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Evaluation of Warm Season Annual Forages for Livestock: Biomass and Cost of Production

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Abstract

Seventeen warm season annual forage options were evaluated as livestock feed to be grazed, hayed, ensiled, or left as a cover crop. Treatments were planted in mid-May and terminated in late September with one harvest for silage, two hay cuttings, and three grazing rotations. One additional treatment was unharvested to serve as a cover crop. Biomass production and cost to produce final outputs were determined. Even with restricted rainfall during the summer months in 2020, the growth for the chosen forage options was at least 1,500 lb of dry matter (DM) per acre, with the exception of sunflowers that had the lowest biomass production. Biomass production was the greatest for the forages that were left in the field as cover crop, followed by hay, then grazed, with the lowest biomass measured for the silage harvest. Monocultures of grass and sunn hemp produced as much biomass as multi-species blends that included grass or sunn hemp. Adding a high-producing grass species to sunflower and cowpeas increased biomass production compared to the respective monoculture. Regardless of harvest method, monocultures of cowpea and the blend of pearl millet + cowpea cost the most per unit of production. The lowest costs per unit of production for all harvest methods were found in three treatments: a monoculture of sorghum-sudan, the low seeding rate of pearl millet, and the blend of sorghum-sudan + sunn hemp.

Keywords

mono-culture annual forage, multi-species annual forage, cover crop, biomass

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Evaluation of Warm Season Annual Forages for Livestock: Biomass and Cost of Production

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Summary

Seventeen warm season annual forage options were evaluated as livestock feed to be grazed, hayed, ensiled, or left as a cover crop. Treatments were planted in mid-May and terminated in late September with one harvest for silage, two hay cuttings, and three grazing rotations. One additional treatment was unharvested to serve as a cover crop. Biomass production and cost to produce final outputs were determined. Even with restricted rainfall during the summer months in 2020, the growth for the chosen forage options was at least 1,500 lb of dry matter (DM) per acre, with the exception of sunflowers that had the lowest biomass production. Biomass production was the greatest for the forages that were left in the field as cover crop, followed by hay, then grazed, with the lowest biomass measured for the silage harvest. Monocultures of grass and sunn hemp produced as much biomass as multi-species blends that included grass or sunn hemp. Adding a high-producing grass species to sunflower and cowpeas increased biomass production compared to the respective monoculture. Regardless of harvest method, monocultures of cowpea and the blend of pearl millet + cowpea cost the most per unit of production. The lowest costs per unit of production for all harvest methods were found in three treatments: a monoculture of sorghum-sudan, the low seeding rate of pearl millet, and the blend of sorghum-sudan + sunn hemp.

Introduction

Forage systems are important components of livestock production. When pasture is not available, harvested forage serves as a timely and important animal nutrient supplement. Adequate production of forages requires careful attention to detail to provide an optimal feedstock for cattle.

There are two broad categories of alternative forage systems: monocultures and multi-species forages. Monocultures are a single species of plant that is planted for a specific purpose. Multi-species forage systems include a diverse population of plants that have been selected to match producer objectives. The thought is that multi-species blends offer benefits to the production system and more accurately mimic native pasture ranges. However, from the perspective of biomass production and forage quality, there have

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been varying responses to whether one plant species or multiple species result in a more desirable forage harvest.

Therefore, the purpose of this study was to evaluate the biomass production of single and multi-species summer forages as harvested in multiple methods for cattle producers and determine the cost of production for outputs.

Experimental Procedures

The study was conducted at the Southeast Research and Extension Center in Parsons, KS. Seventeen treatments were planted in 10- × 95-ft strips in a split-plot design where the whole plot was the seventeen forage treatment options and the split-plot was four harvesting methods of grazed (GRAZE), hay (HAY), silage (SILAGE), or traditional cover crop with no harvest or grazing (COVER). The seventeen forage options are described in Table 1. Treatments were planted May 18, 2020, with a 5-ft drill and fertilized with 50 lb N as 46-0-0. The first grazing event occurred when the grass species were at least 2-ft tall and were "grazed" to 8-inch stubble every time the grass species reached that height, in a simulated grazing system. Grazing harvest dates occurred on July 7, 2020; August 5, 2020; and September 24, 2020. Hay was harvested on July 22, 2020, and September 24, 2020. Silage harvest occurred on August 5, 2020. The unharvested treatment was sampled for biomass on September 24, 2020. Samples were harvested using a Carter flail forage harvester which harvested an area of 3 ft × 20 ft and harvested area was weighed for a wet biomass yield. Grab samples from the harvested samples were collected and dried in forced-air oven to determine DM and then total yield on DM basis was determined by taking the total wet collection amount and multiplying by DM.

