DOUBLE CROPPING SOYBEANS SUCCEEDING SOYBEANS IN FLORIDA

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INTRODUCTION

Growing two crops during the warm season is possible in much of Florida where soil temperature is adequate and the frost-free period exceeds 240 days. Soybean (Glycine max L. Merr,), because of its photoperiodic sensitivity, is usually planted as the second crop, either after a cool season cereal or after a warm season crop such as vegetables, melons, or early maturing corn (Zea mays L.) in Florida (Guilarte et al., 1975; Prine et al., 1978; Gallaher et al., 1979). However, experiments in Florida by Boote (1977, 1980) demonstrated that early maturing soybean cultivars can be planted in March for maturity in late June, with sufficient time to plant a second warm season crop, such as adapted late-maturing soybeans (Guilarte et al., 1975; Prine et al., 1978; Akhanda et al., 1976).

In order to produce two soybean crops per year, the first crop must be planted early to a cultivar from early maturity groups (less than group V) so the crop will progress rapidly into seed growth and mature by late June (Boote 1977, 1980). The optimum Maturity Group (MG) for the first crop was Group III, although Groups II and IV were acceptable. When planted in March, cultivars of MG V through VIII were induced to flower by the initially short days, but the accelerating daylengths delayed subsequent reproductive development and delayed maturity until September-October (Boote, 1977, 1980). Thus planting a second soybean crop was not feasible after MG V, VI, VII, VIII and later cultivars. Long photoperiods after flowering have been shown to prolong post-flowering development and reduce partitioning of dry matter to seeds (Johnson et al., 1960; Lawn and Byth, 1973; Raper and Thomas, 1978; Thomas and Raper, 1976). Hartwig (1954) observed flowering at 49 and 41 days after emergence for MG VI and VII cultivars planted April 10 at Stoneville, MS (latitude 33^0 20' N), but reported that the plants aborted nearly all early flowers and matured in October.

In addition to cultivar selection, March-planted early maturing soybeans may encounter several other problems including the hazard of late frosts and cool soil temperature which causes slow emergence and reduced early growth (Hartwig, 1954). When planted in lower latitudes including Florida, early maturity groups flower early, are short, and set their pods lower (Whigham and Minor, 1978; Boote, 1977). Incomplete canopy cover can be overcome by planting in narrow rows, but low pod set remains a more challenging problem.

This paper addresses the feasibility of double cropping soybeans succeeding soybean. Specific objectives were to evaluate soybean cultivars in a range of Maturity Groups for yield, reproductive development, and suitability as the first crop in double cropping systems or as the second crop in double

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cropping systems in Florida, and to evaluate row spacing, planting methods, and other cultural practices needed to grow two soybean crops per year in Florida.

MATERIALS AND METHODS

First Crops: Soybeans were grown during the spring seasons (1976–1979) at the University of Florida Agronomy Farm, Gainesville, FL (Latitude 29° 40' N). The soybean cultivars and planting dates are listed in the Tables. The soil type in the experimental areas was Kendrick sand, a loamy, siliceous, hyperthermic Arenic Paleudult in 1976, 1978, and 1979; and a Eainesville sand, a hyperthermic, coated Typic Quartzipsamment in 1979. Soil pH was at recommended levels or corrected by preplant dolomite addition. Fertilizer (40 kg N, 35 kg P, and 133 kg K) was incorporated before planting the first crop. The fields were plowed and disked prior to planting. Agricultural chemicals are given as active ingredients per hectare. Nematode control was furnished in 1976 and 1977 by injecting 26 kg/ha of 1,2-dibromo-1-3-chloropropane. In 1978, fenamiphos (ethyl–3–methyl-4-(methylthio)phenyl (1-methylethy1)phosphoramidate) was disked in at 7.5 kg/ha. No nematocide was used in 1979. Weeds were controlled with pre-emergence herbicides: in 1976, 2.2 kg/ha alachlor (2-chloro-2', 6'-diethyl-N-(methoxymethy1) acetanilide) and 2.5 kg/ha dinoseb (2-sec-butyl-4,6-dinitrophenol, in 1977, 1.3 kg/ha benefin (N–butyl–N–ethyl-*a*, a,a-trifluoro-2,6-dinitro-p-toluidine), 2.6 kg/ha vernolate (S–propyl dipropyl thiocarbamate), 2.2 kg/ha alachlor, and 2.8 kg/ha dinoseb; in 1978, 1.3 kg/ha benefin; in 1979, 1.3 kg/ha benefin, 2.2 kg/ha alachlor, 2.2 kg/ha naptalam (N–1–naphthylphthalamic acid), and 1.1 kg/ha dinoseb. Moderate herbicide injury, probably from vernolate, was observed in 1977. Foliar feeding insects were not a problem; however, 0.5 kg/ha of methomyl (S–methyl–N–((methylcarbamoy1)oxy)thioacetimidate) was applied 25 May 1976 for an infestation of southern green stinkbug (Nezara viridula L.). Plots were irrigated to supplement rainfall during the season.

