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LEGUME-GRASS PASTURES ENHANCED THE GROWTH OF YEARLING KIKO DOES

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Abstract

Legumes can be beneficial in increasing pasture productivity and goat performance. This study's objective was to evaluate the impact of legume-grass pastures on goat performance. A 50:50 mixture of hairy vetch (*Vicia villosa* Roth) and Marshall ryegrass (*Lolium* L.) or hairy vetch and rye (*Secale* L.) was sown on 50% of the research area and 50% with Marshall ryegrass or rye. Forage samples were collected and processed for dry matter. Yearling Kiko does (19) were divided into two groups: legume-grass mix (10 does) and grass only (9 does), both rotationally stocked in their respective plots. Animal live weight, FAMACHA score, and body condition score were collected at the beginning, fortnightly, and at the end of the study. The goat group on legume-grass pasture gained more weight (67 ± 0.9 lb.) than the group on the grass pasture (65 ± 0.9 lb.) ($p<0.05$). Results indicated that legume-grass pastures promote the performance of growing does compared to sole-grass pastures.

Keywords: Legume, Grass, Pastures, Animal Growth, Yearling Kiko Does

Introduction

Goats are widely distributed worldwide and are among the most liked small ruminants. They are also well known for their meat and milk. They produce high-quality meat and milk by converting feeds and forages into these products (Solaiman, 2007). The goat industry is one of the fastest growing industries among the livestock industries in the US. Between 2012 and 2017, goat farms in the US increased by 7,986 (USDA-NASS, 2017). Although goat farm numbers increased in the US, the national production is still insufficient to meet the demand for goat meat. In 2021, US imported 1,929 metric tons of goat meat within the first two months (January and February) mostly from Australia and New Zealand (USDA-AMS, 2021). Goats are produced in most of the states, and southeastern US is one of the prime production regions. This region's goat population accounts for 24.5% of the total goat population in the country (2.66 million heads) (USDA-NASS, 2020). More than 90% of goat farm operations in the US depend on fenced pastures; the remaining operations are dependent upon browse species and hay in fenced areas (USDA-APHIS, 2012). Improved pastures are the major source of nutrients for grazing animals, including small ruminants. The poor quality of most goat pastures in Alabama and neighboring states in the Southeast contributes to low performance of goats (Karki and Karki, 2017). Moreover, management of quality pastures is one of the major issues for goat producers in the US (Gillespiex et al., 2013). Since green forages and grasslands are valuable renewable resources for livestock production, grazing opportunity and animal performance can be increased with systematic management of pastures.

Small ruminants require different types of nutrients such as crude protein, energy, fiber, minerals, and water-soluble vitamins for maintenance, growth, and production (Fernandez and Chelsey, 2016). They highly prefer to eat grasses, legumes, and browse species that have high levels of

protein (Poudel et al., 2020). Legumes are rich in nitrogen (N), resulting in a high level of crude protein (CP: CP=Nx6.25); in contrast, grasses contain higher fiber (Karki, 2013b). For small ruminants, CP is essential in increasing dry matter intake and body weight gain (Negesse et al., 2001). Fiber is important for normal rumen function and provide energy to support muscle growth, fight against diseases, and maintain good health (Lu et al., 2005). However, high fiber content in forages retards forage intake and digestibility (Chamberlain et al., 2016). Since pastures are major feed resources for goats, pasture quality is important for their normal growth and performance.

Pastures of most goat producers in Alabama and other states in the Southeastern US are dominated by warm-season perennial forages (Karki, 2013b), which do not produce much during the cool-season from September/October to March/April (Karki and Karki, 2019). Perennial warm-season pastures in the Southeast are dominated with bermudagrass (*Cynodon dactylon* (L. Pers.) and bahiagrass (*Paspalum notatum* Flueggé) (Blount, 2000). These warm-season forages are poor in quality having high fiber and low crude protein (Karki, 2010). It is generally understood that nutritional quality and productivity of pastures can be increased by growing mixed-forage species instead of monoculture (Acharya et al., 2013). Therefore, integration of legume species with grass pastures can play a significant role to enhance productivity and animal performance. However, not much literature is available on how goat performance is impacted with the addition of legumes in the grazing system. This, study's hypothesis was that goats stocked in legume-grass plots would perform better than those in sole-grass plots. Thus, the objective of this study was to evaluate the impact of legume-grass pastures on goat performance.

