SICKLEPOD (*Cassia obtusifolia* L.) COMPETITION WITH SOYBEANS AS INFLUENCED BY ROW SPACING, DENSITY, PLANTING DATE, AND HERBICIDES

BY

JERRY HOLLAND JORDAN, JR.

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JERRY HOLLAND JORDAN, JR.

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Chairman: Dr. W. L. Currey
Major Department: Agronomy

Sicklepod (Cassia obtusifolia L.) competition with soybeans (Glycine max (L.) Merr.), as influenced by soybean row spacing, sicklepod density, and planting date, was studied from 1980 to 1982 at Quincy and Gainesville, Florida. Soybean row spacings were 30, 60 and 90 cm in 1980 and 25, 50 and 75 cm in 1981 and 1982. Sicklepod densities evaluated were 0, 1, 5 and 15 per m^2 in 1980 and 0, 0.5, 1.0 and 5.0 per m^2 in 1981 and 1982.

Soybean yields in 1980 were significantly greater in the 30 cm rows than in the 60 and 90 cm rows, while in 1981 there was no difference in row spacings and in 1982 both the 25 and 50 cm row yields were significantly higher than the 75 cm rows. Soybean yield decreased as sicklepod density increased in 1980. In 1981, yields were similar at low and medium densities. In 1982 yields at the zero and low densities were not significantly different from each other. Soybean yield responded curvilinearly to both sicklepod density and dry weight. Sicklepod dry weight, seed production and light interception were all decreased by soybeans in narrow row spacings.

Mean water use was greater in the 25 and 50 cm rows than in the 75 cm rows in both 1981 and 1982. However, under water stress conditions there was no difference between the narrow and wide rows at 25 cm depth. At 15 cm depth, the narrow rows used more water under all conditions.

When herbicide treatments were evaluated, weed control increased as row spacing decreased. Excellent sicklepod control was obtained with both trifluralin (α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) + metribuzin (4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one) preplant incorporated and alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide) + metribuzin preemergence. Poor sicklepod control resulted with the same herbicides in wide row spacings. Two applications of toxaphene (chlorinated camphene) gave 100% control at all row spacings. Planting date did not affect sicklepod control. Soybean yields were greatest in the recommended planting dates. The narrow rows outyielded the wide rows in the late planting date and ine one of the three recommended planting dates.

INTRODUCTION

Weed competition is one of the primary limiting factors in soybean (Glycine max (L.) Merr.) production throughout the world. In the southeastern United States, sicklepod (Cassia obtusifolia L.) is a major competitor in soybeans, cotton (Gossypium hirsutum L.) and peanuts (Arachis hypogaea L.) (9, 11, 13, 15, 30, 35, 38, 39, 44). McCormick (62) lists sicklepod as one of the ten most troublesome weeds of soybeans in Alabama, Florida, Georgia, Mississippi, North Carolina, and Tennessee. It is also in the top ten weeds of peanuts, cotton and corn in Alabama, Florida and Georgia.

Sicklepod is a non-nodulating legume whose persistence can be attributed to its tolerance of a wide range of soil fertility, pH, and temperatures (25, 27, 92). Also contributing to this success as a major pest is sicklepod's prolific seed production and tolerance to many commonly used herbicides.

Farmers have been reluctant to use narrow rows in their soybean production mainly because cultivation is no longer an option in their weed control program. Recent advances in chemical weed control now make narrow row soybeans an alternative program. Decreasing row spacing in soybeans has advantages and disadvantages. The impact upon various soybean weed pests, such as sicklepod, to this cultural practice has not been completely determined. Numerous studies have investigated the competitiveness of weeds in soybeans. However, most of these investigations involve weeds per meter of linear row in soybeans of 85 cm row spacing or greater. Many researchers and consultants are now advising growers to decrease row spacing to achieve more rapid canopy closure; however, there are little data available evaluating the interaction between weed density and crop row spacing.

Investigations were initiated to evaluate the effect of decreasing soybean row spacing on sicklepod growth. The major objective of this study was to determine whether improved control of sicklepod could be achieved by increasing crop competition through modification of cultural practices. Variables involved include row spacing, sicklepod densities, planting dates, and chemical control.

LITERATURE REVIEW

Classification and Description of Sicklepod

Cassia obtusifolia L. is an erect annual herb of the family Leguminosae (subfamily Caesalpinioideae). The Weed Science Society of America approved common name is sicklepod although it is often referred to as coffeeweed by growers in the South. This species has pinnately compound leaves with leaflets obovate, 2-7 cm long and numbering 4-6. Sicklepod's petiolar gland is elongate. This gland is about 2 mm long. It is located between, or just above, the petiolules of the lowest pair of leaflets. The sepals are unequal and are 5-10 mm long and 2-5 mm wide. The petals are yellow and are 8-17 mm long. There are 6-7 fertile stamens and 3-4 staminodes. The legume is narrowly linear, strongly curved, tetragonal, 1-2 mm long and 3-5 mm broad. Sicklepod often reaches heights of 2 meters or more under conditions of good moisture and fertility. Coffee senna (*Cassia occidentalis* L.), a closely related species found commonly throughout the southeast, is separated from *C. obtusifolia* L. by the number and shape of the leaflets and the petiolar gland which is larger and bulb-shaped at the base of the petiole. Both species are commonly found in Virginia, North and South Carolina, Georgia, Florida, Alabama, Missisippi, and Tennessee (14, 17, 44, 50, 66, 77, 102, 104).

Weed-Crop Competition

Definition

Competition, as a comprehensive term, is defined by Smith (89) as common use of a resource, regardless of supply, resulting in harm to one organism by another seeking the resource. Smith (89) considers competition to be one of two types, exploitative or contest. Exploitation competition is where organisms have equal access to a limited resource. Contest or interference competition is where a competitor is denied access to a resource. However, these theories were developed from animal populations.

Competition between plants has been defined by many authors. One of the first researchers to investigate the subject of plant competition was Pavlychenko (71) who in 1949 defined competition as a natural force exerted by each living organism, tending to attain maximum advantage at the expense of other living organisms occupying the same space. Donald states "competition occurs when each of two or more organisms seeks the measure it wants of any particular factor or thing and when the immediate supply of the factor or thing is below the combined demand of the organisms" (30:356). Although competition theories are well documented, even the term "competition" is somewhat controversial. Harper (42) dislikes the word "competition" because of its connotations to games and sports and its unscientific meaning. He prefers the term "interference" which includes both competition and allelopathy. Allelopathy describes the addition of a chemical substance to the environment, while competition involves the removal or reduction of a necessary factor from the environment (108).

Allelopathic effects will not be addressed in this manuscript and the term "competition" used. Plants usually compete for water, nutrients, light, oxygen, carbon dioxide and agents of pollination and dispersal. Water, nutrients, and light are the most commonly deficient (24, 30, 108).

Nutrient Competition

Competition for nutrients constitutes an important factor in crop production (7, 56). Vengris et al. (98) determined that weeds are important competitors with crop plants for nitrogen and potassium. High phosphorus content of weeds, even when available soil phosphorus is low, indicates weeds compete effectively for this element. However, this may be due to a more efficient utilization of soil phosphates. In competition between leguminous crops and weeds, nitrogen may not be as important a factor as phosphorus or potassium. On a soil acutely deficient in nitrogen and phosphorus, Donald (30) determined that grass weed growth was significantly depressed by gramineous cereal crops but not by peas (*Pisum* sp.). Conversly the growth of clovers was depressed by the peas but was unaffected by barley (*Hordeum vulgare* L.) or oats (Avena sativa L.). Donald concluded that the main factor of competition between the gramineous species was nitrogen, whereas between the leguminous species with an independent nitrogen supply, competition was primarily for phosphorus.

Blackman and Templeman (6) found that annual weeds in cereal crops resulted in lower nitrogen and potassium content of the cereal but did not alter the phosphorus content. Hoveland et al. (48) showed that weeds respond to added potassium and phosphorus. Of the weed species they studied, redroot pigweed (Amaranthus retroflexus L.), jimsonweed (Datura stramonium L.) and Florida beggarweed (Desmodium tortuosum L.) were the most responsive warm-season weeds to potassium and phosphorus levels. Showy crotalaria (Crotalaria spectabilis Roth), tall morningglory (Ipomoea purpurea (L.) Roth), sicklepod, and coffee senna were the most tolerant to low soil phosphorus. Generally, weeds were more sensitive to low soil-test phosphorus than to low levels of potassium. Chambers and Holm (21) found phosphorus competition by weeds to be minimal. In their tests, weeds were found to have less effect on phsophorus uptake than bean plants. Weeds may also compete with crops for Ca and Mg, but nitrogen is usually the nutrient most subject to competitive uptake (10). Response of plants to different levels of Ca is difficult to measure because of its pH-dependent properties (11).

Increased fertility levels may not remedy nutrient competition by weeds but may instead enhance it through increased weed growth thus reducing crop yield. Vengris et al. (98) in a later study concluded that weeds compete for essential nutrients and decrease crop yield even at high fertility levels. Nakoneshny and Friesen (64) determined that wheat (Triticum aestiuum L.) yield increases due to fertilizer applications were not different from increases due to weed removal. Staniforth (91) stated that soybean yield reductions due to weeds were greater in tests where 75 or 150 kg/ha of nitrogen was applied the previous year. In studying competition with wild buckwheat (Polygonum convolvulus L.) Nalewaja (65) reported greater yield reductions of wheat and flax (Linum usitatissimum L.) occurred in fertilized treatments. Zimdahl (108) in his review on weed-crop competition stated that weed control cannot be achieved with fertilizer. Maximum benefits from fertilizer occur only to crops with relatively few weeds. The solution to nutrient deficiencies in weed infested areas is obviously not solely increased fertilizer, but depends on removal or reduction of the weeds.

It is difficult to separate nutrient competition from other confounding factors such as light, moisture and pH since they are all interrelated and a change in one may result in a correspodning change in the other. Numerous investigators have attempted to separate light from nutrient competition in the field by using weeds which are low-growing and have smaller leaf areas (30, 37). Donald, in studying nutrient competition, concluded that secondary effects must be considered. He states "success in gaining a larger share of available nutrients may stimulate growth increases resulting in dominance as much from competition for light as for nutrients" (30:356). However, the ability to compete for nutrients is an important aspect of the success of weeds (103).

Moolani et al. (63) concluded that smooth pigweed (Amaranthus hybridus L.) competition was greatest when early season rainfall was high. Knake and Slife (52) found that giant foxtail (Setaria faberi Herrm.) reduced corn (Zea mays L.) and soybean yields more in years of high rainfall than in years of low initial rainfall followed by adequate midseason moisture. In studying Venice mallow (Hibiscus trionum L.) competition in soybeans, Eaton et al. (36) discovered that competition was greatest when moisture conditions were good initially and poor after midseason than when moisture was limited early but adequate from midseason on. Sicklepod competition in soybeans was found by Thurlow and Buchanan (95) to be less severe in years of high moisture.

Size, distribution, and developmental rate of a plant's root system influence the competitiveness of a plant for water. Scott and Oliver (80) found that, compared with the soybean root system, tall morningglory roots were found deeper and had greater root densities. Little expansion of the soybean root system was found after initiation of reproductive growth; however, during this phase the tall morningglory root system was still increasing.

The quantity and distribution of seasonal rainfall can alter the competitive ability of various weeds as well as crops. Wiese and Vandiver (104) showed that soil conditions can affect the competitive ability of weeds. Barnyardgrass (Echinochloa crus-galli (L.) Beauv.) and large crabgrass (Digitaria sanguinalis (L.) Scop.) were found to be serious competitors when adequate soil moisture was available. However, in semi-arid or arid areas, these weeds are not problems. Kochia (Kochia scoparia (L.) Schrad), Russian thistle (Salsola kali L.), buffalobur (Solanum rostratum Dunal) and tumblegrass (Schedonnardus paniculatus (Nutt.) Trel.) were more competitive under dry conditions, while Palmer amaranth (Amaranthus palmeri S. Wats.) grew equally well under high and moderate soil moisture. Of the species studied, cocklebur (Xanthium pensylvanicum Wallr.) was the only weed that did not survive extreme drought.

Water Competition

Water is often considered to be the primary limiting factor in soybean production throughout the world (33, 72). The effects of water stress on growth and yield of soybeans are dependent on the degree of stress and the stage of growth when the stress occurs. Burnside and

Colville (18) found that soybeans irrigated during the late bloom stage outyielded non-irrigated soybeans by 685 kg/ha. Sionit and Kramer (87) found that of all growth stages, water stress during early pod formation resulted in the greatest decrease in number of pods and seed at harvest. However, stress applied during pod formation or during pod fill resulted in greater yield reductions than stress applied during flower induction or flowering. This phenomenon has been confirmed by numerous investigators (32, 78, 82, 94). Peters and Johnson (75) found that from July 1 to September 20, 2.5 cm of water was required to produce 134 kg/ha of soybeans. Pendleton and Hartwig (72) state that at this rate it would take 625 cm of water during the late growing season to produce a high-yielding soybean crop of 3,369 kg/ha.

