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Management Systems for Southernpea Doublecropped with Wheat

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ABSTRACT

With the growing interest in vegetable production in the southeastern U.S., doublecropping southernpea [*Vigna unguiculata* (L.) Walp.] with wheat (*Triticum aestivum* L.) could be a practical alternative cropping system. Eight management systems were evaluated on Oaklimeter silt loam (coarse-silty, mixed, thermic, *Fluvaquentic Dystrochrepts*) from 1993 through 1995. Objectives were to determine the effects of tillage-straw management systems on (i) stand establishment, plant growth, and seed yield of southernpea, and (ii) plant component and total N content of southernpea. Plants emerged to satisfactory stands in all systems with no significant differences for plant population or plant height. Seed yield components (pods/plants, seeds/pod, and seed weight) were not affected by management systems. Removing or leaving the straw produced seed yields comparable to monocropped southernpea. Plant maturity as indicated by percent first pick was the same for burned straw, removed straw, and monocropped southernpea. Stem and total dry weights responded differently to management systems depending upon growing season (wet year vs. dry year). Removing the straw tended to decrease N content in the stem and pods but was not significantly different from monocropped southernpea.

INTRODUCTION

During the early 1970's, doublecropping soybean [*Glycine max* (L.) Merr.] with wheat became a popular practice. Advantages of this system included higher profits, less soil and water loss, and greater use of energy, soil, and water conserving tillage systems (Sanford, 1982). As interest in doublecropping grew, advances in equipment development and pesticide chemistry made doublecropping more efficient.

Straw management and weed control are essential in doublecropping. Straw can interfere with planting operations, reduce herbicide activity (Banks and Robinson, 1983), inhibit soybean growth and yield (Hairston et al., 1987), and increase the incidence of seedling diseases Cox et al., 1976). However, straw preserves soil moisture and reduces soil erosion. Soil

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moisture is critical in doublecropping since planting may occur during dry weather conditions, which may result in decreased yield. Lack of proper weed control may result in low yields (Hinkle, 1975; Thilsted and Murray, 1980). Weed competition may be reduced by burning straw which can kill emerged weeds and improve cultivation efficiency (Sanford et al., 1973). Sims and Guethle (1992) stated that for doublecropped soybean yields and weed control to be comparable to that of the weed-free check, both preemergence and postemergence herbicides were necessary.

Legume response to inorganic N has been variable. Ham et al. (1975) reported higher soybean yields with applied N while Johnson et al. (1975) reported little or no response to N. Increases in southernpea pod yield were dependent upon the quantity and source of N applied (Eaglesham et al., 1983). Skarphol et al. (1987) reported that dry matter (DM) yield of snap beans (*Phaseolus vulgaris* L.) was increased by 90 kg ha^{-1} but seed production was unaffected.

Southernpea is considered to be a drought tolerant crop. In northern Sudan, southernpea produced a seed crop when sorghum [*Sorghum bicolor* (L.) Moench.] and pearl millet [*Pennisetum glaucum* (L.) R. Br.] grain production failed (Turk et al., 1980). According to Ligon (1958) southernpea can withstand a wide range of climatic, cultural, and soil changes and produce a satisfactory yield. With the growing interest in vegetable production in the southern United States, information is needed regarding their response when doublecropped with a grain crop in a reduced tillage environment. This study was conducted to evaluate the effects of management systems on southernpea doublecropped with wheat.

MATERIALS AND METHODS

This study was conducted on Oaklimeter silt loam at the Jamie L. Whitten Plant Materials Center near Coffeeville, MS from 1993 to 1995. A 1-yr. cycle of doublecropped southernpea with wheat was completed before planting wheat during the fall of 1993. Experimental design was a randomized complete block with four replications. Data were pooled and subjected to analysis of variance (Steel and Torrie, 1960). Duncan's Multiple Range Test was used to separate means that were significantly different ($P<0.05$).

The seven doublecropping and one monocropping management systems evaluated in this study are described in Table 1. Plot size was 4.0 x 7.6m with row spacing of 20 and 102 cm for wheat and southernpea, respectively. Southernpea rows were perpendicular to wheat rows to reduce interference of the wheat stubble when planting southernpea.

