Alternative Intensive Cropping with Corn

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ABSTRACT

Corn *(Zea mays* L.) was continuously cropped in seven systems, with or without irrigation. Baseline irrigated corn yields of 200-210 bu/acre were reduced 65-75 bu/acre by not utilizing standard rotational practices. The best continuous corn yields were from systems with disking in some phase of the operation. The only follow-crop to consistently approach an economically attractive level was sunflower *(Helianthus annuus* L.), but continuous corn yields remained depressed in this system. Corn yields benefitted from soybean *(Glycine max* L.) as a follow-crop, but soybean itself yielded well only 1 of 4 years. In the absence of a follow-crop, delaying disking until immediately before spring corn planting yielded as well as any other treatment compared.

INTRODUCTION

Corn is consistently an economically attractive crop in the Southeastern Coastal Plains; however, continuous corn has been avoided. Research from various physiographic areas has shown that yields can decline over time without rotation. Varieties and chemicals have increased the flexibility of cropping systems. The effects of double cropping with alternative post-corn species in a single cropping year have not been explored in the southeast. The Southeastern Coastal Plain has an average frost free growing season approaching 300 days in much of the region (US Dept. of Commerce, 1968). This might allow the use of various species of alternative post-corn crops for potential enhanced annual return, for nitrogen production or as conservation crops to hold soil and prevent leaching of chemicals and fertilizer.

It was hypothesized that with appropriate pest and weed control, several intensive alternative systems might sustain year-to-year corn yields compared to conventional cropping systems. To test this hypothesis, a multi-year study was established in Florence, SC, to compare conventional continuous corn with reduced tillage and multi-cropped management systems.

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METHODS AND MATERIALS

In the spring of 1982 a field of Norfolk loamy sand (fine, loamy, siliceous, thermic, Typic Paleudult) near Florence, SC, was cropped to field corn. The hybrid Pioneer 3572[2] was planted in 1982 and 1983, and the hybrid Pioneer 3950 was planted in 1984 and 1985. Field preparation in 1982 included multiple diskings of the previous soybean crop stubble and broadcast incorporation of lime (1000 lb/acre to maintain pH near 6.5), fertilizer (180 lb/acre N, 15 lb/acre P and 30 lb/acre K) and herbicide (alachlor and atrazine). Fertilizer and lime applications in following years were similar and were adjusted according to soil test. Corn was in-row subsoil planted at approximately 40,000 viable seeds/acre using a Brown-Harden Super Seeder on 30-in. row centers, which subsoiled 0.45 m deep in line with and ahead of the trailing John Deere 71 flex planters in a single integrated operation. Pests were controlled with terbufos or carbofuran banded above the row at planting and lightly incorporated. No-till corn planting used the same implement and chemical regime as the conventional plots. Plots were 6 rows wide by 100 ft long, and cropping main-plots were split into 50-ft halves for application or absence of irrigation. Irrigation was by inverted drip-lines between rows, operated under 12 lb/in.^{2} pressure to provide uniform "sprinkling" in each plot. Corn was irrigated when tensiometers read >0.4 bar tension at 1-ft soil depth. After the 1982 corn harvest, seven treatments were imposed. The experiment used a randomized split plot design with 4 replications. Treatment and interaction means were also compared using years as a further factorial. Hybrid changes contributed to variance among years. The treatments imposed after initial corn crop establishment were as follows:

1. Multiple winter disking following corn harvest followed by conventional corn planting in spring.

[2]Mention of trademark, proprietary product or vendor does not constitute a guarantee of warranty of the product by the US Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

