

Short Term Effects of Grazing Sheep on Agroforestry based Pasture

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The efficacy of producing sheep by grazing on agroforestry based pasture in relation to growth, breeding traits, and impacts on the pasture were investigated. Sheep were placed on traditional or agroforestry grazing pasture and experiments determined growth rates, organic material and nitrogen concentrations of the soil, forestry utilization, and female breeding traits. There were no differences between the growth traits. There was significantly higher ($P < 0.05$) organic material from the agroforestry vs. the traditional pasture. The nitrogen content from the agroforestry without sheep was significantly higher ($P < 0.05$) compared to the other plots. The percent of understory cover on the agroforestry plot was significantly less ($P < 0.05$) compared to a control. There were no differences in sexual receptivity or pregnancy rates in the ewes, but the lambing rates of the agroforestry was significantly higher ($P < 0.05$) than the traditional pasture.

Keywords: sheep, market lambs, agroforestry, growth rate, soil quality, breeding, nitrogen

Introduction

Although a definition of sustainable agriculture has yet to be accepted by the scientific community, it is at the forefront of both environmental and agricultural issues due to the constant increase in human population (Heitschmidt et al., 1996). The current perception is that sustainable agriculture is a management philosophy and not a specific way to operate (MacRae et al., 1993); explaining why there is little research in the incorporation of animals and sustainable agriculture (Oltjen and Beckett, 1996). Bawden (1989) proposed four steps to establishing animals in sustainable agriculture: pioneering, production, productivity, and persistency. History demonstrates that each step is important in this progression to obtain productive agriculture, but the depletion of nutrients, erosion, environmental concerns and ethics have made persistency the focus of current sustainable agricultural research (Olesen et al., 2000).

Since the 1970's, researchers began exploring agroforestry as a practice for sustainable agriculture. Agroforestry is a form of multiple cropping where there are at least two plant species (one being a woody perennial) that interact biologically, and at least one species is managed for forage, or annual or perennial crop production (Somarrriba, 1992). The benefits of using agroforestry as a sustainable agriculture practice potentially include the production of market goods, including food, forage, and wood, and non-market goods, such as increased biodiversity, improved water and air quality, and soil conservation (Alavalapati et al., 2004).

The inclusion of livestock, specifically ruminants, in sustainable agriculture practices is not only possible but has been shown to increase the quality of product available to the consumer (Oltjen and Beckett, 1996; Franzluebbbers, 2007). Incorporating sustainable agriculture in animal production has been shown to increase weight gain in some livestock species such as cattle (Heitschmidt et al., 1996); although little research has been done specifically on the production of sheep on agroforestry pasture. Groen et al. (1997) discussed the

influences of sustainability on animal production goals and proposed that producers need to include a definition of efficiency, a long term strategic plan, and the overall size of the operation when making decisions about sustainable production systems. Olesen et al. (2000) argued that when using a sustainable agriculture practice, the goals of the producer would become more stringent. Benchmark values that would be acceptable in traditional animal production systems would not suffice in a sustainable agriculture practice, as the producer would have to incorporate the ethical and ecological impacts of these goals. Nonetheless, if sustainable agriculture practices are to become more popular among ruminant livestock producers, the economic efficiency and optimal integration levels need to be determined (Baldwin et al., 1992).

The objectives of these studies (it is actually two separate studies: one concerning market lambs and the other breeding ewes) were to determine the effects of producing sheep on agroforestry based pasture with respect to: 1) average daily gain of market lambs, 2) lamb weight at 90 days, 3) understory of the agroforestry, 4) percent organic material and nitrogen concentration of the soil, and 5) mature ewe breeding traits.

Materials and Methods

Experimental Site

These studies were conducted at the Ferrum College Agriculture Education Center in southwest Virginia (36°92'N), USA, between June 2008 and May 2009. The experimental site was at an altitude of 430 m and consisted of four 0.5 ha plots. Plot 1 contained a fescue and orchard grass mix (traditional pasture) with no sheep whereas Plot 2 was identical except contained sheep. Plot 3 had similar pasture type in addition to a mixed hardwood stand (agroforestry pasture) with no sheep whereas Plot 4 was identical except contained sheep. Free access to unlimited water was available in Plots 2 and 4 throughout the studies.

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Experiment 1: Market lamb production using sustainable agriculture

Weaned market lambs (American black-faced) (n=12) were randomly placed equally between Plot 2 and Plot 4 and weighed every other day using an electronic scale (A and A Scales LLC, Prospect Park, NJ, USA) until they reached 55 kg (market weight) to determine ADG. Their individual weights were recorded at 90 days (accepted industry benchmark).

Experiment 2: Ewe reproductive success using sustainable agriculture

Mature ewes (American black-faced) (n=17) were randomly placed between Plot 2 and Plot 4. After 2 weeks of adaptation, a mature ram (Dorset) fitted with a marking harness was placed with mature ewes for 30 days and markings were recorded every other day. Ewes were recorded as being sexually receptive to the ram when a mark was observed on their rump. Reproductive success was analyzed by ultrasound at 90 days post-ram removal. The numbers of live lambs born were recorded at the end of gestation (mid-April).