'Pioneer 2655' wheat was drilled on 20 November 1993 and 23 November 1994 at 100-kg ha^{-1}. Seedbed was prepared by disking twice, chiseling once and harrowing. Paratill plots were plowed (30-cm depth) perpendicular to wheat rows after harrowing. Fertilizer was broadcast applied at 22-44-84 kg ha^{-1} for N, P, and K respectively, prior to planting wheat. Lime was applied at 1-Mg ha^{-1} on 8 November 1993. Broadleaf weeds were controlled by 2,4-D [(2,4-dichlorophenoxy) acetic acid] applied at 0.84 kg ha^{-1} during mid-March of 1994 and 1995. Wheat was fertilized with an additional 67 kg N ha^{-1} on approximately 25 February of each year. Wheat was combine harvested on 6 June both years, leaving a stubble height of 46 cm. Wheat straw thrashed by the combine was shredded and distributed evenly over the plot area.

Following wheat harvest, straw was either burned, removed (mowed to a 5 cm height and removed by hand), incorporated, or left standing. A no-till planter with a bubble coulter, double-disk openers, dual closing disks, and single press wheel was used to plant 'Mississippi Pinkeye' southernpea at a seeding rate of 13 seeds m^{-1} row. Seeds were inoculated with the proper strain of *Rhizobium* bacteria each year at planting.

Weed control for southernpea consisted of metolachlor [2-chloro-N-(2-ethl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide] and paraquat (1, 1'-dimethyl-4-4'-bibyridinium ion) plus surfactant (0.25% v/v) broadcast applied preemergence at 2.24 and 0.69

kg aim ha^{-1}, respectively, and bentazon [(3-isoproply- 1H)-2,1,3-benzothiadiazin-4(3H)-one 2, 2-dioxide] at 0.84 kg ha^{-1} postemergence. Herbicides were applied in 56.81 l water ha^{-1}. Monocropped, straw incorporated, and no-till + cultivated plots were plowed 10 days after plant emergence. Nitrogen, as ammonium nitrate, was broadcast applied at planting.

Table 1. Management practices and description of individual operations for seven double crop (wheat-southernpea) and one monocrop southernpea systems.

Management system	Seedbed preparation	Individual practice and operation description
Doublecrop:*		
Burn straw/no-till	none	burn straw, no-till plant, apply postemergence, herbicides, harvest
Incorporate straw	prepared	Disk three times, chisel plow twice harrow, plant, apply postemergence herbicides, cultivate, harvest
Leave straw/no-till	none	no-till plant, apply postemergence herbicides, harvest
No-till + cultivate	none	no-till plant, apply postemergence herbicides, cultivate, harvest
No-till + 30 kg N ha^{-1}	none	no-till plant, fertilize, apply Postemergence, herbicides, harvest
Fall paratill/no-till	none	no-till plant, apply postemergence herbicides, harvest
Remove straw/no-till	none	bale straw; no-till plant, apply postemergence herbicides, harvest
Monocrop:		
No straw	prepared	disk twice, chisel plow once, plant, cultivate, apply postemergence herbicides, harvest, disk twice

* Management for doublecrop plots consisted of broadcast applying P and K fertilizer for both wheat and southernpea, disking twice, chiseling once, and harrowing. Wheat was planted with a grain drill, in February and harvested June 6.

Southernpea stand counts were made 5 d after designated plots were cultivated by counting plants from a 1.5-m section in each of the middle two rows. Plant height (stem height) was determined at harvest by measuring ten randomly selected plants in the middle two rows. The second row of each plot was hand harvested three times each year; pods were then air dried and thrashed by hand. Seeds per pod were determined by counting the number of seed per 10 pods. Seed weight was determined by weighing 100 dry seeds from each harvest and averaging. Approximately 76 d after planting, 3.0 m of plants from the third row of each plot were hand harvested at the soil surface. To prevent any damage to these plants, all foot traffic was limited to between the first and second rows of each plot. These plants were separated into stem + petiole, peduncle, leaf, immature (bloom and green pod), mature pod, and seed components. Pods from these plants were used to calculate number of pods of each component to total plant mass, then ground in a Wiley mill to pass a 1 mm screen (Undersander et al., 1993). Nitrogen content was determined colormetrically, following a micro-Kjeldahl digest, by flow injection analysis using a Lachat Quick Chem AE autoanalyzer (Lachat Company, Milwaukee, WI).

RESULTS AND DISCUSSION

Southernpea growth: Plants emerged to good to excellent stands during this study. Soil moisture levels were adequate and plants emerged within 7 days after planting. Standing wheat straw did not interfere with planting; however, extra planter-weights were needed to plant the no-till plots. Straw being pushed into the drill by the bubble coulter was not a problem as compared with a fluted coulter reported by Sanford (1982). Yellowing of the leaves was not evident in any management system as reported for soybean by some researchers (Cochran et al., 1977; Elliot et al., 1978; Sanford, 1982).