Literature Review

Plants in the grass family (Gramineae) serve as the major feed for livestock (Kellogg, 2001). Plants in the legume family (Leguminsae) are the second most important forage species for livestock. Legumes have the following distinct morphological characters: their seeds are in pods; they have two seed leaves; and their roots have nodules (Singh, 2010). Small ruminants prefer legumes to grasses because legumes contain higher levels of crude protein (Table 1) and lower levels of fiber relative to grasses. In addition, legume forages are richer in several minerals than grasses. Juknevičius and Sabienė (2007) reported that when forages are grown in identical conditions, except for Sodium (Na), concentrations of Ca, Mg, Cu, Zn, Mn, Fe, and Co are higher in legumes relative to grasses. Besides nutrient composition, legume species are important for sustainable forage management, as they increase the biomass production and forage intake by animals when it is grown with grasses (Karki and Karki, 2017). Albayrak et al. (2011) found that when alfalfa (*Medicago sativa* L.) was mixed with bromegrass (*Bromus inermis* Leys), the CP content and biomass yield of mixed pasture was increased by 5.25% and 153%, respectively, than when compared to sole bromegrass. Legume roots establish a symbiotic relationship with *Rhizobium* bacteria, which fix the atmospheric nitrogen into the soil (Hancock et al., 2008). As small ruminants prefer eating high-quality forages, integrating legumes with grass species can potentially improve animals' diet and performance.

Abbott (2018) reported that animals' voluntary intake, digestibility, and rumen clearance were enhanced with a higher level of crude protein, which made water-soluble carbohydrate and protein easily available in the digestive system. A study on sheep showed that inclusion of legume (cow pea (*Vigna unguiculata* (L.) Walp.) in Veld hay increased their dry matter (DM) intake by 81% (Baloyi et al., 2008). A high level of protein in the diet would only be utilized in animals' body

when energy derived from fiber is available to perform digestion in small ruminants (Miller, 2004). However, high fiber content in the diet reduces the digestibility which results in poor clearance of rumen and ultimately lowers the DM intake (Capstaff and Miller, 2018). Poor digestibility and low DM intake would results in poor body condition of animals. Therefore, improved pastures are not only the major source of dietary nutrients but also play a key role in the efficient consumption and utilization of nutrients.

Table 1. Crude Protein and Fiber Contents in Legume and Grass Forages

Forage species	Crude Protein (%)	Crude fiber (%)
Sub-clover (*Trifolium subterraneum* L.) [legume]	16.04	21.96
Birdsfoot trefoil (*Lotus corniculatus* L.) [legume]	16.46	25.65
Cocksfoot (*Tetrachne dregei* Nees) [grass]	9.88	27.17
Tall fescue (*Lolium arundinaceum* (Schreb.)) S.J. Darbyshire) [grass]	9.68	25.84

Source: Kirilov & Vasileva (2016).

Increased DM intake and feed digestibility ultimately improve the use of feed for muscle development (Kanani et al., 2006). Gusha et al. (2014) found increased DM intake and greater weight gain of four-month old goats when cactus diet was supplemented with white leadtree (*Leucaena leucocephala* [Lam.] de Wit) compared to cactus supplemented with elephant grass (*Pennisetum purpureum* Schumach.) meal. Besides promoting growth, protein-rich diets enhance small ruminants' resiliency against gastrointestinal parasites and improve the hemoglobin level (Konwar et al., 2015). Marley et al. (2005) reported lower parasite counts in lambs raised on clover than those raised on ryegrass. Bath et al. (2005) stated that fecal egg counts had direct relationships with FAMACHA score (anemic condition), body condition score (thickness of muscle-fat layer covering the backbone, ribs, and brisket bone) and hematocrit value of sheep. Legume integrated with grass pasture can play a vital role to ensure the availability of protein for a longer time, improving the energy and protein utilization, enhancing the feed-conversion ratio, and increasing animals' performance (Kanani et al., 2006). However, the information on how the addition of legumes in pastures would reflect on the performance of growing goats is scant.

Methods and Procedures

Study Site

The study was conducted in 16 grazing plots (1.1 acre/plot) located at the Browse Research and Demonstration site (32°26'00.7" N 85°43'00.2" W) and Atkins Agroforestry Research and Demonstration site (32°26'35.7" N 85°43'56.5" W), Tuskegee University, Tuskegee, Alabama, US. Both sites had good perimeter fence, all plots were cross-fenced, and gates were installed in each plot to move animals in and out for rotational grazing. The browse site consisted of Cowarts loamy sand (89.4%; slope 5-15%) and Marvyn loamy sand (10.6 %; slope 2-5%). The Agroforestry site contained Uchee loamy sand (78.4 %) and Cowarts loamy (21.6 %) sand with a slope of 1–15 % (USDA-NRCS, 2017). Both sites were well equipped with grazing facilities for small ruminants (shelters, water line and watering troughs, and mineral feeders).