Cost per unit of production was determined using actual seed costs from 2020 (Table 1), estimated harvesting costs as reported in Kansas Custom Rates 2020 report, silage bagging costs from the 2020 Nebraska Farm Custom Rate report (McClure and Jansen, 2020), and cattle care estimates from 2019 Bluestem Report. All other costs associated with the analysis are described in Table 2.

Data were analyzed for treatment and harvest effects. Pre-planned contrasts comparing single species versus multiple species; low seeding rate and high seeding rate of pearl millet; grass and legume specie differences; and categorization of forage (i.e. grass only, grass+broadleaf, grass+legume, etc.) were completed.

Results and Discussion

Annual Forage Production Based on Forage Treatment Options

The forages evaluated offered impressive amounts of biomass production, with the exception of sunflower, even in a low moisture late summer such as 2020. On average, all treatments other than sunflowers, had a minimum of 1,500 lb DM per acre of production (Table 2). The greatest biomass yield was for the COVER harvest (5,936 lb DM/acre), followed by HAY (3,826 lb DM/acre), then GRAZE (3,097 lb DM/acre), and finally SILAGE (2,603 lb DM/acre) with the lowest biomass yield.

Sorghum-sudan yielded on average 1,337 lb DM/acre more than pearl millet ($P < 0.001$) and for all harvest methods sorghum-sudan out-yielded pearl millet ($P < 0.001$). Both of the legumes evaluated had similar biomass production whether alone or in mixtures ($P = 0.18$); with the exception of the COVER harvest when sunn hemp had a greater biomass than forages with cowpeas ($P = 0.001$; Table 2).

The addition of a broadleaf or legume into a stand with either sorghum-sudan or pearl millet did not affect biomass production ($P > 0.50$). Adding a legume has been suggested to complement the grass and result in improvements in quantity and quality; however, this was not found in this study. The forage quality is still being analyzed. There is a wide range of seeding rates for pearl millet. No differences in biomass yield were observed between the highest versus lowest seeding rates ($P = 0.69$).

Similar to other research projects, the low biomass-producing plants of sunflower and cowpea, when mixed with a high biomass-producing grass such as sorghum-sudan or pearl millet, significantly increase yield above single species mixtures ($P < 0.02$).

Forage Production Based on Harvest Intervals

The second cutting for HAY resulted in more biomass produced than the first harvest ($P < 0.01$; 2,051 lb DM/acre vs. 1,759 lb DM/acre, respectively). Monoculture of sorghum-sudan had a greater biomass in the 1st cutting than 2nd cutting ($P < 0.01$; Figure 2A). This was probably driven by a severe lack of moisture between the two cutting events. In contrast, the monocultures of sunn hemp and cowpea, and the multi-species blend of sorghum-sudan + sunflower + sunn hemp had greater biomass in the second cutting than in the first ($P < 0.05$; Figure 2A).

For GRAZE, the greatest tonnage occurred with the first grazing event, followed by the second, with the lowest re-growth/biomass in the third grazing event ($P < 0.001$). For many of the warm-season annual forages, the best management practice is to allow the plant to reach at least 2 feet tall before grazing to minimize the chance of prussic acid poisoning in cattle. Generally, if weather is favorable, it takes about 28 days to allow a warm-season annual to reach that 2 feet height. In the summer of 2020, there were three grazing events. Several of the sorghum-sudan treatments showed a decrease in biomass production with a greater number of "grazing" events ($P < 0.001$; Figure 2B). Conversely, sunn hemp biomass increased with more grazing events. Sunn hemp increases branching with more frequent harvests, as has been shown elsewhere, potentially accounting for the greater biomass with increased grazing events.

Annual Forage Production Based on Classification of Forage

An increase in biomass production was observed in two- or five-plant mixtures compared to monocultures; three-plant species mixtures produced intermediate biomass amounts ($P < 0.01$). However, the low-producing monocultures of sunflower and cowpea lowered the average biomass production of the monocultures evaluated. When differentiating biomass production based on single species of grass, legume, broadleaf, and the blends of these plant categories, the grass species in a monoculture produced the same biomass yield as multi-species, legumes were intermediate, and the broadleaf (sunflower) was the lowest (Figure 1).

