Forage Yield of Ten No-Tillage Triple Crop Systems in Florida

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ABSTRACT

Growing crops in conservation tillage and multiple cropping systems is efficient, cost productive, and environmentally beneficial. This experiment was designed to evaluate the potential of ten triple-cropping systems to produce forage. A split-plot design was used with main effects as two winter crops and sub-effects as five fall-planted crops. The winter crops were rye (*Secale cereale* L.) and lupin (*Lupinus angustifolius* L.), and the fall crops consisted of soybean (*Glycine max* [L.] Merr.), cowpea (*Vigna unguiculata* [L.] Walp.), sorghum x sudangrass (*Sorghum bicolor* [L.] Moench), sunn hemp (*Crotalaria juncea* L.), and corn (*Zea mays* L.). A summer crop of corn was planted in all plots between the winter and fall crops. Rye plots yielded higher than lupin plots in the winter. There were no differences in the summer corn yields. A highly significant interaction was observed among fall crop yields, with sorghum x sudangrass plots yielding highest and soybean plots yielding lowest across main treatments. Total dry matter production for all three crops combined was significant among sub-plot means. Systems with sorghum x sudangrass produced the most biomass. As much as 11.5 – 14.5 tons dry matter acre^{-1} can be produced using these triple-cropping systems. Even the results of the lowest yielding systems (soybean and cowpea as fall crops) are considered positive results because of the additional forage production and potential for animal waste utilization in a non-polluting manner during the fall, a non-traditional growing season for the proposed crops.

KEYWORDS

Multiple-cropping, rye, lupin, corn, soybean, cowpea, sudax, sunn hemp.

INTRODUCTION

In Florida, there is a window of opportunity to grow forages in the fall because many dairy farmers use a double-cropping system that includes a small grain in the winter followed by corn (*Zea mays* L.) in the summer. After corn harvest in late summer, their land will often lay unused until planting of the winter crop several months later. Our subtropical climate keeps temperatures warm enough to support growth of a crop in the fall. There are multiple advantages to such a system. Not only would it provide an additional crop for a supplementary feed for cattle, but it could also alleviate some of the waste disposal problems that a dairy farm faces. There would be a new opportunity to dispose of wastes by applying them to the land as a fertilizer to be taken up by the additional crop.

Incorporation of no-till planting methods into this triple cropping system also has numerous benefits. Timely planting is one of the most important because time that is used to prepare the land for planting, incorporation of residues, or weed control is time that could be saved in no-till systems. This saved time translates to savings in labor costs, equipment and fuel costs from fewer trips through the field, and maintenance and upkeep costs (Gallaher, 1980; Teare, 1989). Plus, earlier crop planting can allow more time for biomass production before cooler weather settles in, thereby limiting the production of the fall crop. Also, no-till has been widely documented for its potential to prevent soil erosion and for more efficient water use because of less evaporation and improved root channeling.

Florida has been a leader in no-tillage research for decades. Through the 1980s, many publications demonstrating the beneficial effects of conservation tillage have been documented (Brecke, 1984; Colvin, 1986; Colvin and Wehtje, 1984; Costello, 1984; Costello and Gallaher, 1984; Wright and Cobb, 1984; Wright and Teare, 1993). More recently, the positive trends have continued with conservation tillage in a variety of cropping systems (Barnett *et al.*, 1997; Edenfield *et al.*, 1999; Gallaher, 1999; Tubbs *et al.*, 2000; Tubbs *et al.*, 2001). With such positive results,

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adoption of conservation tillage practices should continue to increase, as they have for the past 20+ years.

Fall plantings of soybean (*Glycine max* [L.] Merr.) (Tubbs and Gallaher, 2001), cowpea (*Vigna unguiculata* [L.] Walp.) (Tubbs and Gallaher, 1998; Tubbs *et al.*, 1998), and sunn hemp (*Crotalaria juncea* L.) (Gallaher *et al.*, 2001; Marshall *et al.*, 2001) have proven successful in Florida. These legume crops also may be used as forages. Wheeler (1950) supplies an abundance of information on forage usage of cowpea, soybean, sorghum (*Sorghum bicolor* [L.] Moench), and sudangrass (*Sorghum sudanense* [Piper] Stapf). Sunn hemp has also been used as a forage for livestock (Comis, 1997). Because of the advantages of conservation tillage and multiple cropping in addition to the positive results seen with fall plantings of several crops that can be used as forages, research was conducted to evaluate the forage yield potential of ten triple-cropping systems using no-tillage management methods.

