be necessary if they grow beyond the reach of goats. Such cuttings should be done once the browse species go to the dormant state, and this can be repeated every year or every couple of years depending on their growth and desired canopy cover. Goats must be taken out of the browse plots at least six weeks before killing frost to replenish plant carbohydrate for winter survival and spring regrowth, and goats should not be brought back until the full canopy develops to avoid debarking and other potential damage (breaking stems and branches, trampling, chewing the tip of the main stem and branches). Poudel et al. (2017) reported significant damage caused by goats and sheep on dormant browse plants. If farmers have woodlands or shrublands, it will be better to utilize such resources for stocking goats and minimize or avoid the need to develop browse plots.

Woodland Grazing

The inclusion of woodlands into the grazing system for goats offers multiple benefits. First, it would increase the grazing and browsing (eating from shrubs, vines, and tree branches that are above the ground level) (Figure 3) opportunity for animals starting in late spring. This is when the understory vegetation and trees develop a full canopy and should be ready for grazing/browsing. Browse species continue producing biomass until mid-fall before leaf falling and dormancy occur. The time from late spring to mid-fall is critical for goats in warm and humid areas, where challenges from internal parasite infestation, especially the barber pole worm, is very high. Goats having access to browse will avoid the chances of picking up parasite larvae that would occur if they had to graze close to the ground surface. Gastrointestinal parasite larvae usually remain within 2-3 inches from the ground level and may move up on the forage blade above that height when the forages are moist, such as during early morning with dews and during and after rain (Karki, 2018; Miller, 2004).

Figure 3. Kiko wethers browsing in woodlands, Tuskegee, Alabama

Second, since several shrubs and trees have a good amount of condensed tannin, a bioactive compound that is harmful to gastrointestinal parasites, woodland grazing can be helpful to minimize the parasite problems in goats other than from browsing as described in the above paragraph. A study conducted at Tuskegee University identified several browse species with good amounts of condensed tannin (CT), along with their nutrient profile and goats' preference for these species (Karki, 2017). Some of these species are wild plum (CT – 5.7%), winged elm (CT – 7.7%), and sweetgum (CT – 3.5%). All these species were eaten well by Kilo wethers used in the study. Other species that contain a good amount of condensed tannin are longleaf and loblolly pines (both

needles and bark; CT – 5-9%), bush indigo (CT – 5%), and white lead tree (CT – 4%) (Karki et al., Unpublished).

Third, animals will have a mild and comfortable environment during the warm-season grazing period because of the tree shade present in the system. Animals would perform better when they are comfortable versus when they face challenging weather or extreme temperatures. Fourth, defoliation of the understory vegetation by goats would reduce the woodland understory that would otherwise impede animal and human movement into the system for management activities (by farmers) and utilization of the available vegetation (by animals). Moreover, such defoliation minimizes the competition of understory vegetation for nutrients, space, and moisture with target trees, thereby facilitating better growth and performance of target trees in the system. Furthermore, grazing/browsing would decrease the fuel load in the system and diminish the risk of woodland fire hazards. The use of goats to minimize the understory vegetation and forest fire is very important in high-risk areas, such as nearby neighborhoods or wildlife reserves.

To take advantage of all the potential benefits described above, farmers should plan on developing grazing facilities in the woodlands they own. The essential facilities for initiating woodland grazing include perimeter and cross fencing along with gates placed in strategic locations for moving animals from plot to plot (for rotational grazing), watering system, mineral feeders, and shelters. Other facilities, such as concentrate (grains, agricultural byproducts, or commercial feeds) and hay feeders (in case animals need to be supplemented during the woodland-grazing period) and guardian animal(s) may be required. Many farmers may be eligible for cost-share from NRCS through the Environmental Quality Incentives Program (EQIP). Producers need to contact the local NRCS office to get detailed information.