Costs of Annual Forage Production Based on Potential Forage Usage

For producers interested in annual forage for grazing, there is a wide range of costs per grazing day (Table 2). Regardless of grazing with growing, stocker calves, or cow-calf pairs, the most expensive options are a monoculture of cowpeas or pearl millet + cowpea. The intermediate cost range, based on production values, includes monocultures of sunflower, sunn hemp, the high seeding rate of pearl millet, and the multi-species blend of sorghum-sudan + sunflower + cowpea. All other forage options evaluated result in similar costs per unit of production and are lower in cost. The cost per grazing day ranged from $0.51 to $1.81 for stocker calves and $0.97 to $3.49 for cow-calf pairs. The cost estimates determined in this study consider several averages for cattle intake, pasture utilization, and costs associated with fence, labor, and water to generate values. Specific operational costs may vary.

The monoculture of cowpea and the multi-species blend of pearl millet + cowpea was the most expensive to produce a ton of hay, but the monoculture of sunflowers also had the same expensive price tag on a per unit of production basis. The lowest cost per ton of hay produced was for the monocultures of sorghum-sudan and sunn hemp, sorghum-sudan + sunflower or sunn hemp, low seeding rate of pearl millet, sorghum-sudan + sunflower + sunn hemp, and the everything blend (Table 2). In general, the base grass that included sorghum-sudan resulted in a low cost of production. The cost per ton of hay produced ranged from $28.27 to $35.92.

The most expensive silage to produce was the monocultures of sunflower and cowpea; pearl millet + cowpea; and pearl millet + sunn hemp (Table 2). The lowest cost per ton of silage produced was sorghum-sudan; sorghum-sudan + sunn hemp; and low seeding rate of pearl millet. Costs per ton of silage produced ranged from $22.78 to $40.87.

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Table 1. Annual forage treatments, seeding rates (lb/acre), and seed price/acre

Forage treatments	Abbreviation	SS	PM	SF	SH	CP	$/acre
Sorghum-sudan[1]	SS	20					$30.00
Pearl millet[2]	PM		20				$32.00
Pearl millet, low rate	PM low		6				$9.60
Sunflower[3]	SF			10			$7.00
Sunn hemp[4]	SH				20		$27.40
Cowpea[5]	CP					60	$58.20
Sorghum-sudan + sunflower	SS-SF	10		10			$22.00
Sorghum sudan + sunn hemp	SS-SH	10			10		$28.70
Sorghum-sudan + cowpea	SS-CP	10				40	$53.80
Pearl millet + sunflower	PM-SF		10	10			$23.00
Pearl millet+ sunn hemp	PM-SH		10		10		$29.70
Pearl millet + cowpea	PM-CP		10			40	$54.80
Sorghum-sudan + sunflower + sunn hemp	SS-SF-SH	8		7.5	8		$28.21
Sorghum-sudan + sunflower + cowpea	SS-SF-CP	8		7.5		20	$36.65
Pearl millet + sunflower + sunn hemp	PM-SF-SH		8	7.5	8		$29.01
Pearl millet + sunflower + cowpea	PM-SF-CP		8	7.5		20	$37.45
Everything[6]	SS-PM-SF-SH-CP	5	5	5	5	10	$34.20

[1] Multi Leaf BMR sorghum-sudan, $1.50/lb.
[2] Graze King BMR Pearl Millet, $1.60/lb.
[3] Peredovik oilseed sunflower, $0.70/lb.
[4] Sunn hemp, $1.37/lb.
[5] Red Ripper cowpea, $0.97/lb.
[6] Everything treatment: sorghum-sudan + pearl millet + sunflower + sunn hemp + cowpea.

Table 2. Yields in both dry matter and actual (as-is) of all forage treatments and harvest methods