It is evident from the above investigations that soybeans require sufficient moisture, especially during the late growing season, in order to produce high yields. With the dependence upon natural rainfall in non-irrigated soybeans, adequate moisture is not always present. When weeds exist the amount of soil moisture available to the soybeans is further depleted. Staniforth (90) found that soybean yields were only slightly reduced by yellow foxtail (*Setaria lutescens* (Weigel) Hubb.) competition when water was limited in early season, but was sufficient later in the season. However, when moisture was plentiful early but limited in late season, there was a 15% reduction in soybean yield.

Light Competition

Competition for light is unique among the factors for which plants compete. With water or nutrients there is a fluctuating reservoir from which to draw; however, light is available from a constant source. Light energy must be intercepted and utilized instantaneously or be lost. Donald (29) points out that this is particularily evident in the young crop where most of the energy passes to the soil surface due to lack of leaf area. Competition for light also differs from other factors in that the competition is not necessarily between species or plants but rather among leaves. This intra-plant competition also occurs for water and nutrients but it is not as intense since water and nutrients are translocated throughout the plant. The competition along leaves for radiant energy is among individual units within the plant canopy (30).

The role which light plays in photosynthetic reactions has been well documented (40, 41). The photosynthetic rate of a whole canopy usually shows a greater response to light intensity than that of a single leaf which may reach light saturation at less than full sunlight. This is due to canopy architecture which includes leaf angle, leaf distribution and leaf area index which allows more leaves to intercept light at an average lower light intensity where they are more efficient. Although single leaves may reach their maximum photosynthetic rate at near full sun intensities, they are not very efficient at utilizing light at that intensity (46). Bowes et al. (9) states that the light saturation intensity of field grown soybeans is approximately equal to the maximum light intensity under which they are grown thus indicating that soybeans acclimate to the light available. Therefore, soybeans appear to develop sufficient, but not excessive, photosynthetic capacity to utilize the maximum available light. In view of these facts the question arises as to how much depletion of soybean yield potential is due to the interception of solar radiation caused by a low or intermediate population of weeds arising above the soybean canopy.

Light interception and subsequent photosynthesis depend largely on foliage density and percent ground cover. Leaf area indes (LAI), the units of leaf area per unit of land area, is the best criterion for analyzing this. Brougham (12) defined the critical LAI as that leaf area required to result in 95% interception at local noon. This value for soybeans is approximately 3.2 (85). The relative light intensity through the plant profile is reported to follow the relationship $I/I_0 = e^{-KA}$, where I = radiant energy received at the bottom of an increment LAI, A, I_0 = incident energy at the canopy top, K = extinction coefficient. Sakamoto and Shaw (79) demonstrated by using the above equation that light interception occurred primarily at the periphery of the soybean canopy. When the open space between rows closed, interception was primarily at the top of the canopy. Several investigators using Beer's Law (30, 79) have shown that light interception by a canopy of leaves is exponential. Light intensity, therefore, decreases sharply as it penetrates into the canopy. Sinclair's (86) equation of light attentuation, derived from Beer's Law, states that the fraction of photon flux density (Pz) reaching any depth in the canopy is an exponential function of cumulative leaf area from the top (Lz), extinction coefficient (K), and the solar elevation (sin θ). $I/I_0 = Pz = e(\frac{-K \cdot Lz}{\sin})$. The majority of the light is therefore found to be intercepted by the upper unit of LAI (57). The effect that weeds extending above the soybean canopy have on this relationship has not been adequately investigated.

Perhaps the single most important factor in weed-crop competition for light is plant height. Blackman and Templeman (6) stated that light competition existed only when the weed species is tall growing and the density is high. Shadbolt and Holm (81) reported that high populations of redroot pigweed and ladysthumb (_Polygonum persicaria_ L.) populations reduced light penetration 85%. Weber and Staniforth (101) found that soybean yields were reduced more by overshadowing weeds than by weeds of approximately the same height as the crop. Moolani et al. (63) found that smooth pigweed had a greater effect on soybeans than on corn due to the height differential between soybean and pigweed. Knake and Slife (53) reported that giant foxtail had the greatest effect on soybeans after reproductive growth had begun or after the weeds began shading the soybeans.

It is evident that light competition is interrelated with water and nutrients and that individual effects are difficult to separate. A shaded plant, for example, suffers reduced photosynthesis leading to poorer growth, and a smaller root system, and ultimately reduced capacity for water or nutrient uptake (30). However, if water and nutrients are in adequate supply, then light will become the major limiting factor controlling rate of growth and the production of dry matter (28).

Weed Density

Crop yield reductions due to weeds have been demonstrated by numerous investigators (11, 22, 26, 39, 51, 81) with much of this work involving soybeans. Wilson and Cole (107) reported that soybean yields were reduced 12 and 44% by tall and ivyleaf morningglory

(*Ipomoea hederacea* (L.) Jacq.) at densities of one plant per 51 and 4 cm or row, respectively. Removal of morningglories at six to eight weeks after planting permitted maximum soybean yields. Oliver et al. (69) found that at one weed per 61, 30, or 15 cm of row, tall morningglory could remain for ten, eight, and six weeks, respectively, without soybean yield reduction. Barrentine (3) indicated that tall morningglory and cocklebur were similar in competitive ability with soybeans. Buchanan and Burns (13) found that one tall morningglory plant per 30 cm of row reduced cotton yields 10 to 40% on Norfolk sandy loam soil and 50 to 75% on Lucedale sandy clay soil. Tall morningglory was found to be more competitive than sicklepod in this study.

In 1976, Bloomberg and Wax (8) stated that common cocklebur ranked as the most important and detrimental weed in soybeans. In a three year study involving common cocklebur in soybeans, Barrentine (3) found that full season competition by cocklebur at 3,300, 6,600, 13,000, and 26,000 plants/ha reduced soybean yields by 10, 28, 43, and 52%, respectively. When controlled for the first four weeks, further cocklebur removal was not necessary in order to obtain maximum yields. In studying the economics of common cocklebur control, Anderson and McWhorter (1) reported that soybean yields were increased about 6% for each 10% increase in cocklebur control. Net returns to land, management, and general farm overhead were $63/ha with 0% control and $119/ha with 95% control of cocklebur. A 70% weed control level was required to escape losses caused by excessive seed moisture. Hauser et al. (45) stated that common cocklebur as well as yellow nutsedge (*Cyperus esculentus* L.) reduced yields 75% in experiments conducted in Georgia. The above data clearly give evidence to support

Bloomberg's and Wax's initial statement. Cotton is also adversely affected by cocklebur competition. Buchanan and Burns (14) found that 8 weeds/7.3 m of row reduced yields more than 20% and 48 reduced yield more than 80%.

Sicklepod competitiveness in soybeans is well documented, although it is reportedly less competitive than cocklebur in some regions of the country. Thurlow and Buchanan (95) found that soybean yields were reduced linearly between 0 and 15 weeds/m^2. In two separate locations, yield was reduced 19 to 32% and 34 to 35%, respectively by densities of 7.7 sicklepod/m^2. Weeds allowed to compete for the first four weeks of crop growth failed to reduce yields. Competition for six weeks reduced yields in two of five experiments. Although early season sicklepod competition may not adversely affect soybean yield at the present, there is currently no reliable means of sicklepod control after the early seedling stage until a weed-crop height differential has been established (27). Teem (92) reported that sicklepod at 3, 5, and 7 weeds/m of row reduced soybean yields 19, 25, and 38%, respectively. A regression coefficient of -.40 was obtained in these studies indicating a reduction in soybean yield of .40 for each kg/ha increase in dry weight of sicklepod. In studies evaluating soybean yield as affected by sicklepod dry weight or density, Teem indicated the coefficient of determination was .93 for the former and .38 for the latter, thus indicating the weed weight is a more precise measure of sicklepod competitiveness than weed density.

Buchanan and Burns (13) reported that cotton yields were reduced 10 to 40% at 8 plants/7.3 m of row, depending on soil type. A density of 48 plants/7.3 m of row resulted in a 45 to 80% yield reduction.

Thurlow and Buchanan (95) stated that in general sicklepod is more effective in reducing cotton yield than soybean yield, probably due to soybean's shorter life cycle.

Numerous other weeds have been found to be deleterious to soybean yields. Moolani et al. (63) reported that soybean yield reductions from the highest population of smooth pigweed averaged 55% during a three year study. Coble and Ritter (22) found that soybean yield was reduced 13% by a density of 8 Pennsylvania smartweed (Polygonum pensylvanicum L.) plants/10 m of row. Further yields reductions of 21, 37, and 62% resulted from full-season competition by densities of 16, 32, and 240 weeds/10 m of row, respectively. Berglund and Nalewaja (5) found that soybean yields were reduced 21% by one wild mustard (Brassica kaber (D.C.) L. C. Wheeler) plant/0.3 m of row. Velvetleaf (Abutilon theophrasti Medic.), Venice mallow, and prickly sida (Sida spinosa L.) were found to decrease soybean yields 720, 250, and 230 kg/ha, respectively.

Monocots are also reported to be competitive with soybeans. Nave and Wax (67) reported giant foxtail at 1 plant/0.3 m of row reduced soybean yields by 13%. Knake and Slife (52) reported that 54 giant foxtail/0.3 m of row caused a 28% soybean yield reduction.

Competition studies aid growers in determining the feasibility of controlling particular weeds at various densities. Thus the term economic threshold has been coined. This concept may have some practicality on a short term basis; however, for a long term weed control program the economic threshold principle may not apply. When even a low population of weeds is allowed to mature and produce seed each year, the seed reserve in the soil can become enormous. A herbicide program giving 95% control may not be adequate if the weed population is extremely high. One pigweed plant has been reported to produce over 117,000 seed (2). At this rate, only a few plants are needed to result in a high weed population for many years. If weeds are not permitted to produce seed, then a long term weed control program may eventually be less costly.

Row Spacing

Soybeans have traditionally been planted in 75 to 100 cm row widths. These widths are also used for cotton, corn, and grain sorghum. Wide rows were necessary to accommodate conventional cultivation equipment; however, with the development of selective herbicides, narrow-row soybeans are becoming a viable alternative (20).

Several studies with indeterminate soybean varieties have shown increased yields with rows narrower than 100 cm (31, 66, 76, 105). Wax and Pendleton (100) noted an increase in soybean yields of 10, 18, and 20% for 76, 51, and 25 cm rows, respectively, when compared to 102 cm rows. Lehman and Lambert (55) found that seed yields obtained from the 50 cm spacing were approximately 15% greater than yields from the 100 cm spacing. Lovely et al. (58) achieved highest yields from 30 cm rows. Hammerton (41) found in competition studies with mixed weed stands that soybeans in 30 cm rows gave higher yields than 60 cm rows.

Weed control is the most important consideration in the production of soybeans in rows too narrow to allow cultivation (99). Studies on the interaction of weed control methods and row spacing have shown that soybeans in narrow rows provided more shade between the rows; therefore fewer cultivations were needed after initial weed control had been obtained in the row with herbicides (73). Wax and Pendleton (100) demonstrated an increased weed growth in the wider soybean row spacings. They stated that weed control by either trifluralin (α,α,α-trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine) or cultivation was more effective in 50 cm rows than in 100 cm rows. Burnside and Colville (18) showed that soybeans planted in 25, 50, 75, and 100 cm rows obtained canopy closure in 36, 47, 58, and 64 days, respectively. They also noted a yield increase of 39% from the 25 to 100 cm rows. Lower rates of chloramben (3-amino-2,5-dichlorobenzoic acid) could be used and still obtain adequate weed control. Kust and Smith (54) found that soybeans planted in narrow rows were much more effective than those planted in wide rows in suppressing the growth of yellow foxtail and barnyardgrass. In addition, they found that lower rates of linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea) were required for comparable weed control as row spacing decreased. Cooper (23) noted that if weeds are controlled with herbicides for four to six weeks after planting, narrow row soybeans may provide more shading than would wide row soybeans and lower rates of herbicide may be required in narrow rows because of the greater shading by soybeans.

Weed control may be increased in narrow row soybeans with effective herbicides, but a serious problem may arise if the herbicides are unsuccessful. At this point, cultivation or a postemergence directed spray could salvage a wide row soybean crop; however, this is not an option with narrow row soybeans. One alternative early in the growing season would be the rotary hoe. Lovely et al. (58) noted 70 to 80% weed control by rotary hoeing when weeds had germinated but not emerged.

Peters and Johnson (75) found the rotary hoe effective on emerged weeds less than 1 cm in height.

Another problem that may arise in narrow rows is the presence of perennial weeds. Perennial weed species that normally do not persist in cultivated row crops may increase if cultivation is eliminated (99).