Silvopasture Development

Additional grazing opportunities can be created by developing silvopasture systems. Silvopasture is one of the most popular agroforestry systems that involve the production of trees and agricultural crops on the same piece of land. A silvopasture system includes trees, forages, and grazing animals managed on the same land unit for economic, environmental, and social benefits. Greater economic benefits are possible from the silvopasture system compared to its components (forest or other tree production systems, pasture-based livestock production, or hay), as it offers short-term incomes from livestock and/or forages and long-term incomes from trees.

Because silvopasture systems are known for higher levels of carbon sequestration and better utilization of nutrients and water within the system, they are considered more environmentally sound compared to its components practiced alone (Sharrow and Ismail, 2004; Shrestha and Alavalapati, 2004). Tree shades present in the system provide milder climatic conditions for grazing animals, resulting in a longer grazing duration compared to pastures without trees (Karki and Goodman, 2010). Greater social benefits are obtained from the silvopasture system because of its appealing scenery (hedonic value) and sound environment compared to its components alone.

Silvopasture development is possible after the first or second thinning in timber plantations. Tree thinning is a usual management practice for managing timber plantations and producing good quality sawlogs. After thinning, forages can be established in the available ground space between trees or tree rows. Similar steps as described earlier under “Pasture Development” can be followed

to establish forages in the silvopasture system. However, while selecting forage species to be grown in this system, shade-tolerant species are to be selected. Silvopasture can also be developed for a nut production system when trees are mature and beyond the risk of animal damage. When trees are young or susceptible to animal damage, forages can still be produced between tree rows and harvested for hay or silage, and used for animal feeding when there is limited forage available for grazing, such as during winter, rather than buying hay or other feeds from outside sources. Alternatively, trees can be protected with electric fencing, tubing, or similar other means and animals used for grazing the available forages in the system. Whichever method is used for protecting trees or harvesting forages, it should be economical to farmers.

If farmers are planning to develop new plantation with timber or other tree species (fruits, nuts, Christmas trees), they can consider establishing forages between tree rows from the very beginning and harvest those forages for hay or silage, which can either be used to feed animals at home or sold for extra incomes if farmers have more than they need.

Precautions: Although the incorporation of tree production systems, such as woodlands, silvopastures, and nut orchards can increase the grazing opportunity for goats, increase diet variety, help minimize gastrointestinal parasite infestation, diversify the income opportunities, minimize the understory brush and consequently fire hazards, and much more, farmers must be aware of the potential damage goats may inflict on the desirable trees present in the system. To avoid such damage, goats should be used in the tree production systems only after trees are grown with their terminal buds beyond the reach of goats and trunks are strong enough to resist goats' rubbing on them and bending them. Goats love to rub their head and body on objects handy to them including trees. They can also easily pull down or bend young trees that have young and weak trunks.

Goats may also debark some species of trees when they have continuous access to them or forages are in limited supply. Therefore, they should be watched closely while stocked in the tree production system and moved out immediately if any tree-damaging behavior is observed. Rotational stocking must be practiced when using goats in the tree production system. Studies conducted with Kiko wethers in the silvopasture system containing 10-12-year-old longleaf and loblolly pine trees in Tuskegee, Alabama found wethers debarking trees, especially longleaf pines during the cool-season grazing period (Karki et al., 2018). However, the debarking was minimal to nil during the warm-season grazing period and even during the cool-season grazing period when plot gates were kept open allowing them in and out of the pine-silvopasture plots at their will (Poudel et al., Unpublished). Another study conducted in woodlands with Kiko wethers during late spring, summer, and fall did not show any significant damage to the desirable trees present in the system. These studies show that various factors (season, available vegetation, and management) influence the tree-debarking behavior of goats.

Farmers can use different strategies, such as non-confinement (keeping the plot-gate open for allowing animals in and out of plots at their will) of animals in the small tree-production plots and the inclusion of other woody species in the grazing system with trees. Other strategies would be to avoid grazing when trees are dormant or more attractive to animals and to select type and breed of goats that are less damaging to trees to minimize possible tree damage while using goats in the tree production system.

