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INFLUENCE OF PEARL MILLET ON PERFORMANCE OF WINTER ANNUAL CROPS

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ABSTRACT

The recent development of disease-resistant dwarf hybrids of pearl millet [*Pennisetum glaucum* (L.) R. Br.] has increased the opportunity for and diversity of double-croppping systems in the South. We began a series of field studies in 1993 to determine the feasibility of several new double-cropping systems which included pearl millet and white lupin (*Lupinus albus* L.). One rotation study in central Alabama includes soybean [*Glycine max* (L.) Merr.], summer fallow, and pearl millet double-cropped with wheat (*Triticum aestivum* L.) and lupin in both a strip-tilled and conventional tilled system. In this study, neither tillage system nor summer crop had an effect on wheat grain yield (average 4633 lb/A). Lupin silage production was greatest following summer fallow in the conventional tillage system (7168 lb/A dry matter) but under strip-tillage summer fallow resulted in the lowest lupin dry matter production (3366 lb/A). Pearl millet reduced total dry matter production of succeeding lupin 15% compared to soybean in the strip-till system but the greatest lupin grain yield (2657 lb/A) was obtained following pearl millet in the strip-till system. In another study conducted at three locations (northeastern and southwestern Alabama and the Florida Panhandle), we are evaluating tropical corn (*Zea mays* L.), pearl millet, and soybean double-cropped with wheat or lupin. Nitrogen rate varies (0, 60, 120, or 180 lb N/A) for tropical corn and pearl millet in the double-cropping systems. In 1994, wheat yield generally increased with N rate applied to pearl millet and tropical corn. Satisfactory lupin yields were only obtained at the southern Alabama location (5677 lb/A dry matter, 1984 lb/A grain) and neither previous crop species nor N rate had an effect on lupin silage or grain yield. These preliminary data suggest a need for more research in the management of pearl millet in double-cropping systems.

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INTRODUCTION

Sustained economic viability and environmental quality of farms in the southern United States can be improved by diversified whole farm systems that effectively integrate livestock and cropping systems. These systems must, however, be adapted to the acid infertile soils of the region. The recent development of disease-resistant dwarf hybrids of pearl millet (Hanna, 1991) has increased the opportunity for and diversity of double-croppping systems in the South. These hybrids can be planted late (May through July) and produce high-quality grain that has shown potential as a protein source in diets of poultry (Smith et al., 1989), swine (Haydon and Hobbs, 1991), cattle (Hill and Hanna, 1990), and catfish (Burtle et al., 1992). Pearl millet is tolerant of acidic and infertile soils (Ahlrichs et al., 1991) and is assumed to have a low N requirement compared to other grain crops and thus should fit well into rotations with legumes like white lupin, peanut (*Arachis hypogaea* L.), and soybean.

We began a series of field studies in 1993 to determine the feasibility of several new double-cropping systems which include pearl millet and winter-hardy white lupin. These ongoing studies are designed to determine the interactive rotational effects of pearl millet and white lupin compared to the conventional double-cropping system in the South, i.e., wheat-soybean. In addition, the role of tillage in developing alternative double-cropping systems will be determined as well as the overall nitrogen use efficiency for the various rotations with these new crops.

MATERIALS AND METHODS

Crop Rotation/Residue Management Study

This study, conducted on a Norfolk sandy loam (fine-loamy, siliceous, thermic, Typic Kandiudult) is a split plot arrangement of three replications. Main plots are tillage systems, either conventional (disk-chisel-disk-field cultivate) or strip-tillage. In-row subsoiling was performed on fall-sown lupin and spring-sown soybean and pearl millet in both conventional and strip-tilled plots. Strip-tillage was accomplished using a narrow parabolic shank subsoiler equipped with rubber closing wheels rather than coulters. This resulted in minimal residue disturbance in the conservation-tilled (strip-tilled) plots. Subplots are ten rotation treatments. The rotations include combinations of winter rotations of wheat 'Coker 9835' and lupin 'Lunoble' and summer rotations of soybean 'Brim', pearl millet 'Georgia-Agra Tech HGM™100' or fallow. The rotations are designed to include lupin every year, every 2 years or every 3 years. For this paper, the effect of the first summer (1993) rotation crop, i.e., soybean, pearl millet, or fallow on wheat grain and lupin grain and total dry matter production is reported.

Wheat was seeded at 20 seed per foot of row with a drill on 8-inch spacings. Lupin was seeded at 7 seed per foot of row on 30-inch rows. Soybean was seeded at 8 seed per foot of row on 30-inch rows and pearl millet was planted at 4 lb/A in 30-inch rows. Plots are 20 ft by 50 ft. Current extension recommendations for weed and pest control are used on wheat and soybean. Atrazine (0.75 lb a.i./A) + 1 qt/A crop oil was applied to pearl millet at the three leaf stage of growth. A tank mix of linuron and metolachlor (1 lb a.i./A each) was applied to lupin pre-emergence.