Experiment 3: Ecological response to sustainable agriculture

Understory was measured weekly in 1.0 x 1.0 x 0.5 m areas within Plot 3 and Plot 4. The amount of vegetation within each plot was determined as a percent of the total plot area by visual observation.

Soil samples were collected weekly using the zigzag method and pooled together within the plots with a soil tube. To determine the percent organic material of the soil, the soil was air dried, sieved using a #10 sieve, and frozen until analysis. Upon analysis, soil was then dried overnight at 105 °C in a drying oven (Napco Model 430, Waltham, MA, USA) and burned in a muffle furnace overnight at 400 °C. The organic content was determined by the difference in mass after drying and burning.

Total nitrogen concentration in the soil was determined by persulfate digestion as described by Pucell and King (1996). Total nitrogen was extracted from 0.1 g soil samples by digesting the soil in alkaline potassium persulfate at 120 °C (0.1MPa) for 1.5 h in an autoclave. The absorbance was determined using a Cary 50 Bio spectrophotometer (Varian Inc., Palo Alto, CA, USA) at 220 nm. The concentration of total nitrogen was determined from a standard curve, where the concentration of nitrogen was plotted against the absorbance at 220 nm.

Statistical analysis

Experiments were set up as completely randomized designs and data were analyzed using the general linear model (GLM) procedure in SAS (SAS Institute, Cary, NC, USA). In experiment 1 and 2, the experimental unit was sheep and the dependent variables were ewes marked, ewes pregnant at 90 days post-breeding, and lamb crop. Chi-square analysis was used to determine percentages. In all analyses, $P < 0.05$ was considered significant. Results are expressed as the least-squares mean \pm s.e.m.

Results

Market lamb production traits

There was no difference between the 90 d weight of the market lambs on Plot 4 (26.0 ± 1.3 kg) when compared to Plot 2 (23.8 ± 1.3 kg). There was no difference between the ADG of the market lambs on Plot 4 (0.26 ± 0.02 kg/d) when compared to Plot 2 (0.24 ± 0.02 kg/d).

Ewe reproduction traits

There was no significant between the percent of ewes marked by the rams on Plot 4 (88.9 ± 11.4 %) when compared to Plot 2 (87.5 ± 12.2 %). There was no difference between the percent of ewes pregnant 90 d post-ram removal on Plot 4 (88.9 ± 11.4 %) when compared to Plot 2 (87.5 ± 12.2 %). The lamb crop from ewes grazing on Plot 4 was significantly higher than those from Plot 2 (100.00 ± 13.60 % vs. 44.44 ± 12.83 %; $P < 0.05$).

Ecological response

The percent of understory cover on the agroforestry pasture with sheep (Plot 4) was significantly less compared to the agroforestry without sheep (Control, Plot 3) after the first week post-weaning ($P < 0.05$ Figure 1).

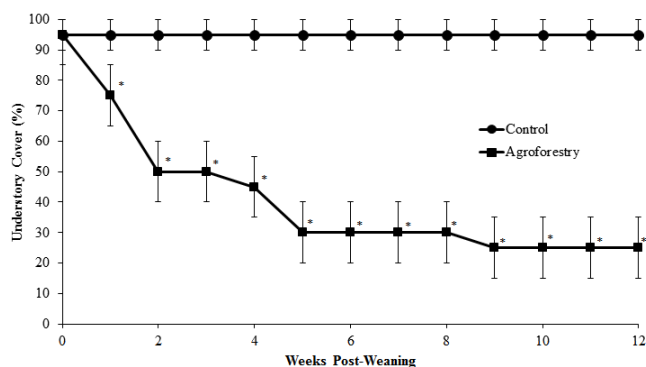


Figure 1: Effects of market lambs on understory percent. Understory cover of the agroforestry pasture containing market lambs (Agroforestry) and agroforestry pasture without market lambs (Control) from weaning to 12 wks post-weaning. Data are expressed as mean \pm s.e.m. * indicates a significant difference ($P < 0.05$) at the indicated time.

There was no difference between the percent organic material of the agroforestry pasture without sheep (Plot 3) and the agroforestry pasture with sheep (Plot 4), data were combined and considered the organic material from agroforestry based pasture. There was no significant between the percent organic material of the soil from the traditional pasture without sheep (Plot 1), the traditional pasture with sheep (Plot 2), and the pasture within the agroforestry pasture with sheep (Plot 4), these data were also combined and considered the organic material from the traditional pastures. The percent organic material of the soil from the traditional pasture was significantly less compared to the agroforestry based pasture for every time during the experiment ($P < 0.05$; Figure 2).