Narrow row soybeans offer advantages other than increased weed control. Mannering and Johnson (61) found that narrow row soybeans provided significantly greater ground cover than wide row soybeans as early as three to four weeks after planting resulting in 24% greater water infiltration and 35% less soil loss to erosion. Hicks et al. (47) noted that a greater leaf area index was provided earlier in the season when plants were spaced in 25 cm rows. One further advantage of narrow rows is the height of the lowest pods on the stems is raised, which can help reduce harvest losses (51). Burnside and Colville (19) found that height to lowest pod decreased with increasing row spacing. Basnet et al. (4) found that in narrow rows the first pods were produced 3 to 9 cm higher above ground level than those in wider soybean row spacings.

One disadvantage is that soybeans planted in narrow rows tend to be lodged more than wide row soybeans (4, 19, 66). Hartwig (43) states that planting more than 10 to 12 soybean seeds per 0.3 m of row gives better early season weed control but a greater amount of loding usually results. Most research has shown that when rows are narrowed to less than 50 cm the seeding rate should be increased 10 to 30% to help assure an adequate stand (51). Water use is supposedly another disadvantage of narrow rows; however, current data do not support this. Johnson et al. (51) state that if narrow rows do use more water it is being used to produce more crop, not just lost to evaporation. Narrow rows may not yield more than wide rows during a dry year, nor should they yield less. Doss and Thurlow (33) reported that average daily water use differed little between row widths except for a period early in the season when plants were 25 to 60 cm high. At this stage more water was used by the 90 cm than the 60 cm rows. The lower water use rate on 60 cm rows probably resulted from less evaporation from the soil surface due to more shading effect by the narrow rows during the early season. Timmons et al. (96) stated that neither row spacing nor plant population significantly altered evapotranspiration.

In contrast to the yield increases found in the northern U.S., row width studies conducted in the major soybean producing areas of the South indicate that there is no yield advantage to planting in rows narrower than 30 to 40 cm. Hartwig (43) in Mississippi and Smith (88) in Florida found that planting narrow rows had no effect on soybean yields. Hartwig (43) explained that adapted southern varieties have more foliage than northern indeterminate varieties and normally will completely fill the row middles in 80 to 100 cm rows. Johnson et al. (51) reported that row spacing will not have an effect on yield as long as the rows are sufficiently narrow to close the soybean canopy by the time the plants have begun flowering. Generally the farther north, the narrower the optimum row width because the plants are smaller at flowering. However, late planted soybeans are more likely to show a greater response to narrow rows than those planted in the spring.

Sicklepod Control Programs

Sicklepod remains one of the South's most troublesome weeds in soybean production despite numerous investigations on herbicide efficacy. In corn and pastures, sicklepod can be easily controlled with phenoxy herbicides, while in soybeans this is not an option (49). Soil applied herbicides such as trifluralin (α,α,α-trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine) and nitralin (4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline) have essentially no activity at normal use rates (16); however, alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide), metribuzin (4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one), and vernolate (S-propyl dipropylthio-carbamate) have been reported to result in fair to good suppression of sicklepod. Oliver et al. (70) reported that alachlor, metribuzin, and vernolate gave 79, 56, and 49% control, respectively, of sicklepod thus providing a height differential adequate for successful directed postemergence herbicide applications. However, Currey et al. (27) stated that metribuzin was the single most effective herbicide to control sicklepod. They also stated that sicklepod control and soybean tolerance were consistently better for preplant incorporated than for preemergence treatments containing metribuzin. Teem (92) also reported that metribuzin gave greater control of sicklepod than either alachlor or vernolate at normal use rates. While vernolate has provided good control of sicklepod in some cases, soybean injury and stand reduction have also occurred (26, 83).

The most effective method of controlling sicklepod involves the use of postemergence applications in addition to preplant or preemergence treatments. Toxaphene (chlorinated camphene) has been the most successful of these chemicals both in terms of efficacy and low crop injury; however, it was never granted a federal use label and will not be available in the future. Sherman et al. (84) reported that toxaphene at 2.24 kg/ha plus an oil concentrate controlled 89 and 95% of the sicklepod in the cotyledon or first true-leaf stage, respectively. Lunsford (59) found that toxaphene at 2.24 kg/ha plus an oil concentrate applied 11 days after planting to soybeans in the V2 stage when sicklepod was in the cotyledon stage provided excellent control. A subsequent application was needed seven to ten days later to control newly emerging sicklepod. Once sicklepod passes the cotyledonary stage, tolerance to toxaphene increased (60, 106). Acifluorfen (sodium 5-[2-chloro-4-trifluoromethyl)-phenoxy]-2-nitrobenzoate) has been shown to provide some control of sicklepod in the cotyledonary stage with a single application; however, split applications resulted in severe soybean injury (34, 59, 68). A single application of acifluorfen at 0.56 kg/ha gave only 30% control of sicklepod while causing 20% soybean injury on the V2 and V4 growth stage. A split application of acifluorfen at 0.56 kg/ha at V2 and V4 stage soybeans resulted in 70% sicklepod control and 60% crop injury; however, a split application of toxaphene at 2.24 kg/ha at the V2 and V4 soybean growth stage gave 95% sicklepod control and no crop injury (59).

Buchanan and Hoveland (16) reported that postemergence applications of chloroxuron (3-[p-(p-chlorophenoxy)phenyl]-1,1-dimethylurea) resulted in adequate control of seedling sicklepod. The addition of a crop oil concentrate improved control; however, some crop injury occurred. Oliver et al. (70) found that chloroxuron at 1.12

kg/ha plus a surfactant (0.5%) resulted in 92% control of sicklepod while experiments in Florida showed that 97% control could be obtained with the chloroxuron treatment (26).

Post-directed spray treatments have been one of the most successful sicklepod control programs according to recent investigations; unfortunately, grower acceptance of this practice has been slow (93). Preemergence treatments of metribuzin, alachlor, alachlor plus metribuzin, or vernolate applied preplant, may provide sufficient suppression of sicklepod to provide the height differential necessary for a post-directed spray (70). Sherman et al. (84) reported that either linuron (3-(3,4-dichloro phenyl)-1-methoxy-1-methylurea) at 0.56 kg/ha or metribuzin at 0.28 and 0.56 kg/ha applied alone or as tank mixes with 2,4-DB (4-(2,4-dichlorophenoxy) butric acid) at 0.22 kg/ha provided greater than 90% sicklepod control when applied to the lower 7 to 10 cm or 20 to 25 cm tall soybeans. Other successful post-directed treatments are paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) alone or in combination with either metribuzin or 2,4-DB (27, 60, 70).

From these results, it is clear that a complete herbicide program is necessary for adequate sicklepod control. Currey et al. (27) found that consistently acceptable control of sicklepod was obtained with use of a dinitroaniline herbicide plus metribuzin preplant incorporated or alachlor plus metribuzin preemergence, toxaphene early postemergence to seedling sicklepod, and a post-directed spray of metribuzin plus either 2,4-DB or paraquat. Oliver et al. (70) stated that by combining the best preemergence and postemergence treatments, excellent control of sicklepod was obtained resulting in a 37% increase in yield over the check.

MATERIALS AND METHODS

Soybean-Sicklepod Competition Studies

Studies to evaluate the competition of various densities of sicklepod with soybeans planted in various row spacings were conducted during 1980 at the University of Florida Agricultural Research and Education Center in Quincy and at Agronomy Farm (Green Acres) in Gainesville. Competition studies were continued with modification during 1981-1982 at the Gainesville location only. The soil at Quincy was a Norfolk loamy fine sand (Fine-loamy, Siliceous, Thermic, Typic, Paleudults) whereas the soil at Gainesville was a Bonneau fine sand (Loamy, Siliceous, Theremic, Arenic Paleudults).

A split-plot design with row spacings as main plots and sicklepod populations as subplots, was utilized. Plots were 3.6 m by 6.0 m and replicated four times. Trifluralin was applied at 0.56 kg/ha over the entire experimental area for annual grass and small seeded broadleaf weed control. Soybean row spacings and sicklepod densities used in these studies are listed in Table 1. Analysis of variance, Duncan's New Multiple Range Test and regression equations were utilized to analyze the data.

Competition of Sicklepod with Soybeans--1980

'Bragg' variety, maturity group VII, was planted on June 12 and June 24, 1980, in Gainesville and Quincy, respectively. Soybean seeding rates were 67, 84 and 100 kg/ha of soybean seed for the 90, 60 and 30 cm row spacings, respectively. Sicklepod populations were established approximately two weeks after planting and maintained by hand weeding. The middle two rows were harvested from each plot on October 28 and November 6, 1980, at Gainesville and Quincy, respectively. Sicklepod plants were harvested from a 1 m^2 area in each plot and its green and dry weights were recorded. Regression analysis was utilized to determine the influence of sicklepod density and dry weight on soybean yield.

Competition of Sicklepod with Soybean--1981

'Bragg' soybeans were planted on May 27, 1981, at Gainesville. After emergence the soybean stand was thinned to densities of 67, 84, and 100 plants/ha for the 75, 50, and 25 cm row spacings, respectively. Weed populations were established approximately two weeks after planting and maintained by hand weeding throughout the test.

Mercury manometric tensiometers were placed at a depth of 25 cm in each plot of the first three replications on June 22, 1981. These tensiometers consist of a 50 cm tube with a 10 cm porous ceramic cup. The tube is placed to the desired depth in the soil and connected to the above ground manometer scale by a single, transparent, plastic tube that served both as the manometer measuring tube as well as the connecting link between the manometer assembly and the tensiometric cup tube. The plastic tube was inserted into a reservoir containing 30 grams of mercury, with the opposite end in the water filled cup tube. The manometer scale was graduated in millibars of soil tension and is a standard unit of measurement for soil moisture. Tensiometers were placed 15 cm laterally from one of the middle soybean rows and 10 to 15 cm from the nearest sicklepod plant. Tensiometric readings were recorded nine times from June 30 to September 25, 1981.

Soybean canopy closure and sicklepod light interception were evaluated utilizing a intergrating radiometer/photometer and line quantum sensor that measured photosynthetically active radiation (PAR). The preferred measurement for PAR is Photosynthetic Photon Flux Density (PPFD) (85), the number of photons in the 400 to 700 nm waveband incident per unit time on a unit surface, and is recorded in microeinsteins sec^{-1} m^{-2}. The line quantum sensor, which has a sensing area of 1 m by 12.7 mm, effectively averages PPFD over its 1 m length thus eliminating the need for averaging measurements from numerous small diameter sensors. Canopy closure was determined by placing the sensor on the ground perpendicular to the soybean rows and recording the output. The sensor was then placed over the canopy and the output again recorded. The difference was calculated as a percent and recorded as amount of canopy closure. This procedure was replicated four times with two observations per replication.

Sicklepod light interception was determined with a light attenuation equation derived from the Beer-Lambert law of light absorbance.

$$\frac{I}{I_0} = e^{\frac{(-K;\ LAI)}{\sin \theta}}$$

where $\frac{I}{I_0}$ = fraction of radiation penetrating to depth 0

K = transmissivity constant (extinction coefficient)

LAI = cumulative leaf area index

Sin θ = solar elevation

The fraction of photon flux density is an exponential function of cumulative leaf area, extinction coefficient, and the altitude of the sun ($\sin \theta$). The extinction coefficient, K, depends upon leaf angle relative to horizontal and to the solar angle. The K value used was derived from results obtained by Shibles and Weber (85). The leaf area index of the canopy can be determined from a derivation of the above equation, $\mathrm{LAI} = \frac{-\ln(\mathrm{frac.}) \times \sin \theta}{K}$

The solar elevation was obtained by the equation,

$$\sin a = \sin L \sin \delta + \cos L \cos \delta \cos t$$

where a = altitude
L = latitude
δ = declination of the sun
t = time before local apparent noon 1 hr = 15°

In the solar elevation equation the only unknown is the declination of the sun which was derived from the equation,

$$\delta = 23.45\frac{\pi}{180} \cos \left[\frac{2\pi}{365}(172-D)\right]$$

where δ = declination in radians
D = day of year

In calculating the LAI, the fraction of light penetrating the canopy was determined. The line quantum sensor was placed on the ground under the soybeans at a specified sicklepod density. Light penetrating the total (soybean + sicklepod) canopy was recorded, the sicklepod plants were removed, and the light recorded again. The sensor was then placed above the canopy to record the total PAR available to the plants. This fraction of light with both weed and crop was inserted into the formula resulting in the cumulative LAI of the canopy. The process was duplicated utilizing the weed removal reading resulting in soybean LAI. Sicklepod LAI was obtained by subtracting the soybean LAI from the total LAI. A ratio was then established between total LAI and sicklepod LAI, thus percent sicklepod light interception can be obtained. These equations assume that leaves are horizontal and the soybean and sicklepod leaves are in the same plane. All light measurements were taken between 11:00 a.m. and 1:00 p.m.