Forage Establishment and Biomass Collection

Each plot was treated with the required amount of lime and fertilizers based on the soil-test results. Lime was applied three months prior to planting and phosphorus (40-50 lbs/plot) and potassium (40-70 lbs/plot) fertilizers were applied at the time of planting. The mixture of hairy vetch and Marshall ryegrass in 50:50 ratio was sown in three plots and other three plots with Marshall ryegrass only at the Atkins Agroforestry Research and Demonstration site. Similarly, at the Browse Research and Demonstration site, four plots were planted with the 50:50 mixture of hairy vetch and rye and remaining four plots with rye only. The planting of forages was initiated in late October and completed in early November. Nitrogen fertilizer (60 lbs/plot) was applied in plots with sole-grass species at green leaf stage (when seedlings developed 2-4 leaves). When forages completed the most vegetative growth and achieved the canopy height of 12 inches or higher, 10 random samples per plot were collected before bringing animals into each plot at each rotation. Forage-biomass samples were collected using 0.25-m^2 quadrat and forages rooting inside the quadrat were clipped at 4-inch from the ground surface to mimic the recommended stubble height for goats (Karki, 2013c). Collected samples were brought to the Agroforestry and Grazing Land laboratory, Tuskegee University, and dried for 72 hours at 60°C. Dried samples were taken out of the drier, cooled down to room temperature, and weighed to determine DM.

Research Animals and Performance Data

Nineteen yearling Kiko does (9 months old, live weight - 58 ± 1.6 lbs) were used in the study. Animals were weighed and assessed for FAMACHA score and body condition score at the beginning of the study. They were divided into two similar groups with identical performance variables based on the initial data. One group (10 does) was deployed to legume-grass-mixed plots and another group (9 does) to sole-grass plots. Does were allowed to graze rotationally in their respective plots for 84 days (early April to mid-July 2020). They were stocked in the initial plots until 50% of the vegetation was consumed, and then moved to new plots. Animals were provided with free choice of goat minerals from Purina® and water in their plots.

Animal performance data (live weight, FAMACHA score, and body condition score) were measured on the first day of the study, at 14-days intervals during the study, and on the last day of the study. Live weight was measured using a digital weighing scale installed at the handling facility located at each study site. FAMACHA was scored by selecting the number corresponding to the color on the chart that most closely matched the color of animals' conjunctiva. FAMACHA score 1 represents the bright red color that indicates non-anemic goats and 5 represents the pale or whitish color that indicates severely-anemic goats. FAMACHA card is commonly used to monitor the anemic condition of small ruminants caused by *Haemonchus contortus*, a blood sucking parasite and the number one killer of small ruminants in the Southeast (Karki, 2013a). The color of animals' conjunctiva on both eyes was compared with the color on the FAMACHA card and scored with the most matching color. Similarly, body condition score (BCS) was assessed by feeling the muscles and fat tissues over the backbone, ribs, and brisket bone and scores were provided ranging from 1 to 5. Score 1 indicates extremely thin animals and 5 implies obese animals. Only one trained and experienced person assessed both FAMACHA score and BCS throughout the study to avoid any potential individual bias that would have occurred if multiple people were involved in the assessment.

Data Analysis

Forage biomass data were analyzed using the Mixed Procedure in SAS 9.4 with plot as a random factor. Correlation among live weight, FAMACHA score, and BCS was explored and found significant. Therefore, the animal-performance data were analyzed using Proc GLM with MANOVA option to account for the correlation present among the dependent variables. The confidence level was set at 95% for hypothesis test.

Results and Discussion

Marshall ryegrass-hairy vetch plots yielded 1,652 lb./acre forage biomass, which was 18.6% higher than that from plots containing Marshall ryegrass only (1,392.9 lb./acre) (Table 2). Similar findings were reported by Albayrak et al. (2011), with greater yield from alfalfa-bromegrass-mixed pastures than from sole-bromegrass plots. Greater biomass yield from legume-grass-mixed plots indicated increased productivity because of legume addition.