The experimental design was a randomized complete block. Replications numbered three, six, four, and four in 1976 through 1979, respectively. Seeds were planted in 31–cm rows in 1976 and 1977, 25–cm rows In 1978, and 35–cm rows in 1979. Seeding density ranged from 56 to 64 seeds/m^2 . Each plot consisted of five or six rows 5 m long of which the center three or four rows were harvested for yield.

Reproductive development of cultivars was observed as days from emergence to R1 (50% of plants having one flower), R4 (50% having a 2.0 cm long pod anywhere on the plant), R5 (50% having detectable bean swelling in any pod), and R8 (95% of the pods at mature color). The reproductive stages differ slightly from those of Fehr et al (1971) and Fehr and Caviness (1977) in that R3, R4, and R5 stages pertain to pods at any node on the plant rather than at the top four nodes having fully-expanded leaves.

The soybeans were hand-harvested a few days after reaching R8 maturity, warm air-dried, and threshed. Yield of clean seed per plot was based on harvested areas (bordered middle rows) of 4.46 m^2 in 1976 and 1977, 4.34 m^2 in 1978,

and 5.12 m^2 in 1979. Average height to tip of main stem was measured at maturity. Seed quality was rated on a scale of 1 (very good) to 5 (very poor). Weight per 100 seeds was determined. To estimate combine harvestability, at least 50 cm of bordered row was cut into two segments; soil line to 8 cm, and above 8 cm. Individual segments were threshed separately and percent seed weight below 8 cm height was determined. All data on reproductive development and yield characteristics were subjected to analysis of variance. Cultivar means were compared by the new Duncan's Multiple Range test. The error term was the cultivar by replication mean square.

Second Crop: The second crop 'Cobb' soybeans were planted 30 June 1977, 29 June 1978, and 27 June 1979 in 92, 46, and 35-cm rows,respectively. Tillage prior to the second crop consisted of disking in 1977, plowing and disking in 1976, and no-tillage in 1979. No nematocide or additional fertilizer was applied. Alachlor, at 2.2 kg/ha was used all three years for weed control with addition of 2.2 kg/ha of glyphosate (N(phosphonemethy1)glycine) on no-tillage plots in 1979. Cultivation was done in 1977 and 1978. The second crops were irrigated in 1978 and 1979. Insecticides were needed in 1978 and 1979. Four yield replicates were harvested each year from bordered rows similar in area to the first crop. Yield and maturity characteristics were handled similarly to the first crop. To convert kg/ha to lb/ac, multiply by 0.892. Divide lb/ac by 60 to obtain bu/ac.

RESULTS AND DISCUSSION

Cultivars with Suitable Reproductive Development for First Crop: Maturity data from 1976 and 1979 (Table 1) shows cultivars from a range of Maturity Groups (MG). Maturity data from 1977 and 1978 were intermediate to those in 1976 and 1979. Reproductive development and maturity was prolonged in 1976, partially due to season and partially due to southern green stinkbug damage. In 1979, the only year nematocide was not applied, nematode injury may have hastened reproductive development and senescence, especially for the first three cultivars listed.