2. Inter-seeding at black-layer initiation with soybean (cv Cobb), controlling weeds in soybean with acifluorfen or sethoxydim and winter weeds with paraquat or glyphosate. No-till corn production in spring.
3. Stover left standing, winter weeds controlled with paraquat or glyphosate, disked immediately before planting in spring.
4. Stover left standing, winter weeds controlled with paraquat, no-till planting in spring.
5. Inter-seeding with 17 lb/acre crimson clover (*Trifolium incarnatum* L. cv Tibee) at black layer initiation, killing clover with paraquat immediately following no-till corn planting in spring.
6. Drilling 90 lb/acre soybean (cv Cobb) into corn stover after corn harvest, controlling weeds in soybean with glyphosate, alachlor and metribuzin. Winter weeds in soybean/corn stover were controlled with glyphosate or paraquat. Corn was no-till planted in spring.
7. After corn harvest, the land was disked once, and PPI chloramben was used to control weeds in sunflowers. Planting was as for corn. Sunflower hybrid availability differed among years. Two hybrids were used in a split-split plot in 1982,1983 and 1984 (DO-844 and MCF610, DO-844 and Sheyenne 24906, DO-855 and Sheyenne 24906, respectively). Only one hybrid, IS-7000, was used in 1985. Since hybrid effects were seldom statistically significant (P> 5%), they were averaged for comparison of years, thereby contributing their variance to the year effect. Winter weeds were controlled with paraquat or glyphosate, followed with no-till corn production in spring.

All pesticides and herbicides were applied at label rates; broadleaf weeds were controlled in corn as needed with 2,4-D. Inter-seeding in treatment 2 was by hand-operated Planet Jr. Inter-seeding in treatment 5 was hand broadcast (1982-1984) or drilled (1985). Treatments 5 and 6 used a grain drill with disk openers on 13-in. centers. All corn and sunflower were planted to 40,000 seeds/acre and thinned to 35,000 irrigated and 20,000 non-irrigated plants/acre 7-10 days after full emergence. Planting dates are presented in Table 1.

RESULTS AND DISCUSSION

Corn in 1982 was all conventionally planted. The 1982 corn had no antecedent cropping system treatments. Instead the study had high and low populations of 20,000 or 35,000 plants/acre, with four irrigation regimes related to corn growth stage. Rainfall and irrigation regimes are described in Tables 2 and 3. Mean non-irrigated corn yield at the low population was 161.2 bu/acre, and mean irrigated yield at the high population was 201.9 bu/acre. The highest treatment yield was 209.4 bu/acre for irrigation of a high population from tasselling until harvest only. The preceding crop had been soybean. Therefore, these yields represent a reasonable baseline for corn grown conventionally in a standard corn/soybean rotation at the populations used in the subsequent treatments and were similar to previous findings (Karlen and Sojka, 1985).

Table 1. Planting dates (mo/day).

Year	Corn	#2	x5	#6	x7
1982	3/23	7/27	10/1	8/6	8/10
1983	3/16	7/20	9/16	8/3	8/18
1984	4/2	7/19	9/18	8/16	8/17
1985	4/1	7/16	9/17	8/14	8/14

In 1983 there was a substantial decline in baseline corn yields (Tables 4 and 5). This reduction was 65-75 bu/acre for irrigated conventional corn and approximately 50 bu/acre for non-irrigated conventional corn. Mean annual yields from 1983-1985 were 129.5, 125.3 and 127.7 for irrigated plots and 107.6, 102.9 and 100.9 for non-irrigated plots, respectively. Furthermore, the yield advantage of irrigation was reduced from about 40 bu/acre to about 20 bu/acre. This sharp yield decline prompted changing hybrids in 1984 to one more suited to intensive cropping. No further decline in baseline yields occurred after 1983.

In both irrigated and non-irrigated treatments, corn yields were generally favored by disking at some point in the system (treatments 1, 3 and 7). This is consistent with other reports of a 10% yield reduction with no-till in the Coastal Plains (Karlen and Sojka, 1985; Sojka and Busscher, 1989). Even though soybean yielded poorly between corn crops (treatments 2 and 6), corn yields appeared to benefit somewhat. Corn yields were usually lowest with crimson clover between corn crops. This was probably a result of soil water depletion in spring, which has been reported before (Campbell et al., 1984). Irrigation did not maintain yields in treatment 5 because system installation could not be completed each vear until well after stand establishment.

Yield of soybean after corn was good only in 1985, particularly for treatment 6 (drilled). The month of August in 1985 had the highest rainfall during the course of the study. This aided soybean

Table 2. Rainfall by month of year (mm).

Year	Jan	Feb	Mar	Apr	Mav'	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1982	117	119	29	104	87	151	141	61	71	92	35	135	95
1983	109	169	236	42	60	66	97	59	85	74	91	164	104
1984	70	102	140	90	146	28	343	61	20	30	8	37	90
1985	119	107	26	22	54	148	194	128	101	29	170	17	93
Mean	104	124	108	65	87	98	194	77	69	56	76	88	96

[1]In 1984 includes 13 mm irrigation to all plots (including "non-irrigated").