Nitrogen was broadcast at a rate of 110 lb/A to wheat in a three way split and applied to pearl millet at a rate of 80 lb/A, with 20 lb/A applied at planting and 60 lb/A applied 5 weeks later in banded applications. Phosphorus, K, and lime are applied according to soil test recommendations in the fall each year. Twenty-five lb-S/A was broadcast applied to wheat and lupin in the fall as $K{\cdot}Mg{\cdot}SO_4$.

Wheat grain yields were determined by harvesting a 7-ft wide area with a combine in the middle of each plot. Lupin grain yields were determined by combining the middle two rows from each plot. Grain yields for all crops were corrected to 13% moisture. In addition lupin dry matter (0 % moisture) for silage yield determinations was determined by harvesting 6 ft. of row from two rows in each plot.

Alternative Grain-Silage Production Systems Study

This cropping system-N management study is being conducted at three locations: Florida Panhandle (Quincy); southwest Alabama (Monroeville); and northeast Alabama (Crossville). The soil at Quincy is a Dothan sandy loam (fine-loamy, siliceous, thermic Plinthic Paleudult), the soil at Monroeville is a Lucedale sandy loam (fine-loamy, siliceous, thermic Rhodic Paleudult), and the soil at Crossville is a Hartsells sandy loam (fine-loamy, siliceous, thermic Typic Hapludult). The experimental design is a strip-plot of four replications. Vertical factors are six cropping systems: (1) wheat/soybean, (2) wheat/tropical corn, (3) wheat/pearl millet, (4) lupin/soybean, (5) lupin/tropical corn, and (6) lupin/pearl millet. Horizontal factors are nitrogen rates (0, 60, 120, or 180 lb-N/A) imposed on summer crops other than soybean, i.e., tropical corn and pearl millet. Varieties used were 'Coker 9835' wheat, 'Lunoble' white lupin, 'Pioneer Hybrid 3098' tropical corn, 'Georgia-Agra Tech HGM™100' pearl millet, and 'Brim' soybean. All wheat plots were fertilized with a split application of 30 lb-N/A at planting and 70 lb-N/A in late February just prior to jointing. Nitrogen was not applied to soybean or lupin.

For this paper, the effect of the first summer (1993) rotation crop and accompanying N rate, i.e., soybean (no N applied) and pearl millet and tropical corn (N rates from 0 to 180 lb-N/A) on grain and silage yield of wheat and lupin is reported.

Planting dates were normal production windows for each location. This is mid-November for wheat, mid-October to mid-November for lupin, and mid-June to early July for soybean, tropical corn, and pearl millet. All planting dates are dependent on harvest date of the previous crop in the double-cropping system.

Plot size is 24 ft by 25 ft at Quincy, 20 ft by 30 ft at Crossville, and 12 ft by 40 ft at Monroeville. Wheat is drilled and row spacing for other crops is 30-inches at Crossville and 36-inches at Quincy and Monroeville. At Crossville, summer crops and lupin are planted using strip-tillage as described above. At Monroeville and Quincy all crops are grown using conventional tillage (disk-chisel-disk-field cultivate) with in-row subsoiling. In addition to in-row subsoiling, lupin was planted on raised beds (rip and hip). Seeding rates, herbicides, and fertility management other than N were similar to that described in the Crop Rotation/Residue Management Study.

Wheat grain yields at all locations were determined by harvesting a 7-ft wide area with a combine in the middle of each plot. Lupin grain yield was determined by harvesting the middle two rows of each plot. Grain yields for all crops were corrected to 13% moisture. In addition lupin dry matter (0 % moisture) for silage yield determinations was determined by harvesting 6 ft. of row from two rows in each plot.

Lupin yield at Crossville could not be determined due to injury from metolachlor application. Only the influence of previous summer crop on wheat grain yield is presented for 1994 at this location.

RESULTS AND DISCUSSION

Crop Rotation/Residue Management Study

Neither tillage nor previous summer crop affected wheat grain yield which averaged 4633 lb/A (Table 1). There was a nonsignificant trend ($P \leq 0.15$) for wheat grown after summer fallow (4348 lb/A) to yield less than when grown after pearl millet (4703 lb/A) or soybean (4706 lb/A).