Benefits of a Year-Round Grazing System

Year-round production of forages and browse, and consequently, goat production based on a year-round grazing system can be possible by implementing several approaches, as described above (I-V) and presented in Figure 4. Multiple benefits are possible from year-round grazing systems. Incorporation and management of various plant species will increase the bio-diversity below and above ground. Biodiversity promotes the sustainability of the whole system. With the year-round vegetation production in the system, the ground surface will be kept covered most of the time, which will reduce the risk of soil erosion. With the presence of active root systems in productive grazing lands, the microbial community will remain active and promote soil health. Moreover, the porous structure of soil is maintained that facilitates root penetration into the soil, water infiltration through the system (less run-off), and soil aeration. All these conditions are desirable for soil health and productivity.

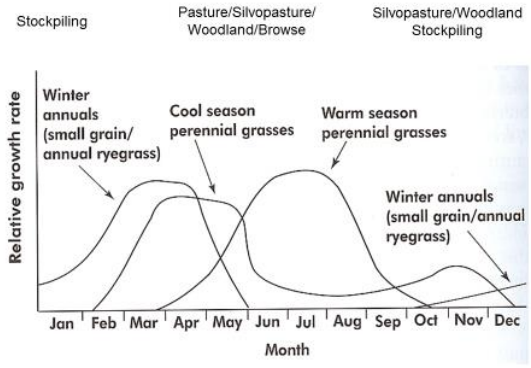

Figure 4. Relative growth rate of different forages throughout a year and potential lean periods, during which the forage need of animals can be supplemented with the provision of stockpiling, silvopastures, woodlands, and browse.
Source: Adapted from Ball et al. (2007) and modified by the author.

Forages and other vegetation available for grazing throughout or during most of the year will minimize requirements for supplementary feeding, thereby making the system economically viable. Karki and Karki (2017) reported that with the development of cool-season pastures, two goat farmers in Alabama were able to save $1,431-$1,537 in the production costs of 35-40 heads of goats during the cool-season grazing period. Moreover, when legume forages or browse are incorporated into the grazing system, forage quality increases that promotes animal performance and reduce health problems, as goats with good nutrition have a stronger immune system than when they are fed poorly. Such improvements will minimize goat-health costs.

Because legumes fix atmospheric nitrogen and make it available for plants, the inclusion of legumes into a grazing system minimizes or eliminates the use of commercial nitrogen fertilizer, thereby reducing forage production costs and protecting environmental quality (by reducing the chances of environmental pollution that would have occurred from the manufacturing and application of N fertilizers). The use of legumes in pastures also increases forage biomass yield and soil quality (Karki et al., 2009). These authors stated that the incorporation of crimson clover into the bahiagrass pastures increased forage biomass by 40 percent, forage quality (crude protein, CP) by 27 percent, and water-stable soil aggregates significantly, as compared to the bahiagrass

pastures maintained with the application of commercial nitrogen fertilizers. Water-stable aggregates are very important for soil health, as they maintain the porous structure in soil that promotes soil aeration, root growth, water infiltration, carbon storage, and microbial activity.

Provision of Supplementary Feed

Depending on weather conditions and location, vegetation available for grazing may be limiting, when plants become dormant or dead such as during winter months or non-productive periods, such as during a drought. For the forage-deficit period, farmers should make a provision for supplementary feeds, such as hay, grains, agricultural byproducts, or commercial feeds, or a combination of two or more of these. Farmers can also stockpile forages grown in the fall, and strip graze the stockpiled forages during forage-deficit periods. Tall fescue, bahiagrass, and bermudagrass can be stockpiled for eight weeks with close grazing or mowing at the beginning and applying sufficient nitrogen fertilizers if necessary for desirable forage biomass accumulation. Stockpiled forage can be grazed after frost when little or no green forage is available.

Conclusion

The provision of year-round availability of vegetation desirable to goats can be made by cultivating the suitable combinations of warm- and cool-season (both annuals and perennials) grasses, legumes, and forbs, along with incorporating browse plants into the grazing system.
Browse can add variety to the diet, minimize gastrointestinal parasite problems, and improve goat health and performance. Browse can be added to grazing systems either through the development of woodland grazing plots or by planting browse in selected paddocks.