	Dry matter, lb/acre				As is, ton/acre		Cost/unit production			
Forage	Graze	Hay	Silage	Cover	Hay	Silage	Hay[1]	Silage[2]	Stocker[3]	Cow[4]
Sorghum-sudan[3]	3,915	4,554	3,678	8,355	9.02	7.24	$29.36	$23.65	$0.61	$1.17
Pearl millet[4]	2,463	3,272	2,149	5,129	5.59	4.30	$33.72	$29.51	$0.97	$1.87
Pearl millet, low rate	2,927	3,190	2,320	3,349	5.88	4.56	$29.45	$23.87	$0.51	$0.97
Sunflower[5]	1,025	1,385	962	1,169	3.12	4.30	$34.71	$32.67	$1.21	$2.33
Sunn hemp[6]	2,079	4,170	1,765	7,514	8.25	2.31	$29.54	$29.61	$1.21	$2.34
Cowpea[7]	2,068	3,078	1,306	3,518	6.88	3.71	$35.92	$40.87	$1.81	$3.49
Sorghum-sudan + sunflower	3,369	4,832	3,085	8,140	9.69	3.60	$28.27	$26.86	$0.69	$1.32
Sorghum-sudan + sunn hemp	4,552	4,982	4,015	10,130	10.67	6.72	$28.29	$22.78	$0.53	$1.01
Sorghum-sudan + cowpea	4,415	5,112	3,671	7,594	10.13	8.16	$31.34	$26.29	$0.78	$1.50
Pearl millet + sunflower	3,190	3,188	2,812	4,462	6.04	7.94	$31.63	$25.22	$0.64	$1.23
Pearl millet+ sunn hemp	3,154	3,671	2,292	6,317	6.86	5.67	$31.40	$32.26	$0.74	$1.42
Pearl millet + cowpea	2,632	3,630	2,180	4,257	6.82	4.56	$35.92	$34.01	$1.42	$2.74
Sorghum-sudan + sunflower + sunn hemp	3,146	4,344	3,409	5,676	8.81	4.58	$29.14	$24.45	$0.74	$1.43
Sorghum-sudan + sunflower + cowpea	3,283	3,963	2,254	6,242	8.62	7.13	$30.89	$31.05	$0.85	$1.63
Pearl millet + sunflower + sunn hemp	3,435	3,674	2,922	6,482	7.09	4.95	$30.96	$25.04	$0.67	$1.29
Pearl millet + sunflower + cowpea	3,340	3,390	2,457	4,148	6.72	5.85	$32.10	$27.98	$0.81	$1.55
Everything[8]	3,661	4,618	2,984	8,436	9.41	5.15	$30.24	$26.68	$0.72	$1.39

[1] Hay unit of production is by the ton. Costs included seed cost (Table 1); fertilizer at $18.75/acre; custom rate to cut, condition, and rake hay at $12.00/acre; and large round baling (<1500-lb bale) with net wrap at $13.24/bale; and custom hauling at $4.54/bale (Kansas Custom Rates 2020).

[2] Silage unit of production is as-received tonnage. Costs include seed cost (Table 1); fertilizer at $18.75/acre; custom rate to chop and haul at $8.76/ton (Kansas Custom Rates 2020); and cost to bag at $8/ton (UNL 2020 Nebraska Farm Custom Rates).

[3] Stocker calf unit cost of production is the cost per grazing day on one acre for an average weight 700-lb stocker steer over a grazing period (estimated intake 2.5% of body weight on DM basis with 40% pasture utilization). Costs include seed (Table 1); fertilizer at $18.75/acre; fencing fee ($0.03/foot single wire electric for 80 acres amortized over 5 years); water ($1.50 per 1000 gallon with $25 per 1000 gallon hauling charge with average estimated intake of 10 gallon/day); care based on equivalent grazing days for class of livestock reported in 2019 Bluestem Pasture report ($6 per head per acre for full summer season).

[4] Cow unit cost of production is the cost per grazing day on one acre for a spring calving cow-calf pair with dam average weight 1,350 lb (estimated intake 2.2% of body weight on DM basis with 35% pasture utilization). Costs include seed (Table 1); fertilizer at $18.75/acre; fencing fee ($0.03/foot single wire electric for 80 acres amortized over 5 years); water ($1.50 per 1000 gallon with $25 per 1000 gallon hauling charge with average estimated intake of 25 gallon/day); care based on equivalent grazing days for class of livestock reported in 2019 Bluestem Pasture report ($6.38 per head per acre for full summer season).

[3] Multi Leaf BMR Sorghum-sudan.

[4] Graze King BMR Pearl Millet.

[5] Peredovik sunflower.

[6] Sunn hemp.

[7] Red Ripper cowpea.

[8] Everything treatment is sorghum-sudan + pearl millet + sunflower + sunn hemp + cowpea.