Table 2. Forage Biomass from Legume-Grass and Sole-Grass Plots

Treatments	Forage biomass (lb./acre)	Lower CL	Upper CL
Sole grass forage	1,392.9	1,122.43	1,728.55
Legume-grass mix forage	1,652.0	1,310.31	2,082.80

The does in legume-grass and grass only group showed live weight at the beginning 57.9 and 58.1 lbs., respectively, while at the end of study, they showed a live weight of 74.3 and 69.8 lbs., respectively, (Figure 1). The overall growth of goats stocked in legume-grass-mixed plots was greater (68 ± 0.9 lbs) than goats stocked in sole-grass plots (65 ± 0.9 lbs) ($p<0.05$). Turner et al. (2017) found greater live weight gain in goats grazing red clover (*Trifolium pratense* L.) compared

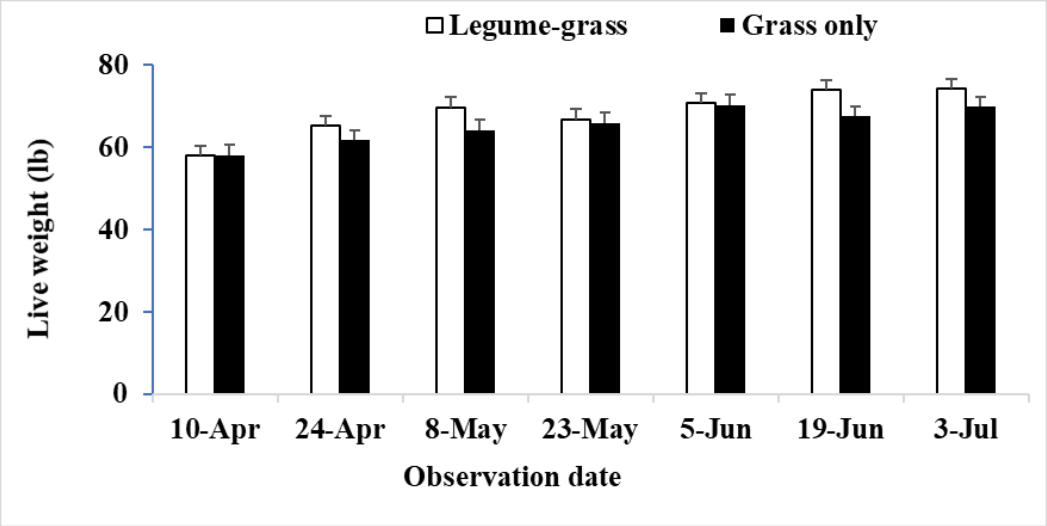

Figure 1. Live Weight of Yearling Kiko Does Stocked in Legume-Grass and Grass-Only Plots from April- July 2020.

to those grazing chicory (*Cichorium intybus* L.). Small ruminants have the ability to select pastures having high nitrogen content (Catanese et al., 2010). Higher live weight gain of does stocked in mixed pastures could be attributed to their high intake due to high crude protein in the diet (Gusha et al., 2014).

BCS also reflects the nutritional status of animals (Fernandez, 2012). However, in the current study, both groups of does maintained similar BCS. Villalba and Provenza (2009) suggested that the performance of grazing animals could be affected by various factors such as forage species, dry matter consumption, plant preference by animals, and the digestibility of forage. FAMACHA and BCSs in both treatment groups were at satisfactory levels for yearling does raised on pastures. No differences in these scores were, however, recorded between does in the two treatment groups. Moreover, there was no incidence of diseases or any other health complications during the study period. No drenching was required for any does during the
study period, indicating no concerning problem of gastrointestinal parasites. As expected, scores of both groups fell within a desirable healthy range (1- <3). Although, there was no statistical difference between the two groups for FAMACHA score, mean value of legume-grass-mixed group (2.2 ± 0.06) tended to be better than the grass-only group (2.4 ± 0.07) as shown in Table 3. A previous study showed that goats fed cowpeas performed well against parasites, resulting improved FAMACHA scores (Worku et al., 2017).

Table 3. Body Weight, FAMACHA Score, and Body Condition Score of Animals

Performance Indicators	**Legume-Grass Group**	**Grass-Only Group**
	Mean ± SE	
Body Weight (lb.)	$68 \pm 0.9^{a**}$	65 ± 0.9^{b}
FAMACHA Score	2.2 ± 0.06	2.4 ± 0.07
Body Condition Score	2.5 ± 0.03	2.4 ± 0.03

Conclusion

Hairy vetch-Marshall ryegrass or hairy vetch-rye-mixed pastures produced around 18.6 % greater biomass than sole-grass pastures. The higher biomass production from legume-grass plots resulted in better growth of yearling Kiko does grazing those plots compared to does grazing on sole-grass pastures. Does in the legume-grass and sole-grass groups showed FAMACHA scores of 2.2 and 2.4, respectively, and BCS 2.5 and 2.4, respectively. No differences were detected in FAMACHA and BCS scores between the groups; these parameters remained at the satisfactory levels for yearling does raised on pastures. Because this study was conducted using yearling does, results may differ for lactating and younger does. Further studies are needed to identify the beneficial impact(s) of legume-grass pastures on the performance of goats in age brackets and physiological conditions that differ from the ones used in the current study.

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