Cultivars in MG 00 through I including 'Corsoy' (MG 11) flowered early (29 days after emergence) and did not differ significantly in days from emergence to R1, R4, and R5. However, they differed up to 6 days in time to maturity. Maturity Group II, III, and IV cultivars flowered 1 to 2 days later; thereafter, each respective MG was progressively somewhat slower in reaching each successive reproductive stage. The largest difference among MG 00 to IV cultivars occurred in days from RS (bean swell) to R8 (95% pod maturity). The slightly slower reproductive development of MG II, III, and IV cultivars contributed to taller plants with 1 to 2 more nodes, but the significantly longer pod fill period (R5 to R8) gave these cultivars a considerable yield advantage over MG 00, 0, and I (Table 2).

The MG V, VI, and VII cultivars were delayed in flowering and slower in reproductive development than MG IV and earlier cultivars. They flowered at least 10 days later than MG IV cultivars. The substantial shift in reproductive behavior from MG IV to MG V is noteworthy. Reproductive

behavior of 'Essex', typical of MG V, was more comparable to that of MG VI and VII than to that of MG IV. 'Hill' does not exhibit flowering behavior typical of MG V (K. Hinson, personal communication). Cultivars later than MG IV required 3 to 20 more days from R1 to R4 than did earlier MG's. Most of this delay was lag time before any active pod elongation. Subsequent reproductive development (R5 to R8) was also prolonged for MG V to VII cultivars. Essex and Hill set a reasonable pod load, but later cultivars such as 'Bragg' (MG VII) remained green and set pods at a very slow rate and did not mature until the normal time in October. Essex and Hill had 80 to 90% mature pods by 25 July and 31 July, respectively, but the remainder of the pods stayed green, and the plants retained one-third of their green leaf area at that time.

Table 1. Reproductive development of soybean cultivars planted in March of 1976 and 1979 at Gainesville, FL.

Cultivar	Maturity Group	Nodes at Maturity	Reproductive Development Stage			
			R1	R4	R5	R8
			--------days after emergence--------			
— — — — — — — — — — March 1976† — — — — — — — — — —						
Fiskeby V	000		30ef*	38f	45f	77f
Altona	00		29f	38f	46ef	81e
Portage	00		29f	38f	46ef	82e
Clay	0		29f	38f	46ef	82e
Evans	0		30ef	38f	47ef	86d
Hodgson	I		29f	38f	47def	87d
Steele	I		30ef	39f	47def	85d
Corsoy	II		29f	39f	47def	93c
Amsoy 71	II		31d	41e	48cde	94c
Williams	III		32cd	42d	49cd	99b
Calland	III		31de	42d	49c	109a
Cutler 71	IV		33c	44c	52b	109a
Bonus	IV		33c	44c	50bc	108a
Hood	VI		52a	71a	76a	-
Bragg	VII		45b	68b	75a	-
— — — — — — — — — — 15 March 1979— — — — — — — — — —						
Maple Arrow	00	6.4e*	28e	37g	40f	76h
Amsoy 71	II	8.1d	29de	39fg	43e	79g
Woodworth	III	8.6d	29de	39fg	42e	82f
Williams	III	9.7c	30cd	40ef	43de	88e
Union	IV	10.Ibc	31cd	41cd	46c	90d
Franklin	IV	9.8c	30cd	41de	44d	89de
Cutler 71	V	10.9a	32c	42c	46c	93c
Essex	V	10.7ab	42b	56b	61b	124b
Hill	V	11.3a	52a	64a	69a	131a

* Means in a column within a given year not followed by the same letter are significantly different at the 0.05 level according to Duncans New Multiple Range test.

† Results for 1976 averaged over three planting dates: 8, 18, and 29 March, and three replications per planting date.