No differences were found between management systems for plant population (Table 2). Soil crusting in the prepared seedbed plots hindered cotyledon emergence of some plants in 1994 but these soon recovered after rains loosened the soil surface. Sanford (1982) attributed a lower stand count for double-cropped soybean planted in a prepared seedbed to low soil moisture and no rainfall for 11 days after planting.

Management systems did not influence plant height (Table 2). Hairston et al. (1984) reported that inorganic N (28-kg ha^{-1}) increased doublecropped soybean height except when wheat straw was incorporated. Pods per plant is a major component in determining seed yield of southernpea; however, it is highly variable, greatly affected by physiological and morphological factors, and very responsive to the environment (Fernandez and Miller, 1985). Doublecropping southernpea with wheat did not influence pods per plant or seeds per pod (Table 2).

Table 2. Management system effects on plant population, plant height, pods per plant, and seeds per pod, 1994-1995.

Management System	Plant population	Plant height	Pods per plant	Seeds per pods
	(x 1000 ha^{-1})	(cm)		
Burn straw	36.3*	35	12	12
Incorporate	38	35	15	12
Leave straw	37.5	40	14	12
Cultivate	36.6	35	13	12
34 kg N ha^{-1}	37.1	35	18	12
Paratill	33.8	40	16	13
Remove straw	39	40	21	12
Monocropped	47.2	38	15	12

* Management within a column not followed by a common letter are significantly different as determined by DMRT ($P \leq 0.05$).

Research has suggested that biological N_2 fixation and remobilization are substantial sources of N for pod development (Atkins et al., 1978; Eaglesham et al., 1977; Neves et al., 1982). Data from this study indicates that N_2 fixation was adequate since 34 kg N ha^{-1} applied to southernpea did not affect seed weight (Table 3). Applying 56 kg N ha^{-1} to soybean at planting did not increase seed yield or seed weight (Reese and Buss, 1992).

Table 3. Management system effects on seed weight, seed yield, and percent first pick, 1994-1995.

Management system	Seed Weight	Seed Yield	Percent first pick
	(g/100)	(kg ha^{-1})	
Burn straw	15*	271c	30ab
Incorporate	15	332bc	26bc
Leave straw	15	402abc	22bc
Cultivate	15	298bc	20c
34kg N ha^{-1}	15	403abc	25bc
Paratill	15	339bc	20c
Remove straw	14	515a	36a
Monocropped	14	459ab	28abc

*Means within a column not followed by a common letter are significantly different as determined by DMRT ($P \leq 0.05$).

Southernpea yield: Weather conditions for the 1994 and 1995 growing seasons were completely opposite. In 1994, soil moisture levels were high from frequent rains in July and August; however, in 1995, almost no rainfall fell from mid-July to September. Average total seed yield for 1995 was less than half of the average yield for 1994.

Graminicides provided satisfactory control of annual grasses; however, morning glories (*Ipomoea* spp.) were the major weed problem. Presently, there are a limited number of postemergence broadleaf herbicides recommended for southerpea. Even though bentazon is labeled for broadleaf weed control in southernpea, it does not control most morning glory species.

Averaged over years, removing the straw produced a significantly higher yield (Table 3). The difference between burning the straw and physically removing the straw may not be related to soil moisture levels. In 1994, soil moisture at the 15-cm depth was monitored weekly using gypsum blocks. No significant differences occurred at any date between these two systems, which tended to have the lowest levels (data not shown).

Percent first pick, an indicator of plant maturity, was increased by removing the straw either physically or by burning (Table 3). Hall and Grantz (1981) showed that plants with early-maturing pods had a higher drought resistance. This is important to note since double-cropped southernpea will mature in August, a month with a low total rainfall amount.

Statistical analyses revealed significant year x management system interactions for stem and total DM weights and significant differences among management systems for leaf, peduncle, and seed weights (Table 4). Burning or incorporating straw tended to have opposite effects on stem weight during a wet year (1994) and a dry year (1995) while monocropped southernpea performed similarly both years. Nitrogen increased stem weight in 1995 as compared to 1994. Planting southernpea into standing stubble decreased leaf and peduncle weights as compared to the monocropped system. Burning or leaving the straw decreased seed weight as compared to incorporating the straw but was not significantly different from monocropped southernpea. In 1994, total DM yields were comparable for all management systems; however, during the dry weather of 1995 straw incorporation and N significantly increased total plant weight.