Development of silvopastures, when possible, in tree production systems, such as timber plantations and nut orchards, increases and extends grazing opportunities for goats.

Proper grazing management is necessary for maintaining persistent, productive grazing lands and protecting trees and browse plants present in goats' grazing systems.

Development and management of year-round production of desirable vegetation for goats can minimize production costs, improve the productivity and health of the whole-farm system, and promote environmental health.

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Appendix

Table 1. Selected grasses with suitable soil type, production region, planting time, seed rate, planting depth, and suitable companions.

Forage species	Soil type	Region	Planting time	Seed rate (lb/acre)	Planting depth (in.)	Suitable companion
Warm-season perennial grasses						
Bahiagrass	Sandy	Coastal plain	Spring	10-15	1/4-1/2	Clovers (arrowleaf, berseem, crimson, rose, subterranean) hairy vetch, small grains, annual ryegrass
Bermudagrass	Wide range, but sandy is the best	Warm climate with mild winter	Spring	5-10	0-1/4	
Dallisgrass	Loam and clay	Southern coastal plain	Spring	10-15	1/4-1/2	Clovers (red, white, berseem)
Johnsongrass	Clay	Most of the Southeast	Spring	20-30	1/2-1.0	Clovers (red, berseem)
Warm-season annual grasses						
Crabgrass	Wide range	Most of the Southeast	Spring	4-6	1/4-1/2	
Cool-season perennial grasses						
Tall fescue (MaxQ)	Clay and loam	Humid temperate areas (mid to upper Southeast)	Aug.-Oct.; Early spring in the northern part	20-25	1/4-1/2	Alfalfa, birdsfoot trefoil, clovers (red, white)
Orchard grass			Aug.-Sept.	15-20	1/4-1/2	
Cool-season annual grasses						
Annual ryegrass	Wide range	Most of the Southeast	Sept.-early Oct.	20-30	1/4-1/2	Annual legumes
Small grains (Oats, rye, triticale, wheat)	Wide range	All states	Late summer or fall	90-120	1-1.5	Annual legumes

Source: Karki (2015), Ball et al. (2007).

Table 2. Selected legumes and forbs with suitable soil type, production region, planting time, seed rate, planting depth, and suitable companion forages.

Forage species	Soil type	Region	Planting time	Seed rate (lb/acre)	Planting depth (in.)	Suitable companion
Warm-season perennial legume						
Sericea lespedeza*	Clay and loam	Humid region (most of the Southeast)	Spring	20-30	1/4-1/2	Small grains, ryegrass
Cool-season perennial legumes						
White clover	Clay and loam	Humid temperate areas (most of the Southeast)	Early spring or late summer	2-3	1/4-1/2	
Alfalfa	Well-drained clay and loam	All states	Early spring or late summer	15-20	1/4-1/2	
Red clover[1]	Well-drained clay and loam	Humid region (all Southeast States)	Spring or late summer	8-12	1/4-1/2	
Cool-season annual legumes						
Arrowleaf clover	Well drained	Humid areas with mild winter	Sept.-early Nov.	10-15	1/4-1/2	
Crimson clover	Well drained	Humid areas with mild winter	Late summer to early fall	20-30	1/4-1/2	
Hairy vetch	Wide range; sandy is the best	Most of the Southeast	Sept.-Oct.	20-25	1-2	
Forbs						
Chicory	Wide range, but moderately to well-drained soil is the best	All states	Sept.-Oct., or Apr.-May (upper Southeast)	3-4	1/4-1/2	Bermudagras, tall fescue
Brassicas (Kale, rape, turnip)	Moderately to well-drained soils	All states	Spring or Summer	Rape, Kale: 3.5-4.5 Turnip: 1.5-2.5	1/4-1/2	

[1]Biennial or annual in the South

*May be considered as noxious weeds. Check with your state Natural Resources Conservation Service (NRCS) office about its status.

Source: Karki (2015), Ball et al. (2007).