The cause for this abnormal reproductive behavior is the sensitivity of each particular genotype to photoperiod. The later the MG of a cultivar, the shorter days it requires to successfully complete reproductive development. When planted in March, the days were short enough to induce flowering and pod set of these later cultivars. But the subsequently lengthening days of May, June and July affected reproductive development even though flowering had been initiated. The later the MG, the more sensitive it is to the effect of a given lengthening photoperiod on reproductive development (Major et al., 1975). This means that only certain combinations of cultivars and planting dates will fit for an early soybean crop at a given temperature-and-increasing-daylength location. For Gainesville, MG V and later cultivars planted in March were adversely affected by daylength and matured too late to allow a second crop. In fact, they produced less and poorer quality seed than if planted at recommended dates (May-June). MG II, III, and IV cultivars were early enough to allow a second crop.

Yield Characteristics of First Crop Soybean Cultivars: Good yield levels were achieved in all four years under conditions of narrow rows, irrigation, and good weed control. A comparison of yield characteristics to maturity group indicates MG 000 to I cultivars were uniformly early, short and low yielding, with low pod set (Table 2). Their low yield potential can be attributed to a short filling period (days from R5 to R8). Successively later maturity groups were later maturing, taller, had poorer quality seed, and set fewer seeds below 8 cm. Potentially economical yield levels were generally achieved with MG III and IV cultivars which matured between June 20 and 30 at Gainesville if planted March 14. 'Amsoy 71' of MG II also yielded well, except in 1979 when no nematocide was used. 'Williams' (MG III) was probably the most consistently good performer over the years. This agrees with Williams' unusually good adaptation in INTSOY's tropical-subtropical trials in spite of being in MG III (Whigham, 1975; Whigham and Minor, 1978). Certain other MG III and IV cultivars: 'Woodworth', 'Bonus', and 'Franklin' yielded significantly less than Williams. 'Union', being of Williams parentage, appeared similar to Williams. While 'Calland' (MG III) and 'Cutler 71' (MG IV) were tall and yielded well, they had some negative attributes: poorer seed quality, later maturity, and a tendency to maintain green stems and a few green leaves at maturity, possibly in response to lengthening days. This "staygreen" trait was even more pronounced on MG V cultivars which "matured" with poor quality seed in late July, but retained about one-third green leaves and about 10-20% green pods. While the plant and pod height of MG IV cultivars is desirable, their poorer seed quality and later maturity conflict with prompt early harvest in the warm humid rainy season in Florida which arrives in late June. Delayed maturity and harvest delays planting and reduces the growth period of the second soybean crop.

Second crop soybeans and total seed yield from two crops. Second crop 'Cobb' soybeans were planted June 30, June 29, and June 27 after harvesting early soybean crops in 1977, 1978, and 1979, respectively. First crop 'Williams' yield, second crop 'Cobb' yield, and combined yield of two crops is shown in Table 3. The yield potential of the second crop in 1977 was limited by incomplete canopy cover in 92 cm rows and growth under rainfed conditions. The

Table 2. Yield characteristics of soybean cultivars planted in March of 1976, 1977, 1978, and 1979 at Gainesville, FL.