Table 3. Irrigation plus rainfall by month of year (mm).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1982	117	119	29	104	87	208	166	61	105	92	35	135	105
1983	109	169	236	42	60	116	135	04	124	74	91	164	117
1984	70	102	140	90	177	110	343	86	70	30	8	37	105
1985	119	107	26	72	98	148	194	128	139	29	170	17	104
Mean	104	124	108	77	106	146	210	90	110	56	76	88	108

Table 4. Crop Yields[1].

		Corn (bu/acre)				Soybean (bu/acre) or sunflower (lb/acre)				
	Treatment	1983	1984	1985	**Mean**	1982	1983	1984	1985	**Mean**
Irrigated	1	137.9	132.7	131.8	134.1					
	2	128.6	130.9	135.8	131.8	4.0	8.5	6.8	14.3	8.4
	3	139.6	134.0	121.2	131.6					
	4	119.5	132.2	108.5	120.1					
	5	105.7	102.0	118.7	108.8					
	6	143.4	128.4	136.3	136.0	9.5	6.3	6.7	25.0	11.9
	7	131.7	116.6	141.3	129.9	1065	312	898	728	751
	5% LSD	16.9	17.2	23.4	12.8	7.22	4.9	7.0	2.2	3.3
Non-irrigated	1	110.6	110.3	113.3	111.4					
	2	109.4	111.7	108.6	109.9	6.7	12.7	4.2	11.8	8.9
	3	114.1	112.0	100.0	108.7					
	4	102.7	101.2	98.1	100.7					
	5	107.5	90.7	79.9	92.7					
	6	100.9	101.3	104.8	102.4	6.2	5.4	3.4	19.9	8.7
	7	108.1	93.1	101.5	100.9	1022	226	1052	1052	838
	5% LSD	14.4	12.9	13.5	8.2	2.8	8.5	2.2	7.1	3.0

[1]Corn, soybean and sunflower are at 15.5, 13.0 and 9.0% moisture, respectively.
[2]For follow-crops, 5% LSD could be calculated only to compare soybean treatments (treatments 2 and 6)

stand establishment. Inter-seeded soybean (treatment 2) consistently suffered mechanical damage during corn harvest and also possibly atrazine damage in some years. The intensity of harvest activity in August made it difficult to insure timely cultural practices and irrigation for treatments 2 and 6. The most promising follow-crop yields were from sunflower, which are known to yield well after corn in the Coastal Plains if planted by mid-August (Sojka et al., 1989). The lowest sunflower yields occurred in 1983 as a result of poor stand establishment, possibly due to poor seed viability (low germination percentage). Given the numbers of additional operations, the additional cost of herbicides and the generally poor corn and follow-crop yields, it is apparent that these cropping systems cannot substitute for rotation of the main crop. Yields of sunflower (treatment 7) were the most consistently promising, but only in association with reduced corn yields. If the rationale for adopting an intensive

Table 5. Analysis of variance (P>F.

Crop	Variance source	1982	1983	1984	1985	Mean
Corn	Treatment	---	2.60	0.03	1.33	0.01
	Irrigation	---	0.01	0.01	0.01	0.01
	Treatment x irrigation	---	0.50	N.S.[1]	N.S.[2]	N.S.
Soybean	Treatment	7.69	5.91	N.S.	0.54	6.89
	Irrigation	N.S.	N.S.	5.13	4.97	9.54
	Treatment x irrigation	4.61	N.S.[2]	N.S.	N.S.	3.87
Sunflower	Hybrid	N.S.	N.S.	1.70	---	N.S.
	Irrigation	N.S.	N.S.	N.S.	2.27	N.S.
	Hybrid x irrigation	N.S.	N.S.	N.S.	---	N.S.

[1]Comparisons were considered non-significant at $P > 10\%$.
[2]$P < 15\%$ and $> 10\%$ = trends.

cropping system is to provide ground cover against soil erosion, the yields from treatment 2 suggest that delaying primary tillage until immediately before planting in spring does not significantly reduce corn yield.

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