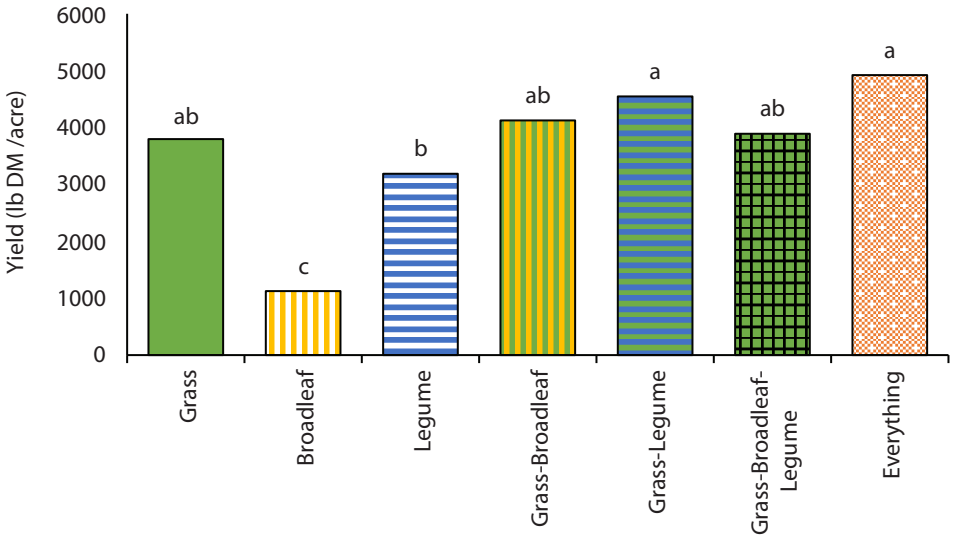

Figure 1. Biomass yield based on forage classification.
[ab] Different superscripts indicate biomass yield difference at $P < 0.05$. DM = dry matter.

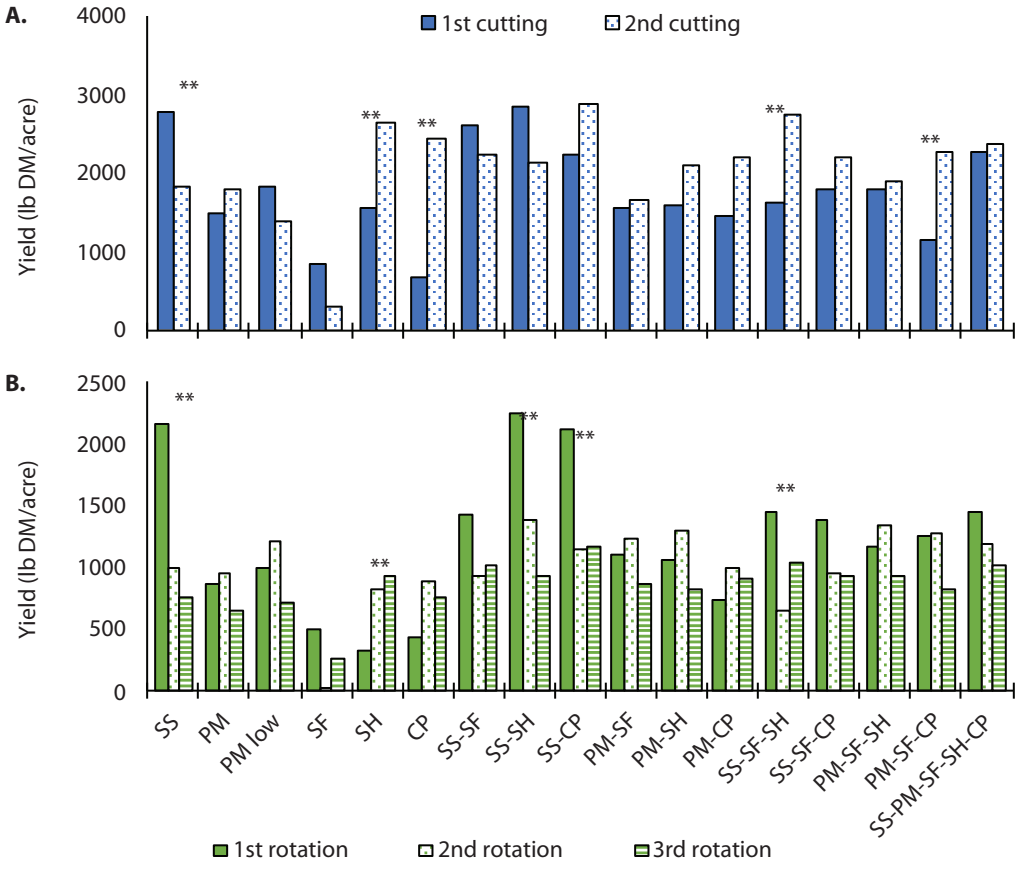

Figure 2. Biomass yields for the hay and grazing harvests based on the number of cuttings or grazing events. See Table 2 for the forage type per abbreviations in this figure.
DM = dry matter. ** Indicate that there is a difference in biomass yield for that forage treatment at $P < 0.05$.