Cultivar	Maturity Group	Maturity Datet	Height at Harvest	Seed Yield	Yield below 8 cm	Seed Qualitytt
			cm	kg/ha	%	1-5
			—March 1976†—			
Fiskeby V	000	6-5f"	33g	1890d	24a	1.6e
Altona	00	6-9e	53e	2600b	12def	1.8de
Portage	00	6-10e	51e	2610b	9efg	2.0cd
Clay	0	6-10e	45f	2150c	17abcd	1.7de
Evans	0	6-14d	47f	2590b	12cdef	1.8de
Hodgson	I	6-15d	47f	2330c	14bcde	2.0cd
Steele	I	6-13d	48f	2660b	17abcd	1.7de
Corsoy	II	6-21c	52e	2910a	18ab	2.3bc
Amsoy 71	II	6-22c	59d	3110a	11def	2.4bc
Williams	III	6-27b	66c	3000a	10efg	2.4b
Calland	III	7-7a	75b	3010a	7fg	3.4a
Cutler 71	IV	7-7a	83a	2920a	5g	3.4a
Bonus	IV	7-6a	78b	2650b	9efg	3.2a
			—14 March 1977—			
M65-217	00	6-8e	36d	2130bcd	22abc	1.3f
Altona	00	6-3f	39d	1940cd	20bc	1.5def
Portage	00	6-4f	37d	1800d	12c	1.8bc
Maple Arrow	00	6-9d	40d	1990cd	21bc	1.4ef
Evans	0	6-9d	36d	2280bc	28ab	1.8bcd
Corsoy	II	6-14c	45c	2390b	31a	2.0ab
Amsoy 71	II	6-16b	55b	2990a	19bc	2.2a
Williams	III	6-20a	60a	3200a	17c	1.7cde
			—14 March 1978—			
M65-217	00	6-12c	41c	1800b	27b	1.9b
Prize	II	6-12c	36c	1540b	41a	2.4a
Amsoy 71	II	6-19b	52b	2630a	22bc	2.0b
Williams	III	6-22a	54b	2760a	12c	2.0b
Franklin	IV	6-24a	60a	2320a	13c	2.2ab
			—15 March 1979—			
Maple Arrow	00	6-7h	28h	1580d	12a	1.4f
Amsoy 71	II	6-10g	40g	1830d	10ab	1.7def
Woodworth	III	6-13g	45f	1980cd	9abc	1.6ef
Williams	III	6-19e	51e	2800b	4cd	1.7def
Union	IV	6-21d	55d	2900ab	6bcd	2.0de
Franklin	IV	6-20de	60c	2370c	1d	2.0d
Cutler 71	IV	6-24c	65b	2840ab	1d	2.7c
Essex	V	7-25b	55d	3280a	#	3.2b
Hill	V	8-1a	72a	1880d	#	4.3a

* Means in a column within a given year not followed by the same letter are significantly different at the 0.05 level.

t Results for 1976 averaged over three planting dates: 8, 18, and 29 March. Maturity dates for 1976 adjusted to a hypothetical 14 March planting date to allow comparison to the other three years.

†† 1 = Very Good; 5 = Very Poor.

\# Not measured, but was less than 3%.

yield potential of both the first and second crop in 1978 were limited by insufficient irrigation frequency in a dry season coupled with a sting nematode infestation in one-third of the cxperimcnt. In 1979 the two crops received nearly optimum irrigation and rainfall frequency, hut received no nematocide. The excellent weather is reflected in the high yields for 1979. The 1979 yields were 2800 kg/ha (42 bu/ac) plus 3410 kg/ha (51 bu/ac) for a total of 6210 kg/ha (93 bu/ac) per season. Even under the adverse conditions of 1978, total yield was 4400 kg/ha (65 bu/ac), a yield more than twice the state average. The second crop responded well to narrow row spacing with a 30% increase in 1978 from 46 versus 92 cm rows and a 9% increase in 1979 from 35 versus 105 cm rows. The cultivar Bragg yielded as well as Cobb in the two years it was planted.

Table 3. 'Total yield of 'Cobb' soybeans succeding 'Williams' soybeans during 1977, 1978, and 1979 at Gainesville, FL.

Year	Crop	Cultivar	Row Spacing	Planting Date	Maturity Date	Seed Yield	Total Yield
			cm			kg/ha	kg/ha
1977	First	Williams	31	3/14	6/20	3200	
	Second	Cobb	92	6/30	10/30	2070	5270
1978	First	Williams	25	3/14	6/22	2760	
	Second	Cobb	46	6/29	10/29	1640	4400
1979	First	Williams	35	3/15	6/18	2800	
	Second	Cobb	35	6/27	11/1	3410	6210

Tillage conditions differed for the second crops in each year. Disking in 1977 was not satisfactory, because it provided a good seed depth in which first crop soybeans volunteered in the second crop. This was not desirable, because volunteers from first crop seed were short, matured early, and had poor seed quality by the time the full season crop was mature. In other words, first crop volunteer soybeans acted like 'weeds'. Morever, the low pod set of the first crop is likely to result in sufficient cutter bar loss to give a volunteer soybean problem. After the 1978 early crop, the field was plowed with a moldboard plow to bury the seed lost during harvest. This worked, but the second crop was planted in dry soil and irrigated too heavily. Emergence and stand was reduced by soil compaction and weed pressure increased. In 1979, the second crop was seeded no-till into the residue left from the first soybean crop. Lasso-Roundup (2.2 kg/ha alachlor and 2.2 kg/ha glyphosate) were applied to control future weeds as well as weed escapes from the first crop. The second crop in 35 cm rows covered the ground quickly and weeds were not a problem. This no-tillage method effectively solved the volunteer soybean problem, controlled weeds, maintained soil moisture for germination, and speeded replanting with lower energy input.