Sicklepod morphological data were obtained by randomly selecting plants from each plot and recording the number of pods per plant, seeds per pod, seeds per plant, plant height, plant width, distance from ground to first lateral branch, and plant dry weight. Seeds per hectare were also calculated. Soybean height measurements were recorded both from soil to first pod and from soil to top pod. Soybeans were hand harvested on November 4, 1981, and yields recorded. Regression analyses were used to determine the influence of sicklepod density and dry weight on soybean yield.

Competition of Sicklepod With Soybeans--1982

'Bragg' soybeans were planted on May 21, 1982. After emergence soybean stand was thinned to densities of 67, 84, and 100 plant/ha for the 75, 50, and 25 cm row spacings, respectively. Weed populations were established two weeks after planting and maintained by hand weeding throughout the test.

Mercury manometric tensiometers were placed in the first two replications. Two tensiometers at 15 cm depth and one tensiometer at 25 cm depth were placed in each plot in the first replication. In the second replication, one at each depth was placed in each plot. Readings were recorded 17 times from June 16 to September 15, 1982. Soybean canopy closure, sicklepod light interception, and morphological data were measured by the same procedures used in 1981. Soybeans were hand harvested on November 12, 1982, and yields recorded. Regression analyses were again used to measure the influence of sicklepod density and dry weight on soybean yield.

Herbicide Programs and Planting Date Studies

In 1981 and 1982, field studies were conducted at the University of Florida's Agronomy Research Farm (Green Acres) in Gainesville, to determine the effect of soybean row spacing, herbicide programs and planting date on sicklepod control. In 1981, one planting date (June 5) and in 1982 five planting dates (May 3, May 17, May 31, June 14, and June 28) were utilized. Hereafter, these five planting dates will be referred to as A, B, C, D, and E. The recommended planting dates for 'Bragg' soybeans in Florida are May 15 through June 15. These planting dates are approximately two weeks apart, thus representing one planting date two weeks prior to, three planting dates during, and one planting date two weeks after the recommended period.

A split-plot design was utilized with three replications in which row spacings were the main plots and herbicide treatments were subplots. All herbicide treatments were applied in 187 liters of water/hectare at 3.08 kg/cm^2 with a CO_2 backpack sprayer. In 1982, each planting date was considered a separate test; therefore data from different planting dates cannot be statistically compared. Plot diminsions were 3.6 m by 4.5 m. Table 2 lists herbicide treatments for 1981 and 1982. Analysis of variance, Duncan's New Multiple Range Test, and regression equations were used to analyze the data.

Canopy closure was determined according to the procedure used in the competition studies. Readings were initiated four weeks after planting and were repeated at weekly intervals until canopy closure. Weed control ratings were recorded once. A scale of 0 to 10 was used, where 0 = no control and 10 = total control. In 1982, the last three planting dates did not contain sufficient uniform sicklepod stands to warrant weed control ratings. Soybeans were hand harvested on November 18, 1981, and November 11 and 12, 1982.

TABLE 1. Treatment Variables for Competition Studies

	1980 Quincy	1980 Gainesville	1981 Gainesville	1982 Gainesville
Row Spacing:	Narrow-30cm	Narrow-30cm	Narrow-25cm	Narrow-25cm
	Medium-60cm	Medium-60cm	Medium-50cm	Medium-50cm
	Wide-90cm	Wide-90cm	Wide-75cm	Wide-75cm
Weed Population:	0	0	0	0
	Low-1/m^2	Low-1/m^2	Low-0.5/m^2	Low-0.5/m^2
	Medium-5/m^2	Medium-5/m^2	Medium-1/m^2	Medium-1/m^2
	High-15/m^2	High-15/m^2	High-5/m^2	High-5/m^2

TABLE 2. Treatments for Herbicide Programs and Planting Date Studies.

Common Name	Chemical Name	Rate (kg/ha)
trifluralin + metribuzin[†]	α,α,α-trifluro-2,6-dinitro-N,N-dipropyl-p-toludine + 4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one	0.56 + 0.42
alachlor + metribuzin[Ψ,§]	2-chloro-2',6'diethyl-N-(methoxymethul)acetanilide	3.30 + 0.42
trifluralin + metribuzin + toxaphene[Φ]	chlorinated camphene	0.56 + 0.42 + 3.30
check		

[†] Applied preplant incorporated.

[Ψ] Applied preemergence.

[§] Not used in 1981 test.

[Φ] Toxaphene applied twice postemergence, 10 days apart.

RESULTS AND DISCUSSION

Soybean-Sicklepod Competition Studies

Competition of Sicklepod with Soybeans-1980

Soybean yields at both Quincy and Gainesville locations were significantly higher in the 30 cm rows than in the 50 and 75 cm rows (Table 3). Previous research (43, 51) in the southern U.S. has not shown a yield advantage due to narrow row spacing. The late planting may provide an explanation since higher soybean populations of narrow row spacings have been shown to produce higher yields than wide rows at late planting dates (20). Soybean yields showed a significant decrease with increasing sicklepod density at both locations. Sicklepod dry weight was not affected by row spacing in Gainesville but weed dry weight increased with increasing sicklepod density.

In Quincy, there was a significant interaction between row spacing and sicklepod density. At the high weed density, the narrow row soybeans produced the greatest sicklepod dry matter. At the low and medium densities, weed dry weight was not affected by row spacing (Table 4). Competition from the 50 cm row soybeans resulted in a decrease in sicklepod dry weight from that in the 90 cm rows. However, an expected decrease in sicklepod dry weight in the 30 cm rows did not occur. Since the sicklepod density of $15/m^2$ is so great, the lower populated soybeans in the 60 and 90 cm rows did not produce a yield increase over the 30 cm rows even with a lower sicklepod biomass.

TABLE 3. Soybean Yield and Sicklepod Dry Weight as Affected by Soybean Row Spacing and Sicklepod Densities, 1980.

Parameters	Soybean Yield Quincy (kg/ha)[†]	Sicklepod D.W. Quincy (kg/ha)[Ψ]	Soybean Yield Gainesville (kg/ha)	Sicklepod D.W. Gainesville (kg/ha)
Row Spacing (cm)				
30	1470 a	4866	1016 a	5144 a
60	1219 b	3435	663 b	4823 a
90	1137 b	3146	546 b	4645 a
Sicklepod/m^2				
0.0	1916 (a)		1254 (a)	
1.0	1667 (b)	423	941 (b)	384 (a)
5.0	1000 (c)	2490	672 (c)	3023 (b)
15.0	518 (d)	12351	100 (d)	16078 (c)

[†] Means in a column within row spacing or densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

[Ψ] Interaction of soybean row spacing x sicklepod population present.

TABLE 4. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Dry Weight (kg/ha). Quincy, 1980.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	1.0	5.0	15.0
30	$^{a}558^{e}$	$^{b}2257^{e}$	$^{c}16650^{e}$
60	$^{a}340^{e}$	$^{b}2720^{e}$	$^{c}9525^{g}$
90	$^{a}371^{e}$	$^{b}2492^{e}$	$^{c}10879^{f}$

† Means within a row preceeded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

With all row spacings, sicklepod dry weight increased as density increased.

Increasing sicklepod density and sicklepod dry weight decreased soybean yield curvilinearly at both locations (Figs. 1-4). Yield decrease was rapid initially but was similar at the medium and high densities. At Quincy, the coefficient of determination was slightly higher for sicklepod density than for sicklepod dry weight, 0.78 vs. 0.72, respectively. This was a result of the large sicklepod dry weight value in the 30 cm rows at the high sicklepod density. In Gainesville, the coefficients of determination were similar at 0.64 and 0.63, for density and dry weight, respectively. Yields and correlations were lower at the Gainesville location.

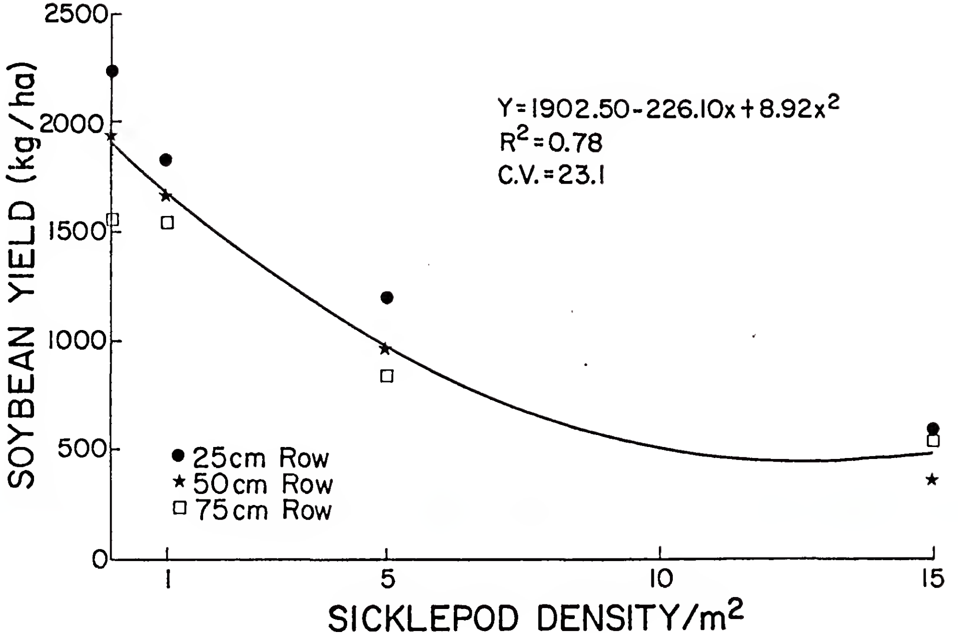
Competition of Sicklepod with Soybeans-1981

Soybean yields in 1981 (Table 5) were not significantly different between row spacings. This experiment, unlike 1980 tests, was planted during the recommended planting dates for the 'Bragg' variety. Increasing sicklepod density reduced yield across all row spacings except the low and medium densities. The suboptimal rainfall in 1981 resulted in a decrease of 401 kg/ha with the low sicklepod density, whereas in 1980 the decrease for the same densities was 249 and 313 kg/ha at Quincy and Gainesville, respectively. The yields were higher over all row spacing and sicklepod densities in 1981 compared to 1980 probably due to a more favorable planting date in 1981.

Other soybean morphological characteristics evaluated were soybean height and height of first pod (Table 5). Plants were significantly taller in the 25 cm rows than in either the 50 or 75 cm rows,

Figure 1. Soybean yield as influenced by sicklepod density. Quincy (1980).

Symbols represent average of four replications.



$Y = 1902.50 - 226.10x + 8.92x^2$
$R^2 = 0.78$
C.V. = 23.1
● 25cm Row
★ 50cm Row
□ 75cm Row
SOYBEAN YIELD (kg/ha)
2500
2000
1500
1000
500
0
1
5
10
15
SICKLEPOD DENSITY/m^2

Figure 2. Soybean yield as influenced by sicklepod density. Gainesville (1980).

Symbols represent average of four replications.

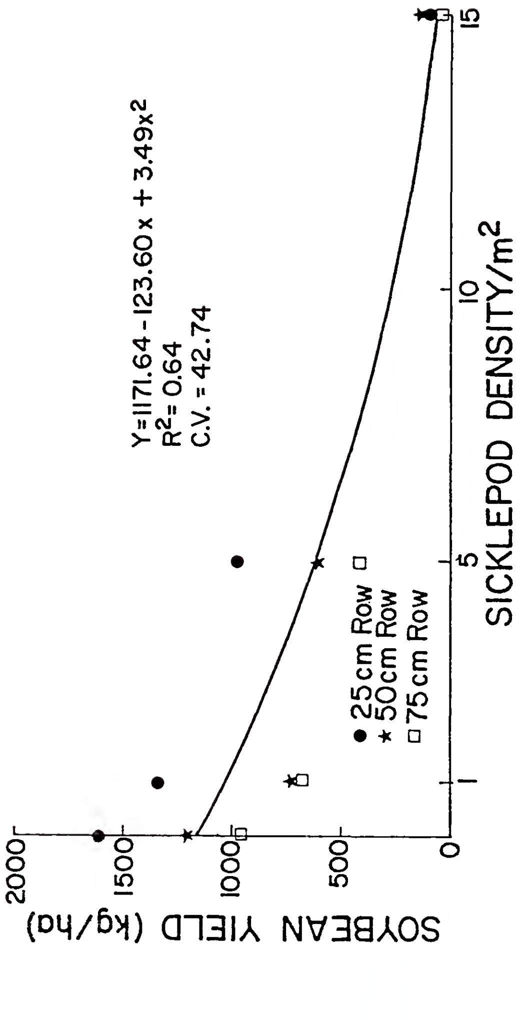

Y=1171.64-123.60x + 3.49x^2
R^2= 0.64
C.V. = 42.74
● 25cm Row
★ 50cm Row
□ 75cm Row
SOYBEAN YIELD (kg/ha)
2000
1500
1000
500
0
1
5
10
15
SICKLEPOD DENSITY/m^2

Figure 3. Soybean yield as influenced by sicklepod dry weight. Quincy (1980).