MATERIALS AND METHODS

This experiment took place at the Institute of Food and Agricultural Sciences (IFAS) Plant Science Research and Education Center in Citra, FL. A split-plot design was used with main plots of two winter crops and sub-plots of five fall crops. Rye (*Secale cereale* L.) and lupin (*Lupinus angustifolius* L.) were each planted in two blocks within each rep to allow for a crop rotation effect in future years. Thus, the study was analyzed as if there were 20 cropping systems, yet there were actually 10 systems with winter crops duplicated.

Two winter crops, ‘Wrens 96’ rye and ‘Tift Blue’ lupin were planted on 20 November 2000 using a Tye no-till drill (10-inch spacing) into a minimum tilled seedbed that consisted of using a tandem harrow two times. Rye seed was planted at 90 lbs acre^{-1} and lupin seed at 40 lbs acre^{-1}. All plots were fertilized with 500 lbs acre^{-1} of a fertilizer mix containing 17.6% N, 5.7% P_2O_5, 17.8% K_2O, 1.4% Mg, and 2.85% S and received a supplemental application of 100 lbs acre^{-1} of ammonium nitrate (34% N). No chemical pesticides were required for control of pests in the winter crops. The winter crops were harvested at ground level for above-ground forage yield on 13 March 2001.

All plots were planted to ‘Florida IRR’ corn on 21 March 2001 into the stubble of the previous crop. The Tye no-till drill was used and 50,000 seeds acre^{-1} were planted. A fertilizer containing 18.8% N, 4.6% P_2O_5, 17.2% K_2O, 1.12% Mg, and 2.28% S was applied in three applications of 375 lbs acre^{-1} at planting, at 12-inch crop height, and at 24-inch crop height. Corn was harvested for above ground forage yield on 28 June 2001. Labeled rates of Roundup Ultra and Atrazine + Dual Magnum were applied pre-emergence for weed control. A labeled rate of Furadan was applied pre-emergence and labeled rates of Lannate were applied post-emergence for insect control.

The five fall crops of ‘Hinson Long Juvenile’ soybean, ‘Iron Clay’ cowpea, ‘Cow Chow’ sorghum x sudangrass (*Sorghum bicolor* [L.] Moench) (henceforth sudax), ‘Tropic Sun’ sunn hemp, and ‘Florida IRR’ corn were planted on 19 July 2001 using the Tye no-till drill into the remaining corn stubble. Soybean, cowpea, and sudax were planted at 420,000 seeds acre^{-1}, sunn hemp at 260,000 seeds acre^{-1}, and corn at 50,000 seeds acre^{-1}. All plots were fertilized using the same fertilizer mix as mentioned above for the summer corn crop, again in three applications of 375 lbs acre^{-1} at planting, at 12-inch crop height, and at 24-inch crop height (based on height of sudax). A labeled rate of Roundup Ultra was used pre-emergence for weed control. Labeled rates of Lannate were applied for insect control. Overhead irrigation was used on all crops. The fall crops were harvested on 3 October 2001 for above ground forage yield. Data were analyzed using analysis of variance for a split-plot design, and where appropriate, means separated by LSD test at $P = 0.05$.

RESULTS AND DISCUSSION

The blocks planted to rye in the winter yielded higher than blocks planted to lupin (Table 1). In the summer corn crop, there were no significant differences in above-ground forage yields (Table 2). However, there was a highly significant interaction for the yields of the fall crops (Table 3). When all dry matter was added together for the three crops combined, the sub-plot effect was significant for total biomass produced (Table 4).

As seen in Table 3, sudax yielded highest in each of the winter crop main plots, and sunn hemp was equally as high in one of the main plot rye treatments. Soybean had lowest

Table 1. Forage yield for the 1st (winter) crop averaged over fall crops, Citra, FL 2001, R.S. Tubbs, R.N. Gallaher, K-H. Wang, and R. McSorley. Means followed by the same letter are not significantly different based on $LSD_{0.05}$.

Winter crop	Dry matter yield
	------ tons DM acre $^{-1}$ -------
Rye 1	2.47 A
Lupin 1	1.97 B
Rye 2	2.52 A
Lupin 2	2.07 B

Table 2. Forage yield for 2nd (summer) crop - corn in 10 triple-cropping systems and rotations with winter crops, Citra, FL 2001. The main effects for fall crops and winter crops as well as the fall crop x winter crop interaction were all non-significant ($P = 0.05$).