Conclusions and Recommended Cultivars and Practices for Growing Soybeans Succeeding Soybeans in Florida: March-planting of soybean cultivars in MG 000 to VIII during four years indicated that the cultivar for the first crop

should be from MG II, III, or IV for best yield potential, seed quality, sufficient pod and plant height, and sufficiently early maturity to allow a second crop. Williams was the best performing cultivar, but Union, Cutler 71, and Amsoy 71 were also good within MG II to IV. Cultivars from MG V, VI. VII, VIII, and IX, when planted in March, were adversely affected by the lengthening days. As a result their reproductive development was slow and they matured too late to allow planting a second crop.

Growing two soybean crops per year will require careful management. The first crop must be planted no later than the end of March on well-drained, productive soils that have previously produced good soybean yields. Irrigation and good weed control are absolutely essential. Plant in narrow rows at populations near 60 plants per m^2 (Table 4). This will give a closed canopy and reduce weed competition. Yield was increased 21% by planting in 25cm as compared to 102 cm row spacing. Yield was not increased by doubling seeding rate to 112 seeds/m^2. The fraction of seed yield below 8 cm was reduced by either greater in-row plant competition (fewer rows at the same area planting density) or by greater overall planting density at the same in-row competition. Because pods are set low, careful combine harvest and low cutter bar height are needed. Harvesting at the earliest possible time is essential to prevent loss of seed quality in the warm humid summer and to give maximum growing time for the second crop planted. Spraying a harvest aid desicant such as paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) may be desirahle if the last few leaves fail to die as pods begin to mature. Seed drying may be needed.

The second crop should be a full-season adapted cultivar. Bragg (MG VII) and Cobb (MG VIII) have performed better than the few MG IX experimental lines tried. Best yield performance of the second crop occurred in years when no-till planting methods, narrow rows, optimum irrigation was practiced. The

Table 4. Effect of row spacing and population on yield characteristics of 'Amsoy 71' and 'Williams' soybean planted 14 March 1978 at Gainesville, FL.

Cultivar	Row Spacing	Harvest Plant Density	Height at Harvest	Seed Yield	Yield below 8 cm	Weight of 100 Seed	Seed Quality††
	cm	no/m^2	cm	kg/ha	%	g	1-5
Amsoy 71	25	47	52a*	2630a	22a	17.9abc	2.0a
	51	51	53a	2400a	15b	17.6bc	2.2a
	51†	99†	53a	2370a	2c	16.9c	2.2a
	76	50	55a	2130a	11b	18.8ab	2.2a
	102	50	59a	2280a	4c	19.4a	2.4a
Williams	25	47	54a	2760a	12a	19.8a	2.0a
	51	50	55a	2610ab	6b	19.6a	1.9a
	51†	98†	53a	2520ab	1c	18.9a	1.9a
	76	49	57a	2330ab	2c	20.1a	1.9a
	102	48	58a	2190b	3c	19.9a	2.03

* Means in a column within a given cultivar not followed by the same letter are significantly different at the 0.05 level according to Duncans New Multiple Range test.

† This row spacing treatment seeded at 112 seeds/m^2; all other treatments seeded at 56 seeds/m^2.

††1 = Very Good; 5 = Very Poor.

combined total yields of two soyhean crops per season were 5270, 4400. and 6210 kg/ha in 1977, 1978, and 1979. In spite of the apparent success of these experiments, further experimental and farm level evaluation is needed before the practice is recommended *to* Florida producers. Careful management is the key.

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