Symbols represent average of four replications.

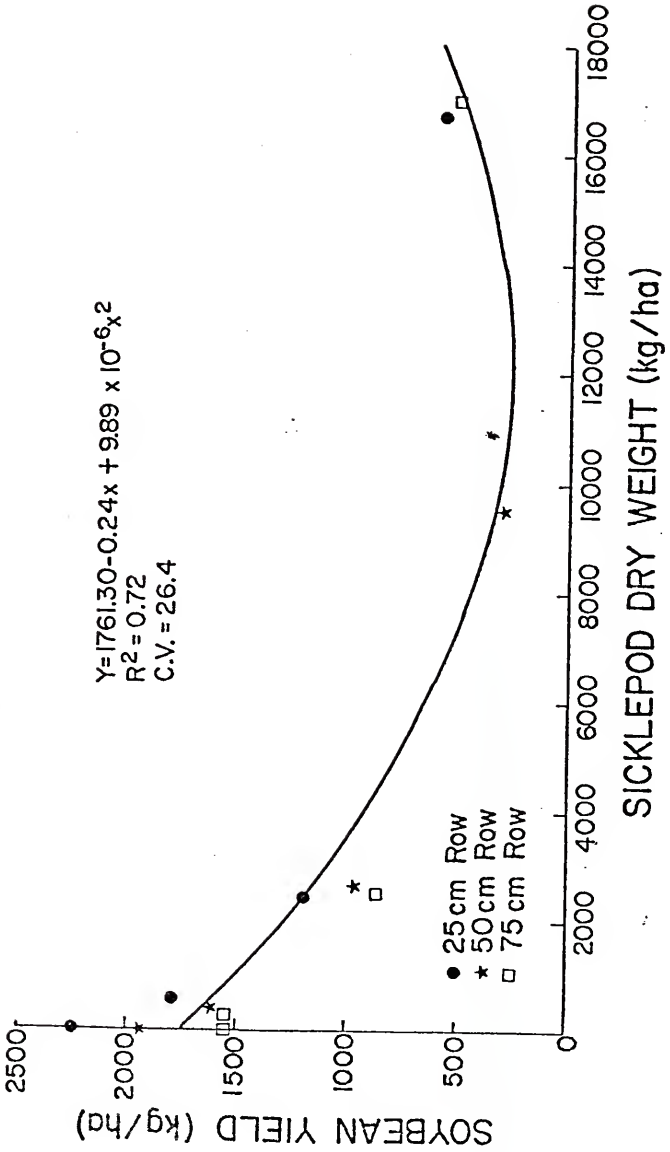

$Y=1761.30-0.24x+9.89\times10^{-6}x^2$
$R^2=0.72$
C.V.=26.4
● 25cm Row
★ 50cm Row
□ 75cm Row
SOYBEAN YIELD (kg/ha)
0
500
1000
1500
2000
2500
SICKLEPOD DRY WEIGHT (kg/ha)
2000
4000
6000
8000
10000
12000
14000
16000
18000

Figure 4. Soybean yield as influenced by sicklepod dry weight. Gainesville (1980).

Symbols represent average of four replications.

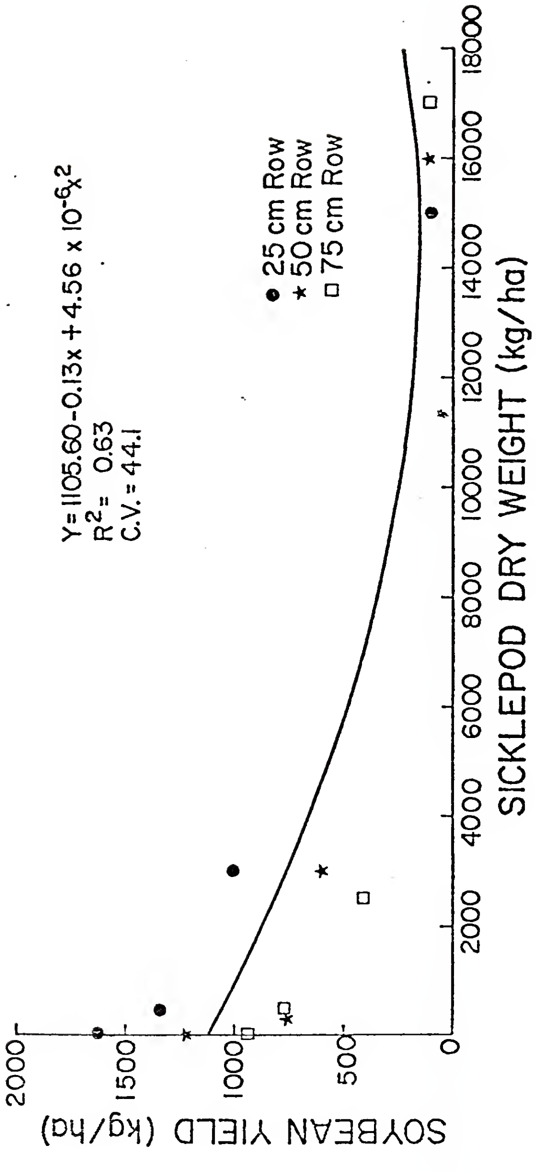

Y = 1105.60 - 0.13x + 4.56 x 10^{-6}x^2
R^2 = 0.63
C.V. = 44.1
● 25 cm Row
★ 50 cm Row
□ 75 cm Row
SOYBEAN YIELD (kg/ha)
0
500
1000
1500
2000
SICKLEPOD DRY WEIGHT (kg/ha)
2000
4000
6000
8000
10000
12000
14000
16000
18000

TABLE 5. Soybean Yield and Heights as Influenced by Soybean Row Spacing and Sicklepod Density in 1981. Gainesville.

Parameters	Soybean Yield[†] (kg/ha)	Soybean 1st Pod Ht. (cm)	Soybean Ht. (cm)
Row Spacing (cm)[Ψ]			
25	1537 a	19.1 a	73.6 a
50	1768 a	15.9 b	65.9 b
75	1670 a	14.3 b	67.5 b
Sicklepod/m^2			
0.0	2144 (a)	16.3 (a)	70.9 (a)
0.5	1743 (b)	15.7 (a)	68.9 (a)
1.0	1572 (b)	16.7 (a)	67.1 (a)
5.0	1175 (c)	17.2 (a)	69.0 (a)

[†] Means within columns within row spacings or within densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

[Ψ] Interaction of soybean row spacing x sicklepod population present.

while sicklepod densities did not significantly alter soybean height. The 25 cm rows also resulted in the soybean's first pod being significantly higher from the ground than the other rows, thus resulting in the possibility of less harvest loss associated with reduced row spacing.

Sicklepod dry weight (Table 6) was significantly lower in the 25 cm rows than in the 50 and 75 cm rows at each density. Again, however, the 50 cm rows resulted in the greatest dry weight which was not expected. Although not significant, the 50 cm rows on the average outyielded the 25 and 75 cm rows. Growing conditions for both the crop and the weed seemed to be at an optimum at this row spacing. On a per hectare basis, sicklepod dry weight increased as sicklepod density increased for each row spacing. This increase was 32 and 27% from low to intermediate density for the 25 and 50 cm rows, respectively. However, a 63% increase in sicklepod biomass resulted in the 75 cm rows. When yield was correlated to sicklepod dry weight, a curvilinear response was obtained with a coefficient of determination of only 0.24 (Fig. 5). Similar results were obtained between soybean yield and sicklepod density giving a R^2 of 0.43 (Fig. 6). These low correlations are indicative of the unfavorable growing conditions in 1981.

Water use did not differ between soybean row spacings or between weed densities at sampling times 4, 6, 7, 8, and 9 (Table 7). Water use was also not significant at these times between densities. Analysis of variance indicated a significant interaction between row spacing and density at sampling times 1, 2, 3, and 5. Interactions were only analyzed when water use across row spacing was greater than 100 millibars, thereby omitting sampling time 1. This procedure was followed because water reservoirs were sampledat readings below 100 millibars,

TABLE 6. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Dry Weight (kg/ha), 1981. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 [†]		
	0.5	1.0	5.0
25	$^{a}401^{e}$	$^{a}592^{e}$	$^{b}2300^{e}$
50	$^{a}1861^{f}$	$^{a}2577^{f}$	$^{b}7863^{g}$
75	$^{a}653^{e}$	$^{b}1975^{f}$	$^{c}5013^{f}$

[†] Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 7. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 25 cm depth, 1981. Gainesville.

Sampling Times†	1^{Ψ}	2^{Ψ}	3^{Ψ}	4	5^{Ψ}	6	7	8	9	$\overline{X}$
Row Spacing (cm)										
25	99	180	230	92 a	273	316 a	67 a	128 a	269 a	185 a
50	47	115	160	55 a	181	247 a	69 a	101 a	166 a	174 a
75	62	160	225	74 a	265	333 a	72 a	106 a	271 a	127 b
Sicklepod/m^2										
0.0	50	112	177	50 (a)	219	233 (a)	74 (a)	124 (a)	206 (a)	138 (a)
0.5	57	162	206	84 (a)	297	318 (a)	68 (a)	113 (a)	298 (a)	177 (ab)
1.0	57	121	185	57 (a)	153	296 (a)	70 (a)	99 (a)	244 (a)	142 (a)
5.0	130	210	252	105 (a)	289	347 (a)	66 (a)	112 (a)	193 (a)	189 (b)

[†] Means within a column within row spacings or within densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

[Ψ] Interaction of soybean row spacing and sicklepod populations exits.

Figure 5. Soybean yield as influenced by sicklepod dry weight. 1981.

Symbols represent average of four replications.

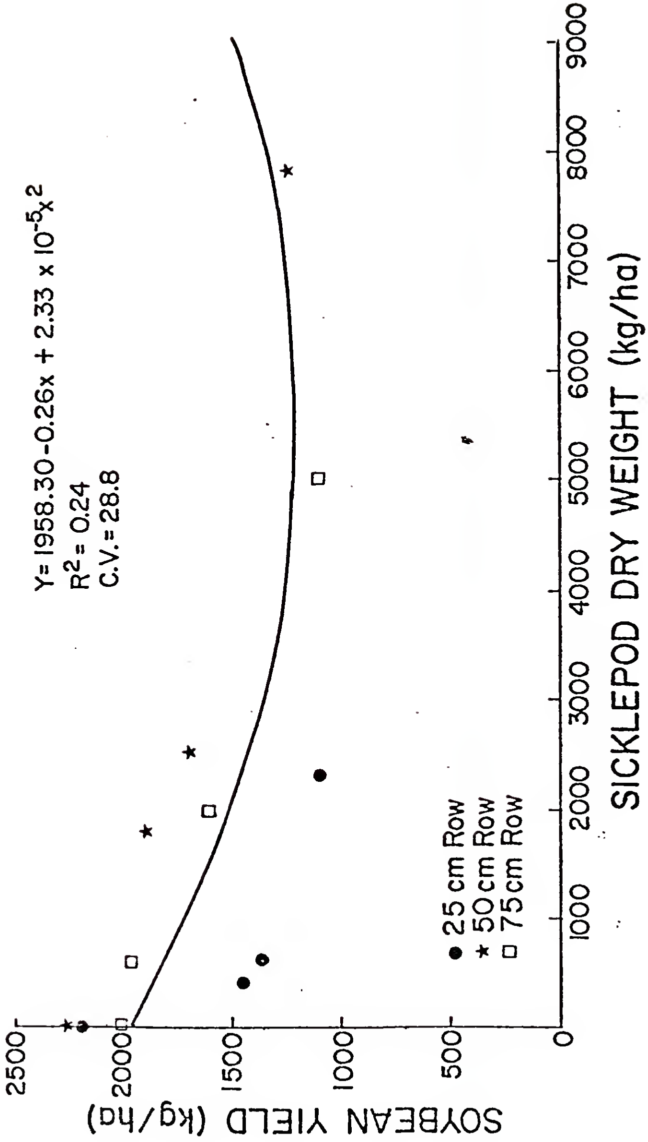
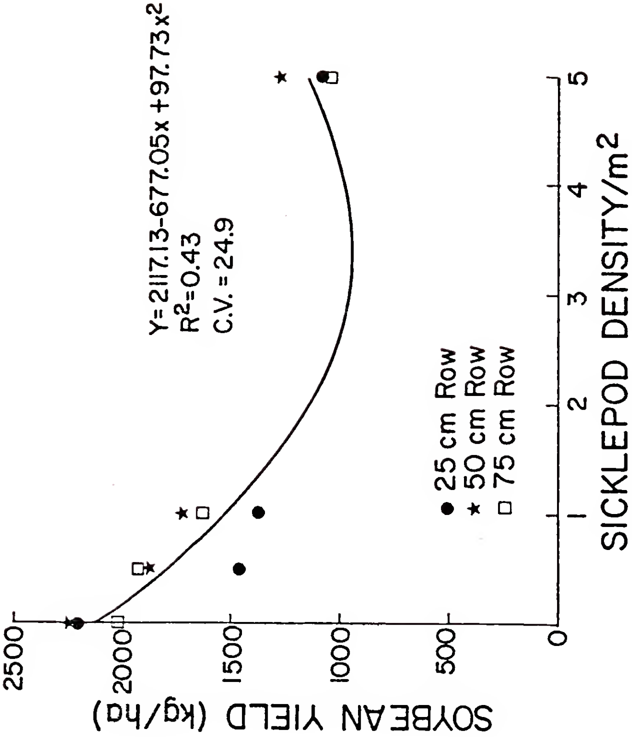

Y= 1958.30-0.26x + 2.33 x 10⁻⁵x²
R² = 0.24
C.V. = 28.8
● 25 cm Row
★ 50 cm Row
□ 75 cm Row
SOYBEAN YIELD (kg/ha)
2500
2000
1500
1000
500
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
SICKLEPOD DRY WEIGHT (kg/ha)

Figure 6. Soybean yield as influenced by sicklepod density. 1981.