	Winter Crop				
Fall Crop	Rye 1	Lupin 1	Rye 2	Lupin 2	Average
	------------------------------ tons DM acre $^{-1}$ ---------------------				
Soybean	7.39	6.39	7.14	7.63	7.14
Cowpea	6.42	6.67	6.42	7.25	6.69
Sorghum X Sudangrass	7.99	7.12	7.21	7.31	7.41
Sunn Hemp	7.26	6.79	6.48	7.16	6.92
Corn	8.18	6.19	7.40	6.53	7.07
Average	7.45	6.63	6.93	7.18	

Table 3. Forage yield for 3rd (fall) crop in 10 triple-cropping systems and rotations with winter crops, Citra, FL 2001. The interaction was highly significant ($P < 0.001$). Therefore the weighted $LSD_{0.05} = 0.58$ was used for comparison of interaction means. The $LSD_{0.05} = 0.45$ was calculated for comparison among sub-plot (fall crop) means within whole plots (winter cover).

	Winter Crop				
Fall Crop	Rye 1	Lupin 1	Rye 2	Lupin 2	Average
	-------------------------- tons DM acre $^{-1}$ ----------------------				
Soybean	1.98	2.13	1.90	2.09	2.03
Cowpea	2.16	2.69	2.84	2.17	2.47
Sorghum X Sudangrass	4.19	4.49	5.02	4.17	4.47
Sunn Hemp	3.84	3.05	3.00	3.57	3.37
Corn	3.08	3.25	2.65	2.89	2.97
Average	3.05	3.12	3.08	2.98	

yields in all of the winter main plots and cowpea was equally as low in one of the rye and one of the lupin treatments. The total forage yields show that systems with sudax planted as the fall crop yielded higher than any of the other triple-cropping systems (Table 4). The systems with sunn hemp and corn as the fall crop were statistically equal, and those with soybean, cowpea, and corn in the fall yielded similarly to each other as well, but lower than sunn hemp and sudax.

Although the winter production of rye was higher than for

Table 4. Total forage yield for 10 triple-cropping systems and rotations with winter crops, Citra, FL 2001. The main effect for winter crop was non-significant (*P* = 0.05). The sub-plot (fall crop) main effect was significant at *P* = 0.001. Fall crop means followed by the same letter are not significantly different based on $LSD_{0.05}$= 0.87.

	Winter Crop				
Fall Crop	Rye 1	Lupin 1	Rye 2	Lupin 2	Average
	----------------------tons DM acre $^{-1}$ ------------------				
Soybean	11.84	10.49	11.56	11.79	11.42
Cowpea	11.05	11.33	11.78	11.49	11.41
Sorghum X Sudangrass	14.65	13.58	14.75	13.55	14.13
Sunn Hemp	13.57	11.81	12.0	12.8	12.55
Corn	13.73	11.41	12.57	11.49	12.30
Average	12.97	11.72	12.53	12.22	

lupin, the same effect did not show up in total forage yields. Based on these results, growing either rye or lupin in the fall, followed by corn, followed by sudax would provide a farmer with the most feed for his or her cattle. This does not necessarily mean that this system would be the most beneficial for maximizing nutrient removal from application of waste materials, however. Different crops have different capacities for nutrient removal. In addition, farmers want high quality forages that are rich in nutrients so the cattle get more benefit from each bite. Quality is often more important than quantity when it comes to feeding lactating animals. More analyses on plant material for nutrient removal and digestibility would need to be done in order to give a more thorough recommendation of the optimal triple-cropping system for waste disposal and highest quality feed.

Growing three grasses in a row, as is the case in the rye-corn-sudax and rye-corn-corn systems, may not be the best option in the long run for sustainability because of potential pest problems. Alternating grasses and legumes are often wiser crop rotation strategies to break pest cycles. Legumes have greater concentrations of N than grasses in most cases (Morrison, 1947), making legumes important in crop rotations for nutrient removal and improving forage quality. Nitrogen is the element with the most potential for leaching and pollution so more research is needed to determine the best system for removal of this element to prevent losses to groundwater.

CONCLUSIONS

Regardless of which triple-cropping system is chosen, all could provide the grower with the opportunity to utilize nutrients in animal wastes while supplementing their feed stocks during a time of the year when feed supplies are low. Depending on the system, anywhere from 11.5 to 14.5 tons dry matter acre^{-1} can be produced using a triple cropping system of rye or lupin in the winter, corn in the summer, and soybean, cowpea, sudax, sunn hemp, or corn in the fall. Maximized biomass production came from the systems with sudax as the fall crop. Back to back corn crops in the summer and fall yielded fairly well, but only additional years of data from this area will tell if such a system is sustainable. Although sunn hemp systems did not yield quite as high as those with sudax, this fall-grown legume still performed very well. It may have promise for a number of purposes in Florida including cover crops, green manure, organic fertilizers, and possibly forages.

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