There was a significant tillage by summer crop interaction effect on both lupin silage and grain yield production (Table 1). Lupin silage production was greatest following summer fallow in the conventional tillage system (7168 lb/A dry matter) but under strip-tillage summer fallow resulted in the lowest lupin dry matter production (3366 lb/A). Pearl millet reduced total dry matter production of succeeding lupin 15% compared to soybean in the strip-till system but the greatest lupin grain yields (2657 lb/A) were obtained following pearl millet in the strip-till system. Some of the interaction effects could be attributed to severe stand losses in some strip-tilled plots following summer fallow. The losses were due to severe infestation by lupin brown spot (*Pleiochaeta setosa* Kirchn., Huges). Without a summer crop rotation, the residue from the previous year's lupin crop served as a source of inoculum for this disease when left on the soil surface. The tendency for pearl millet compared to soybean to reduce lupin silage yield but increase grain yield, especially under strip-tillage, may be due to reduced N mineralization from pearl millet residue compared to soybean residue. The variety of lupin used in these studies, 'Lunoble', has an indeterminate growth habit and a generally low harvest index. It may be that reduced N mineralization following pearl millet under strip-tillage reduced excessive vegetative

Table 1. Effect of previous summer crop and tillage system on lupin silage (dry matter) and grain yield and wheat grain yield in 1994 in central Alabama.

Previous Crop	Lupin Silage		Lupin Grain		Wheat Grain	
	Strip-Till	Conventional	Strip-till	Conventional	Strip-Till	Conventional
	lb/A					
Pearl Millet	5394	6329	2657	2285	4523	4882
Soybean	6301	6807	2251	2089	4674	4739
Fallow	3366	7168	1370	1949	4025	4671
$LSD_{0.05}$	1135		672		ns	

Table 2. Effect of previous summer crop and summer crop N rate on grain yield (lb/A) of wheat at three locations in 1994.

	Location											
	Quincy				Monroeville				Crossville			
	Summer Crop N Rate (lb/A)											
Previous Crop	0	60	120	180	0	60	120	180	0	60	120	180
Pearl Millet	3171	3498	3670	3912	4274	4334	4847	5008	3065	3082	3227	3069
Soybean[†]	4052	-	-	-	4964	-	-	-	3637	-	-	-
Tropical Corn	3644	3705	4413	4104	4204	4305	4453	4294	2497	2805	3190	3520
$LSD_{0.05}$	873				417				504			

[†]N not applied to soybean

Table 3. Effect of previous summer crop and summer crop N rate on lupin silage (lb/A dry matter) and grain yield (lb/A) at two locations in 1994.

	Location															
	Quincy								Monroeville							
	Grain				Silage				Grain				Silage			
	Summer Crop N Rate (lb/A)															
Previous Crop	0	60	120	180	0	60	120	180	0	60	120	180	0	60	120	180
Pearl Millet	781	630	653	694	2380	2380	2450	3010	1982	1960	2066	2116	5795	5616	6311	5659
Soybean[†]	775	-	-	-	2730	-	-	-	1961	-	-	-	5803		-	-
Tropical Corn	805	1234	837	1175	2520	3010	2590	2660	1959	1915	1996	1989	5532	5584	4716	5705
$LSD_{0.05}$	432				ns				ns				ns			

[†]N not applied to soybean

growth in lupin, reducing competition between vegetative and reproductive structures resulting in improved partitioning of photosynthates to seed vs. vegetative organs.

Alternative Grain-Silage Production Systems Study

At Quincy, wheat grain yield following soybean averaged 4052 lb/A (Table 2). There was a significant previous crop N rate by previous crop species interaction effect on wheat grain yield. There was a trend for wheat yields to increase with N rate applied to pearl millet.

At Monroeville and Crossville a similar interaction occurred (Table 2). Wheat yields at Monroeville were better than at the other locations. When wheat followed pearl millet a minimum of 120 lb-N/A applied to the millet was required for wheat to reach maximum yields at this location.

Wheat grain yields at Crossville were greatest following soybean. Previous crop N rate had no effect on wheat yields following pearl millet but yields increased with each increment of N applied to tropical corn. Unlike at Quincy and Monroeville, increasing N rate applied to millet and tropical corn could not compensate for the the rotational response of soybean grown previous to wheat at Crossville.

Lupin grain and silage yields were low at Quincy (Table 3). This was due to extremely wet conditions during late pod fill and harvest. Despite the low yields, previous crop species and N rate had an interactive effect on lupin grain yield. The effect was inconsistent and was due to increased yields with the 60 and 180 lb-N/A applied to tropical corn. There were no significant treatment effects on lupin silage production.

Neither lupin grain nor silage was harvested at Crossville due to herbicide damage to plots. At Monroeville, lupin grain and silage yields were more than double that at the Quincy location, despite also undergoing excessive rainfall which delayed harvest. There were no effects of either previous crop species or N rate applied to the previous crop on lupin grain and silage yields at Monroeville.

CONCLUSIONS

The flexibility in planting date for pearl millet lends itself well to double-cropping. First year data from the studies reported here suggest that management of pearl millet, including tillage system and N fertilizer requirement, may not only be expected to affect the millet crop but may also impact the subsequent crop in the double-cropping system. Our preliminary observation is that the shorter growing season for pearl millet compared to soybean or tropical corn will fit better in a rotation with white lupin than the other two summer crops. A conservation-tillage system for double-cropped pearl millet and white lupin looks promising but these observations must be evaluated in the long term.

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