Symbols represent average of four replications.


Y=2117.13-677.05x+97.73x^2
R^2=0.43
C.V.=24.9
● 25 cm Row
★ 50 cm Row
□ 75 cm Row
SOYBEAN YIELD (kg/ha)
2500
2000
1500
1000
500
0
1
2
3
4
5
SICKLEPOD DENSITY/m^2

thus no immediate competition for water was occurring. At sampling time 2 the 0.0 and 1.0 sicklepod densities showed no significant differences in water use among row spacings (Table 8). At 0.5 density, the 75 cm rows used more water than the narrow rows while at the 5.0 density the 25 cm rows used the most water. With 25 cm rows, water use was significantly greater only at the high weed density. There was no significant difference in water use between densities in the 50 cm rows while the 75 cm rows had increased water use only at the low sicklepod density. At sampling time 3 (Table 9) increasing sicklepod density did not increase water use except in the 25 cm rows where the medium and high densities are similar. Water use in the 25 cm rows was significantly higher than in the 75 cm rows at 0.0 and 5.0 densities. No difference occurred at the 0.5 and 1.0 densities. At sampling time 5 (Table 10) no significant difference among densities was found in the 50 cm rows. Water use in the 25 cm rows at 0.5 and 5.0 densities was greater than at 0.0 and 1.0 densities, whereas 0.0 and 5.0 density water use was not significantly different in the 75 cm rows. At this row spacing however, the greatest water use was at the 0.5 density. The mean water use (Table 7) of all row spacings shows that the 25 and 50 cm rows used significantly more water than the 75 cm rows. Across sicklepod densities, mean water use indicates that the high weed population used more water than the zero or medium density. However, after examining each sampling date where stress occurred (average above 200 millibars for at least one row spacing), there was no significant difference between the 25 and 75 cm rows. This indicates that during conditions where moisture is limited, narrow rows do not use more water but when water is plentiful the narrow rows are using water thus producing more

TABLE 8. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 25 cm depth. Sampling Time 2, 1981. Gainesville.

Row Spacing (cm)	Sicklepod Densities/m^{2} †			
	0.0	0.5	1.0	5.0
25	$^{a}95^{c}$	$^{a}137^{c}$	$^{a}128^{c}$	$^{b}359^{c}$
50	$^{a}111^{c}$	$^{a}120^{c}$	$^{a}115^{c}$	$^{a}115^{d}$
75	$^{a}131^{c}$	$^{b}231^{d}$	$^{a}120^{c}$	$^{a}156^{d}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 9. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 25 cm Depth. Sampling Time 3, 1981. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^{2} †			
	0.0	0.5	1.0	5.0
25	$^{a}141^{c}$	$^{a}209^{cd}$	$^{a}166^{c}$	$^{b}405^{c}$
50	$^{a}111^{c}$	$^{a}153^{c}$	$^{a}173^{c}$	$^{a}169^{d}$
75	$^{a}247^{d}$	$^{a}257^{d}$	$^{a}215^{c}$	$^{a}181^{d}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

photosynthate. Although this may or may not increase yields, it should increase early leaf area and therefore quicker canopy closure. In addition, when soil moisture is most critical, the period during flowering through pod fill (sample times 5-8), there were no significant differences between the 25 and 75 cm rows.

No significant correlation existed between mean water use and soybean yield. This is expected since high water use at field capacity would increase production while stress situations would decrease production if water use were high.

A parameter that could alter soybean competitiveness with sicklepod is canopy closure. The progression of canopy closure is shown in Table 11. At four weeks after planting, the 25 cm row canopy had a canopy closure of 83.7% which was significantly higher than the 50 and 75 cm rows which were 56.5 and 39%, respectively. Five weeks after planting, canopy closures in the 25 cm rows were still significantly higher than the other spacings. Canopy closure did not equalize between row spacings until ten weeks after planting. Five weeks were required for the 25 cm rows to reach 90% closure while the 75 cm rows required nine weeks.

Other sicklepod characteristics evaluated include sicklepod height, width, first branch height, seed per plant, and seed per hectare. Sicklepod height was not altered by row spacing or sicklepod density (Table 12). A significant interaction was detected between both row spacing and sicklepod density relative to sicklepod plant width (Table 13). A decrease in plant width occurred as density increased at all row spacings. Sicklepod width was also less in the 25 cm rows due to the competitive ability of the soybeans. The soybeans in the

TABLE 10. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 25 cm Depth. Sampling Time 5, 1981. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^{2} †			
	0.0	0.5	1.0	5.0
25	$^{a}167^{d}$	$^{b}226^{d}$	$^{a}193^{d}$	$^{b}407^{d}$
50	$^{a}199^{d}$	$^{a}167^{e}$	$^{a}172^{d}$	$^{a}184^{f}$
75	$^{b}290^{e}$	$^{c}397^{d}$	$^{a}95^{e}$	$^{b}277^{e}$

† Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 11. Effect of Soybean Row Spacing on Percent Canopy Closure, 1981. Gainesville.

Row Spacing (cm)	Weeks After Planting†						
	4	5	6	7	8	9	10
25	83 a	92 a	96 a	98 a	97 a	96 a	97 a
50	56 b	74 b	90 a	93 b	96 a	97 a	95 a
75	39 c	57 c	76 b	84 c	89 b	95 a	95 a

† Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 12. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Height (cm), 1981. Gainesville.

Parameters	Sicklepod Height †Ψ (cm)
Row Spacing (cm)	
25	118 a
50	135 b
75	128 b
Sicklepod/m^2	
0.5	169 (b)
1.0	172 (b)
5.0	167 (b)

† Means in a column within row spacings or within densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

Ψ No interaction exists between row spacings and sicklepod densities.

50 cm rows had the greatest plant width, the same row width which produced the most sicklepod dry weight. Sicklepod plants delayed lateral branch initiation in the 25 cm rows until breakthrough of the soybean canopy occurred (Table 14).

The effect of row spacing and sicklepod density on sicklepod seed production is shown in Table 15. In the 25 cm rows only the high density produced significantly greater weed seed. In the 50 cm rows the weed seed production in low and medium dersities was not significantly different but both did produce significantly less seed than the high density. As sicklepod density increased in the 75 cm rows, weed seed production also increased. At all densities, sicklepod seed per hectare was least in the 25 cm rows and greatest in the 50 cm rows. The 25 cm rows reduced sicklepod seed production an average of 76% compared to the 50 cm rows and 60% compared to the 75 cm rows. This reduction was due to soybean competition with the sicklepod.

One important competition variable is light. No significant difference was measured between light intercepted at the low and medium density in all row spacings (Table 16). Light interception was greatest at the high density of sicklepod in each row spacing. At each density the sicklepod intercepted the least light in the 25 cm rows. Over all densities the sicklepod in the 75 cm rows intercepted 75% more light than those in the 25 cm rows, while those in the 50 cm rows intercepted 67% more light than those in the 25 cm rows. A reduction in sicklepod biomass by soybean competition caused the reduction of light interception by sicklepod in the narrow row spacing.

TABLE 13. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Width (cm), 1981. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	0.5	1.0	5.0
25	$^{b}97^{e}$	$^{ab}84^{e}$	$^{a}73^{e}$
50	$^{b}176^{f}$	$^{ab}168^{g}$	$^{a}152^{g}$
75	$^{b}147^{g}$	$^{b}145^{f}$	$^{a}119^{f}$

† Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 14. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod 1st Branch Height (cm), 1981. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	0.5	1.0	5.0
25	$^{a}65.3^{e}$	$^{a}61.0^{e}$	$^{b}89.0^{e}$
50	$^{a}9.0^{f}$	$^{a}20.3^{f}$	$^{a}12.0^{f}$
75	$^{a}6.0^{f}$	$^{a}4.8^{g}$	$^{a}17.0^{f}$

† Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 15. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Seed (per ha), 1981. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 [†]		
	0.5	1.0	5.0
25	$^{a}5165^{e}$	$^{a}8550^{e}$	$^{b}31606^{e}$
50	$^{a}26469^{f}$	$^{a}34413^{f}$	$^{b}122193^{g}$
75	$^{a}10437^{e}$	$^{b}29212^{f}$	$^{c}79800^{f}$

[†] Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 16. Effect of Soybean Row Spacing and Sicklepod Densities on Percent Sicklepod Light Interception, 1981. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 [†]		
	0.5	1.0	5.0
25	$^{a}3.9^{e}$	$^{a}5.5^{e}$	$^{b}9.3^{e}$
50	$^{a}14.1^{f}$	$^{a}17.2^{f}$	$^{b}24.4^{f}$
75	$^{a}20.6^{g}$	$^{a}18.8^{f}$	$^{b}35.9^{g}$

[†] Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

Competition of Sicklepod with Soybeans--1982

Unlike the 1981 results, significant differences between soybean yields across row spacings were observed (Table 17). Yields in the 25 and 50 cm rows were significantly greater than those from the 75 cm rows. Growing conditions were excellent in 1982; therefore moisture stress was much less than in 1981. Yields increased 25% from 1981 to 1982 in the 25 cm rows while increasing only 12% in the 50 cm rows and no increase in the 75 cm rows. Soybean yield did not decrease significantly from the zero to low weed density. This was probably due to the increased rainfall in 1982. There was a 19% decrease in yield when sicklepod density increased from 0 to 0.5 weed/m^2 in 1981 and 13% decrease in 1980. Soybean height, as in 1981, was greatest in the 25 cm rows. Although taller, soybeans in the 25 cm rows were not subject to increased lodging. Sicklepod densities did not affect soybean height. Soybean first pod height was also greatest in the 25 cm rows and lowest in the 75 cm rows. This could increase harvesting efficiency. Sicklepod densities had no effect on first pod height.

Sicklepod dry weight was greatest at the high weed density for each soybean row spacing (Table 18). No significant difference in sicklepod dry weight between row spacing was observed at the low weed density. Sicklepod dry weight in the 75 cm rows was significantly greater than that in the 25 cm rows at the intermediate and high weed densities. Soybean yields were therefore greatest where sicklepod dry weight was the least. From 1981 (a dry year) to 1982 (a wet year), sicklepod dry weight increased 1% in the 25 cm rows while the yield increased 25%. For the 75 cm rows, sicklepod dry weight increased

TABLE 17. Soybean Yield and Characteristics as Influenced by Soybean Row Spacing and Sicklepod Density, 1982. Gainesville.

Parameters	Soybean Yield[†] (kg/ha)	Soybean 1st Pod Ht. (cm)	Soybean Ht. (cm)
Row Spacing (cm)			
25	2054 a	17.6 a	68 a
50	2013 a	14.2 b	59 b
75	1663 b	11.6 c	59 b
Sicklepod/m^2			
0.0	2458 (a)	13.9 (a)	65 (a)
0.5	2264 (a)	14.9 (a)	62 (a)
1.0	1905 (b)	14.6 (a)	61 (a)
5.0	1012 (c)	14.6 (a)	60 (a)

[†] Means within a column within row spacings or sicklepod densities followed by the same letter do not differ significantly at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 18. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Dry Weight (kg/ha), 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	0.5	1.0	5.0
25	$^{a}285^{e}$	$^{a}660^{e}$	$^{b}2600^{e}$
50	$^{a}1129^{e}$	$^{a}1383^{ef}$	$^{b}7688^{f}$
75	$^{a}811^{e}$	$^{a}2295^{f}$	$^{b}10088^{g}$

[†] Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

42% while yield did not increase. Thus in the 25 cm rows, the additional water would appear to be utilized more efficiently by the soybeans while in the 75 cm rows, the sicklepod was using the additional water. These results indicate that narrow row soybeans in a dry growing season yield similarly to the wide rows. However, in a wet growing season, narrow rows may be more beneficial.