Southernpea N content: Awonaike et al. (1991) found that southernpea derived more N from the atmosphere and the soil than from fertilizer. Data from this study suggest that residual N level from N fertilizer applied to the wheat were adequate since 34 kg N ha^{-1} applied at planting did not significantly increase N content of any component (Table 5). Physically removing wheat straw did significant decrease N content in the stem and pod as compared to the burn straw system. Nitrogen in the leaves, which is distributed to the developing fruit in amounts five times that of peduncles (Peoples et al., 1983), was not influenced by management systems.

Wheat grain yields were 2.5 and 1.5-Mg ha^{-1} for 1994 and 1995, respectively. The low yield in 1995 was attributed to high rainfall amounts during the wheat growing season which decreased stand and increased denitrification. Straw yields were 1724 and 505 kg ha^{-1} for 1994 and 1995, respectively.

Southernpea yields ranged from about 3.4 Mg (green unshelled) ha^{-1} for the burn straw system to 7.15-Mg ha^{-1} for the remove straw system in 1994. In 1995, yields ranged from 1.6 Mg (burn straw) to 4.3-Mg ha^{-1} (paratill).

CONCLUSIONS

Results from this study indicate that southernpea can be successfully grown no-till when double-cropped with wheat. This offers producers an alternative cash crop during periods of low soybean prices; however, further observations are needed to evaluate economic risk and management system for which it is adaptable. Additional years of results would allow stronger conclusions about risk, and types of systems double cropping might follow.

Table 4. Management system effects on component and total plant dry weight of southernpea, 1994 – 1995.

System	Dry Weight						
	Stem	Leaf	Peduncle	Immature	Pod	Seed	Total
				lbs/acre			
				1994			
Burn straw	697abc*	664	252	130	174	406	2323bcd
Incorporate straw	488cde	594	298	124	234	717	2455bcd
Leave straw	311e	416	222	83	260	692	1984cd
Cultivate	352e	425	208	114	190	490	1779cd
30 lb N/acre	380de	425	261	117	246	668	2097cd
Paratill	299e	360	203	98	160	518	1638d
Remove Straw	366	359	279	74	280	912	2270bcd
Monocropped peas	660abc	538	250	114	256	461	2279bcd
				1995			
Burn straw	506cde	602	390	82	319	820	2719bc
Incorporate straw	820a	904	559	86	448	1331	4148a
Leave straw	499cde	624	357	60	295	580	2415bcd
Cultivate	427de	670	410	82	331	818	2738bc
30 lb N/acre	787ab	1034	642	142	465	1185	4255a
Paratill	585bcd	800	496	124	372	818	3195b
Remove Straw	501cde	630	439	64	364	804	2802bc
Monocropped peas	731ab	960	577	60	506	1420	4254a
				Average			
Burn straw	601	633abc	321cd	106	246	613b	2521
Incorporate straw	654	749a	428ab	105	341	1024a	3303
Leave straw	405	520bc	289d	71	277	636b	2200
Cultivate	389	547abc	309d	98	260	653b	2259
30 lb N/acre	483	730ab	454a	129	356	926ab	3176
Paratill	442	579abc	349bcd	111	266	668b	2417
Remove Straw	433	494c	359abc	69	322	857ab	2536
Monocropped peas	696	749a	413abd	87	381	940ab	3267

*Means (year or average) within a column not followed by a common letter are significantly different as determined by DMRT (P≤0.05).

Table 5. Management system effects on component and total plant N content of southernpea, 1994-1995.

System	N Content						
	Stem	Leaf	Peduncle	Immature	Pod	Seed	Total
				Percent			
Burn straw	1.18ab*	2.92	1.31	4.00	1.19a	4.05	14.65
Incorporate straw	1.08abc	3.07	1.33	3.91	1.00abc	3.92	14.31
Leave straw	1.10abc	2.85	1.24	3.91	1.16ab	3.99	14.25
Cultivate	1.20a	3.11	1.29	3.84	1.14ab	3.79	14.37
34 kg ha^{-1}	0.97bc	3.11	1.16	3.74	1.11ab	3.95	14.04
Paratill	1.06abc	3.02	1.20	3.82	1.12ab	4.02	14.24
Remove straw	0.92c	2.69	1.09	3.66	0.90c	3.94	13.20
Monocropped Peas	1.11abc	2.86	1.30	3.88	0.97bc	4.00	14.12

*Means within a column not followed by a common letter are significantly different as determined by DMRT (P<≤0.05).

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NOTES