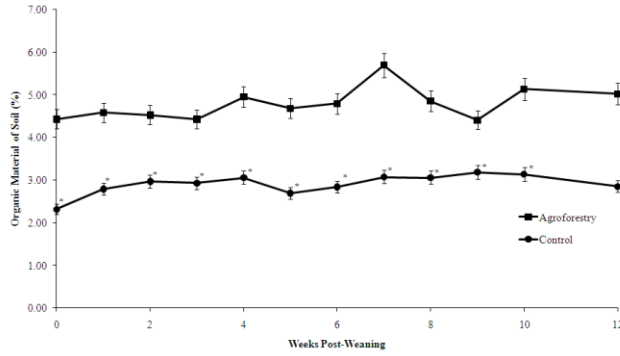


Figure 2: Effects of market lambs on percent organic material of the soil. The percent organic material of the soil from the agroforestry plots and the traditional pasture plots (Control) from weaning to 12 weeks post-weaning. Data are expressed as mean +/- s.e.m. * indicates a significant difference ($P < 0.05$) at the indicated time.

There was no difference in the nitrogen concentration in the soil between the agroforestry pasture (Plot 3, 0.069 ± 0.018 mg N/mg soil), agroforestry forest (Plot 3, 0.091 ± 0.017 mg N/mg soil), the traditional pasture without sheep (Plot 1, 0.040 ± 0.018 mg N/mg soil), and the traditional pasture with sheep (Plot 2, 0.046 ± 0.017 mg N/mg soil). The nitrogen concentration in the soil from the agroforestry pasture without sheep (Plot 3, 0.178 ± 0.019 mg N/mg soil) was significantly greater compared to the other pastures ($P < 0.05$; Figure 3).

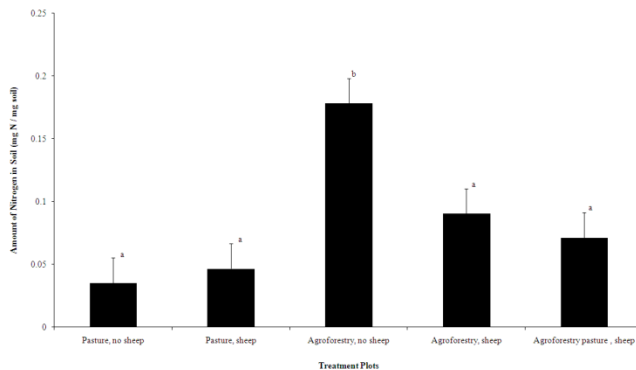


Figure 3: Effects of market lambs on nitrogen concentration in the soil. The amount of nitrogen (mg) per mg of soil 12 weeks post-weaning of market lambs. a, b different superscripts indicate significant difference ($P < 0.05$). Data are expressed as mean +/- s.e.m.

Discussion

The results presented in this paper compare the breeding and production traits of sheep grazed on traditional pasture compared to agroforestry pasture in addition to the effects of these two production systems on the environment. As more land is being utilized to sustain the increasing human population, agriculture producers will be required to find alternative methods to produce commodities more efficiently with similar demands of

output (Heitschmidt, 1991). Our results indicate that implementing agroforestry pastures as an alternative to traditional pasture grazing for sheep production is one such method.

We observed no difference in the ADG of market lambs during the grazing period between the two pasture types, indicating that market lambs can potentially be raised using agroforestry without losing weight gain efficiency. The 90 day weight is an economically important trait utilized by sheep producers that indicates the milking ability of the ewe and growing ability of the lamb (Olsen et al., 1976). Placing market lambs on agroforestry pasture does not decrease the 90 day weights compared to traditional pastures, making the agroforestry a viable alternative.

Breeding ewes in the fall on the agroforestry pasture did not result in diminished reproductive success. We observed that the live lamb crop was significantly higher from the ewes bred on the agroforestry pasture compared to the traditional pasture. This could be a result of more natural protective covering due to the hardwood trees during the summer months, compared to the open, shade-free pasture plots. The decrease in understory cover in the agroforestry pasture compared to the forest plots without sheep further demonstrates the utilization of the forest by the animals. Using ruminants to thin and fertilize agroforestry pasture has been shown to increase vegetative cover by promoting the establishment of the seeded grass (Papanastasis et al., 1995).

Higher concentrations of nitrogen in the soil from the agroforestry plots, regardless of the presence of animals, indicate that the inclusion of trees and other larger plant material increases the organic content of the soil, beneficial for the surrounding ecosystem. This suggests that within this time frame, the nitrogen in the soil is a result of the existing trees and not from the presence of animals. Increased temperatures in the summer months in combination with lack of precipitation causes nitrogen in the soil to evaporate and move towards the surface, hence the presence of animals in the pastures and forest could possibly assist in the release of free nitrogen into the environment (Rotz, 2004). This explains the elevated levels of nitrogen in the samples from the agroforestry plots without animals.

In conclusion, producing sheep on agroforestry pasture does not reduce the productivity compared to traditional pasture grazing. In addition to producing higher lamb crops, sheep raised on agroforestry pasture increase the organic and nitrogen content of the soil. A better understanding of producing sheep using sustainable agriculture is crucial as agriculturalists search for ways to become more sustainable throughout the world.

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