A curvilinear response was obtained when yield was correlated to sicklepod dry weight (Fig. 7), and sicklepod density in 1982 (Fig. 8). A coefficient of determination of 0.81 and 0.74 was calculated for dry weight and density, respectively. These results indicate that dry weight of weeds is a more precise indicator of soybean yield than weed density. Teem (92) reported similar results with dry weight and density correlations.

Mean water use at the 25 cm depth was significantly greater in the 25 cm rows than in the 75 cm rows (Table 19). However, no difference was observed between 25 and 50 cm rows. When examining individual sampling time where stress was approached (average above 200 millibars for at least one row spacing) there was no significant difference between 25 and 75 cm rows 80% of the time. Thus indicating that even though the mean tensiometer value is greater during the 17 readings, in stress situations the narrow rows may not be depleting more soil moisture than the wide rows. This trend was also shown in the 1981 data (Table 7). Mean water use across sicklepod densities revealed that only the high weed population used significantly more water. This is not surprising considering the heavy rainfall in the 1982 growing season.

Figure 7. Soybean yield as influenced by sicklepod dry weight. 1982.

Symbols represent average of four replications.

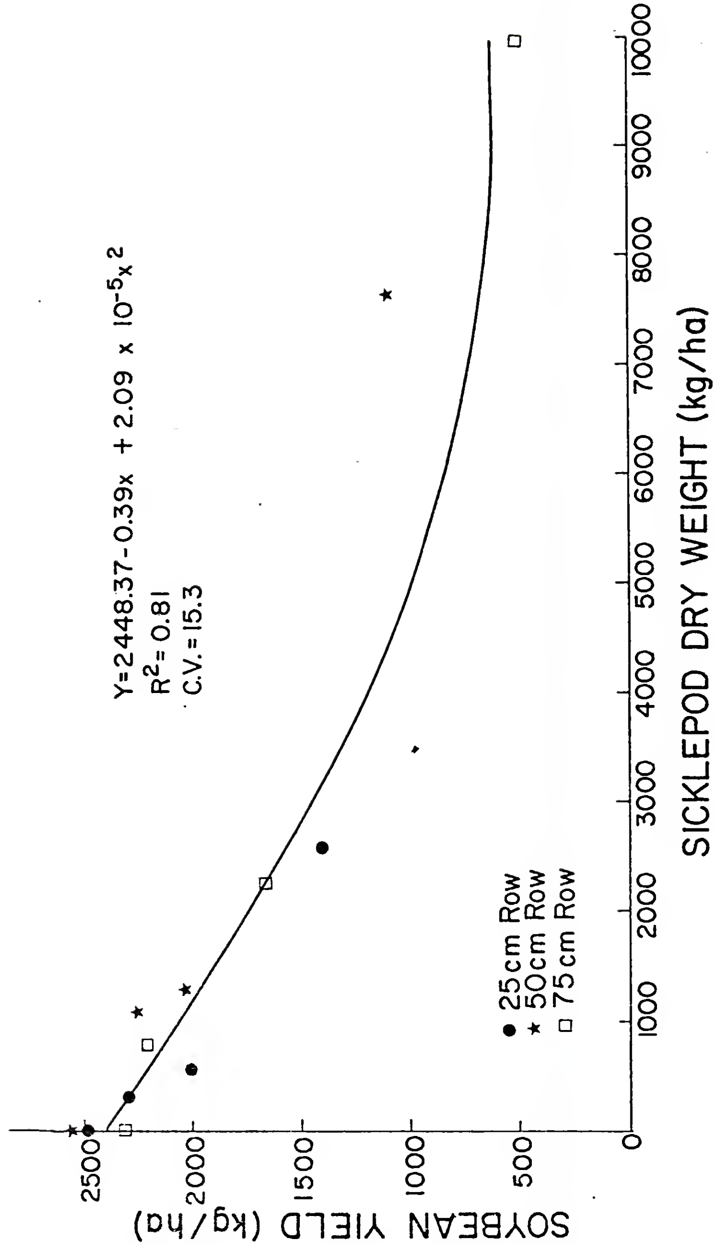

Y=2448.37-0.39x +2.09 x 10^{-5}x^2
R^2= 0.81
C.V.= 15.3
● 25 cm Row
★ 50 cm Row
□ 75 cm Row
SOYBEAN YIELD (kg/ha)
2500
2000
1500
1000
500
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
SICKLEPOD DRY WEIGHT (kg/ha)

Figure 8. Soybean yield as influenced by sicklepod density. 1982.

Symbols represent average of four replications.

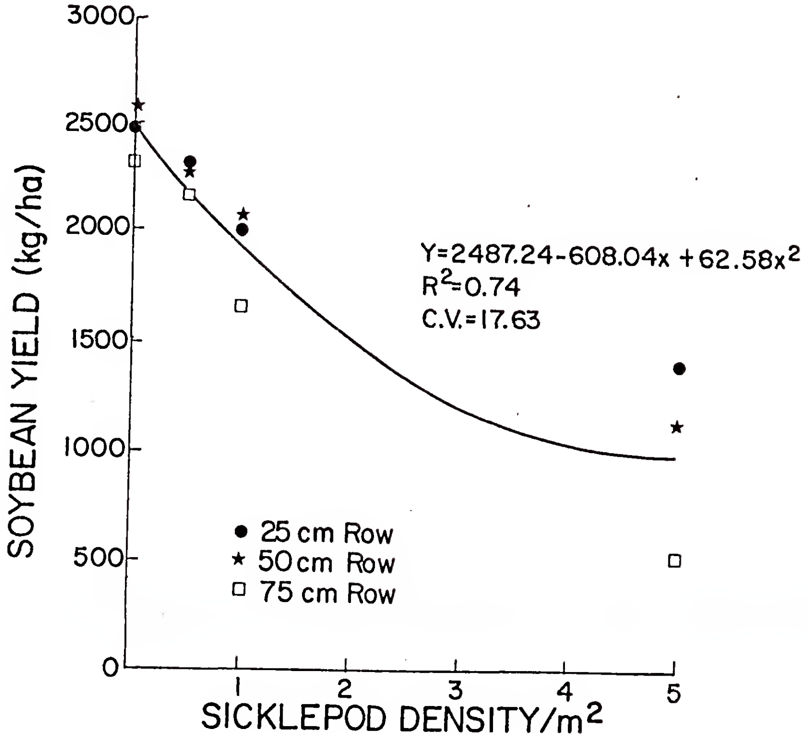

SOYBEAN YIELD (kg/ha)
3000
2500
2000
1500
1000
500
0
SICKLEPOD DENSITY/m^2
1
2
3
4
5
Y=2487.24-608.04x +62.58x^2
R^2=0.74
C.V.=17.63
● 25 cm Row
★ 50 cm Row
□ 75 cm Row

TABLE T9. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 25 cm Depth, 1982. Gainesville.

Sampling Times	1[†]	2	3	4	5	6	7	8	9
Row Spacing (cm)									
25	80 a	103 a	176 a	394 ab	301 a	404 a	265 ab	198 a	270 a
50	75 a	87 a	168 a	481 a	270 a	441 a	344 a	179 a	260 a
75	70 a	81 a	113 b	239 b	166 a	218 a	196 b	168 a	174 a
Sicklepod/m^2									
0.0	75 (a)	93 (a)	163 (a)	418 (a)	252 (ab)	327 (ab)	262 (a)	162 (a)	163 (a)
0.5	77 (a)	88 (a)	166 (a)	385 (a)	268 (ab)	350 (ab)	243 (a)	158 (a)	202 (ab)
1.0	73 (a)	83 (a)	135 (a)	338 (a)	142 (b)	225 (b)	225 (a)	180 (a)	258 (ab)
5.0	76 (a)	98 (a)	143 (a)	345 (a)	322 (a)	515 (a)	343 (a)	225 (a)	315 (b)

[†] Means in a column within row spacing or densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 19 - continued

Sampling Times	10[†]	11	12	13	14	15	16	17	$\overline{X}$
Row Spacing (cm)									
25	186 a	325 a	388 a	215 a	121 a	265 a	118 a	213 a	236 a
50	145 ab	323 a	365 a	201 a	135 a	216 a	78 a	103 b	227 a
75	110 b	140 b	270 a	140 a	80 a	173 a	110 a	119 b	151 b
Sicklepod/m^2									
0.0	110 (a)	197 (a)	275 (a)	130 (a)	103 (a)	195 (a)	85 (a)	147 (a)	185 (a)
0.5	122 (ab)	245 (a)	327 (a)	170 (a)	97 (a)	178 (a)	97 (a)	142 (a)	194 (a)
1.0	167 (ab)	267 (ab)	342 (a)	193 (a)	120 (a)	215 (a)	120 (a)	127 (a)	188 (a)
5.0	190 (b)	342 (b)	420 (a)	248 (a)	128 (a)	283 (a)	105 (a)	163 (a)	251 (b)

[†] Means in a column within row spacings or densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

At the 15 cm depth there was no significant difference in mean water use between 25 and 50 cm rows (Table 20), but the water use was greater than that for the 75 cm rows. Only 37% of the time was there no significant difference between the 25 and 75 cm rows during periods of stress as compared to 82% at the 25 cm depth. Difference in row spacing water use is greater at the 15 cm depth than at the 25 cm depth. Drying of the soil is faster at the shallow depth and the higher populations of soybeans in the 25 cm rows use the soil moisture at this depth more rapidly. However, at the growing season where soybean roots can utilize water in the 25 cm depth range, water use difference is not as great between the row spacings.

A significant interaction with the tensiometer measurements was present at sampling times 1, 2, 3, 13, 14, and 16 (Table 20). At sampling time 1 (Table 21) there was no significant difference in water use between row spacings at 0 and 0.5 densities. Density 1.0 showed higher tensiometer readings for the 25 and 50 cm rows than for the 75 cm rows and at 5.0 density the 25 cm row readings were greater than those from the 50 and 75 cm rows. Within row spacing, there was no significant difference between densities at 75 cm while only the 5.0 sicklepod/m^2 density was higher in the 50 cm rows. In the 25 cm rows the 0.0 and 0.5 densities were similar. At sample time 3 the 25 cm rows were greater than the 75 cm rows at 0.0 and 1.0 densities (Table 22). Within row spacing, there was no significant difference between densities in the 50 and 75 cm rows. In the 25 cm rows 0.5 and 5.0 sicklepod densities were greater than the 0.0 and 1.0 densities. At sampling time 17, as sicklepod density increased, water use did not increase for the 50 and 75 cm rows, but in the 25 cm rows water use in the low

TABLE 20. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 15 cm Depth, 1982. Gainesville.

Sampling Times	1[†] [Ψ]	2	3	4	5	6	7	8	9
Row Spacing (cm)									
25	168	99	249	474 a	353 a	343 a	153 a	98 a	273 a
50	128	84	168	357 b	258 ab	327 a	138 a	79 a	254 a
75	93	73	109	193 c	194 b	208 a	124 a	72 a	184 a
Sicklepod/m^2									
0.0	121	85	179	333 (a)	266 (a)	286 (a)	63 (a)	54 (a)	196 (a)
0.5	107	84	217	346 (a)	299 (a)	314 (a)	154 (a)	69 (a)	249 (a)
1.0	147	76	120	263 (a)	202 (a)	231 (a)	93 (a)	77 (a)	200 (a)
5.0	142	108	186	423 (a)	307 (a)	339 (a)	241 (b)	131 (b)	303 (a)

[†] Means in a column within row spacings or densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

[Ψ] Interaction of soybean row spacing and sicklepod populations exists.

TABLE 20 - continued

Sampling Times	10[†]	11	12	13[Ψ]	14[Ψ]	15	16[Ψ]	17	$\overline{X}$
Row Spacing (cm)									
25	101 a	295 a	318 a	88	78	208 a	88	159	208 a
50	108 a	277 a	313 a	97	67	158 a	91	132	178 a
75	98 a	194 b	153 b	76	56	160 a	96	108	129 b
Sicklepod/m^2							68		
0.0	60 (a)	194 (a)	200 (a)	60	56	202 (a)	79	137	136 (a)
0.5	101 (ab)	201 (a)	176 (a)	87	71	159 (a)	90	128	127 (a)
1.0	98 (ab)	293 (b)	256 (ab)	88	63	204 (a)	129	147	147 (a)
5.0	151 (b)	332 (b)	416 (b)	113	77	136 (a)		120	190 (b)

[†] Means in a column within row spacings or densities followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

[Ψ] Interaction of soybean row spacing and sicklepod populations exists.

TABLE 21. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 15 cm Depth. Sampling Time 1, 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †			
	0.0	0.5	1.0	5.0
25	$^{a}117^{e}$	$^{a}113^{e}$	$^{b}200^{e}$	$^{b}240^{e}$
50	$^{a}130^{e}$	$^{ab}117^{e}$	$^{a}178^{e}$	$^{b}87^{f}$
75	$^{a}117^{e}$	$^{a}92^{e}$	$^{a}63^{f}$	$^{a}100^{f}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 22. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 15 cm Depth. Sampling Time 3, 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †			
	0.0	0.5	1.0	5.0
25	$^{a}220^{e}$	$^{b}387^{e}$	$^{a}147^{e}$	$^{a}243^{e}$
50	$^{a}203^{e}$	$^{a}170^{f}$	$^{a}140^{e}$	$^{a}157^{f}$
75	$^{a}113^{f}$	$^{a}93^{g}$	$^{a}73^{f}$	$^{a}157^{f}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

and high sicklepod densities was significantly greater than water use at the zero and medium densities (Table 23). Water use at this time was significantly greater in the 25 cm rows compared to the 75 cm rows at the zero and medium sicklepod densities. The mean tensiometer reading across sicklepod densities was significantly higher only at the high density which is similar to the 25 cm depth.

The effect of soybean row spacing and densities on canopy closure for 1982 is shown in Table 24. At four weeks after planting, canopy closure was 74% in the 25 cm rows which was significantly greater than the 50 cm rows at 55% and the 75 cm rows at 38%. At five weeks the 25 cm rows had greater canopy closure than the 50 and 75 cm rows. Greater than 90% canopy closure occurred five weeks after planting in the 25 cm rows and not until seven and nine weeks for the 50 and 75 cm rows, respectively.

As in 1981, sicklepod height, width, first branch height, seed per plant and seed per hectare were measured. Sicklepod height increased as density increased in the 25 and 75 cm rows (Table 25). Sicklepod height in the 75 cm rows was greater than in the 25 cm rows at all densities. Sicklepod width was unaffected by density in each row spacing (Table 26). In the 25 cm rows, sicklepod width was significanly lower than the 50 and 75 cm rows at all densities. Sicklepod first branch height was greatest in the 25 cm rows indicating lateral branching was delayed until the soybean canopy was penetrated by the plant (Table 27).

Sicklepod seed per hectare increased significantly at the high sicklepod density for all row spacings (Table 28). At the medium and high densities, seed per hectare was significantly lower in the 25 cm

TABLE 23. Effect of Soybean Row Spacing and Sicklepod Densities on Soil Moisture (millibars) at 15 cm Depth. Sampling Time 17, 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †			
	0.0	0.5	1.0	5.0
25	$^{a}197^{e}$	$^{b}127^{e}$	$^{a}212^{e}$	$^{b}100^{e}$
50	$^{a}117^{f}$	$^{a}120^{e}$	$^{a}123^{f}$	$^{a}167^{f}$
75	$^{a}97^{f}$	$^{a}137^{e}$	$^{a}107^{f}$	$^{a}93^{e}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 24. Effect of Soybean Row Spacing on Percent Canopy Closure, 1982. Gainesville.

Row Spacing (cm)	Weeks After Planting†						
	4	5	6	7	8	9	10
25	74 a	91 a	97 a	99 a	97 a	98 a	97 a
50	55 b	72 b	88 a	95 a	95 a	98 a	96 a
75	38 c	49 c	70 b	83 b	89 b	94 b	96 a

†Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 25. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Height (cm), 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	0.5	1.0	5.0
25	$^{a}126^{e}$	$^{b}147^{e}$	$^{c}156^{e}$
50	$^{b}155^{g}$	$^{a}138^{e}$	$^{b}163^{e}$
75	$^{a}142^{f}$	$^{b}160^{f}$	$^{c}176^{f}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 26. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Width (cm), 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	0.5	1.0	5.0
25	$^{a}59^{e}$	$^{a}82^{e}$	$^{a}61^{e}$
50	$^{a}140^{f}$	$^{a}114^{f}$	$^{a}122^{f}$
75	$^{a}129^{f}$	$^{a}143^{g}$	$^{a}144^{g}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 27. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod 1st Branch Height (cm), 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	0.5	1.0	5.0
25	$^{a}70^{e}$	$^{a}68^{e}$	$^{a}71^{e}$
50	$^{a}29^{f}$	$^{a}15^{f}$	$^{b}47^{f}$
75	$^{a}13^{g}$	$^{a}18^{f}$	$^{a}15^{g}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 28. Effect of Soybean Row Spacing and Sicklepod Densities on Sicklepod Seed (per ha), 1982. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^2 †		
	0.5	1.0	5.0
25	$^{a}6021^{e}$	$^{a}12184^{e}$	$^{b}52725^{e}$
50	$^{a}15426^{e}$	$^{a}21090^{ef}$	$^{b}129675^{f}$
75	$^{a}15532^{e}$	$^{a}38333^{f}$	$^{b}168150^{g}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability as determined by Duncan's new multiple range test.

rows than in the 75 cm rows. There was no significant difference between row spacings at the low density. The 25 cm rows reduced sicklepod seed per hectare an average of 54% from the 50 cm rows and 66% from the 75 cm rows. The greatest sicklepod seed production was 168.15 million seeds/ha produced in the 75 cm rows at the high density.

The effect of soybean row spacing and sicklepod densities on percent light interception by sicklepod is shown in Table 29. In the 25 cm rows, light interception was significantly greater in the medium and high densities than in the low sicklepod density. In the 50 and 75 cm rows, the low and medium densities are similar but significantly lower than the high density. Sicklepod light interception was least in the 25 cm rows at the low and high densities and lower than the 75 cm rows at all densities. The sicklepod in the 75 cm rows on the average of all densities intercepted 78% more light than those in the 25 cm rows. The sicklepod in the 50 cm rows intercepted 42% more light than those in the 25 cm rows.

Herbicide Programs and Planting Date Studies

Effects of soybean row spacing and herbicide programs on soybean yield in 1981 are shown in Table 30. There was no significant difference in soybean yield among row spacings which is similar to the results obtained from the competition studies in 1981. For all herbicide treatments, no difference in soybean yield was found between trifluralin + metribuzin and trifluralin + metribuzin + toxaphene which were both greater than the check. Excellent weed control in the narrow rows (Table 31) seemed to mask the effect of the two treatments on soybean yield. Although the toxaphene treatment resulted in significantly

TABLE 29. Effect of Soybean Row Spacing and Sicklepod Densities on Percent Light Interception by Sicklepod. Gainesville.

Row Spacing (cm)	Sicklepod Density/m^{2}†		
	0.5	1.0	5.0
25	$^{a}2.4^{e}$	$^{b}12.7^{e}$	$^{b}13.7^{e}$
50	$^{a}10.8^{f}$	$^{a}13.7^{e}$	$^{b}26.6^{f}$
75	$^{a}32.1^{g}$	$^{a}39.1^{f}$	$^{b}53.3^{g}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 30. Effect of Soybean Row Spacing and Herbicide Programs on Soybean Yield, 1981. Gainesville.

Parameters	Soybean Yield[†] (kg/ha)
Row Spacing (cm)	
25	1610 a
50	1761 a
75	1623 a
Treatments	
Trifluralin + Metribuzin	2114 (a)
Trifluralin + Metribuzin + Toxaphene	2222 (a)
Check	658 (b)

[†] Means in a column within row spacings or treatments followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

greater weed control ratings than the preplant treatment alone at all row spacings, the actual differences were not great enough to decrease yield significantly. The 25 cm rows at all densities resulted in the best weed control. The trifluralin + metribuzin + toxaphene treatment provided excellent sicklepod control in both the 25 and 50 cm rows. An unexpected result was 39% reduction of sicklepod in the 25 cm rows receiving no herbicide application due to competition of the soybeans with sicklepod.

Directly affecting weed control is the rate of soybean canopy closure. At four weeks after planting the 25 cm rows had a canopy closure of 85% which is significantly greater than both 50 cm rows at 60% and the 75 cm rows at 34% (Table 32). The 25 cm rows were over 90% closed after only five weeks, whereas the 50 cm rows required seven weeks and the 75 cm rows needed nine weeks. The early canopy closure of the 25 cm rows is responsible for the excellent weed control with only a preplant herbicide treatment which gave early suppression of sicklepod. However, in the wide rows when additional sicklepod plants emerged, there were adequate light and space for the weed to become established.

In 1982, five planting dates were used and an additional herbicide treatment of alachlor + metribuzin. Soybean yield from different row spacings was affected at planting dates A and C while at planting date D no difference was found between the 25 and 75 cm rows. The 1982 competition test showed that the 25 and 50 cm rows produced significantly greater yields than the 75 cm rows. Nonuniform and low sicklepod populations resulted in the overall yields to be similar in planting dates C and D. It was expected that in both the early planting date A and late planting date E, narrow rows would result in a yield increase over the wide rows. However, this held true for only the late planting date E. In planting date B, where weed population was dense and uniform, the 25 and 50 cm yields were significantly greater than the 75 cm rows. There were no significant differences between herbicide treatments except when compared to the check in planting dates A, B, and E. In planting dates C and D the check was not significantly different from the preplant and preemergence treatments. This is indicative of the low weed density present in planting dates C and D areas (Table 33).

Weed control ratings for planting date A are shown in Table 34. There was no significant difference between the preplant and preemergence treatments at the 50 and 75 cm row spacings. Alachlor + metribuzin at a 9.9 rating was significantly greater than trifluralin + metribuzin at a 9.0 rating. Control with trifluralin + metribuzin + toxaphene was significantly better than that obtained with the preplant and preemergence treatments at all row spacings. Weed control in the 25 cm rows was excellent for all treatments. The 25 cm row check reduced sicklepod density by 40% due to soybean competition. Weed control in planting date B was similar to A except in the trifluralin + metribuzin treatment where the rating in the 75 cm rows was significantly lower than the 50 cm row in planting date B (Table 35). In general, as row spacing decreased, weed control increased with the exception of the toxaphene applications, where 100% control was obtained for all row spacing. However, toxaphene may not be available for use in soybeans in the future due to its banning by EPA.

TABLE 31. Effect of Soybean Row Spacing and Herbicide Programs on Sicklepod Control, 1981. Gainesville.

Row Spacing (cm)	Treatments†		
	Trifluralin + Metribuzin	Trifluralin+Metribuzin+ Toxaphene	Check
25	$^{a}9.0^{d}$	$^{b}10.0^{d}$	$^{c}3.9^{d}$
50	$^{a}7.1^{e}$	$^{b}9.4^{e}$	$^{c}0.0^{e}$
75	$^{a}5.6^{f}$	$^{b}7.7^{f}$	$^{c}0.0^{e}$

†Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 32. Effect of Soybean Row Spacing on Percent Canopy Closure, 1981. Gainesville.

Row Spacing (cm)	Weeks After Planting†						
	4	5	6	7	8	9	10
25	85 a	91 a	96 a	97 a	97 a	96 a	97 a
50	60 b	72 b	88 b	94 a	97 a	97 a	97 a
75	34 c	45 c	60 c	80 b	88 b	96 a	96 a

†Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 33. Effect of Soybean Row Spacing, Herbicide Programs, and Planting Date on Soybean Yield and Sicklepod Control, 1982. Gainesville.

Planting Dates	A May 3	B May 17	C May 31	D June 14	E June 28
	Yield (kg/ha)†	Yield (kg/ha)	Yield (kg/ha)	Yield (kg/ha)	Yield (kg/ha)
Row Spacing (cm)					
25	2229 a	1988 a	2105 a	2251 ab	1932 a
50	2117 a	1927 a	2200 a	2470 a	1809 a
75	2262 a	1574 b	1865 a	2061 b	1355 b
Treatments					
Trifluralin+Metribuzin	2464 (a)	1869 (a)	2030 (ab)	2210 (ab)	1814 (a)
Alachlor+Metribuzin	2501 (a)	1979 (a)	2075 (ab)	2232 (ab)	1754 (a)
Trifluralin+Metribuzin+Toxaphene	2449 (a)	2225 (a)	2389 (a)	2553 (a)	1859 (a)
Check	1396 (b)	1247 (b)	1732 (b)	2046 (b)	1366 (b)

†Means in a column within row spacing or treatments followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 34. Effect of Soybean Row Spacing, Herbicide Programs, and Planting Date on Sicklepod Weed Control. Planting Date A (May 3), 1982. Gainesville.

Row Spacing (cm)	Treatments[†]			
	Trifluralin + Metribuzin	Alachlor + Metribuzin	Trifluralin + Metribuzin + Toxaphene	Check
25	$^{a}9.0^{d}$	$^{b}9.9^{d}$	$^{b}10.0^{d}$	$^{c}4.0^{d}$
50	$^{a}6.3^{e}$	$^{a}6.5^{e}$	$^{b}10.0^{d}$	$^{c}0.0^{e}$
75	$^{a}5.7^{e}$	$^{a}4.3^{f}$	$^{b}10.0^{d}$	$^{c}0.0^{e}$

[†] Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 35. Effect of Soybean Row Spacing, Herbicide Programs, and Planting Date on Sicklepod Weed Control. Planting Date B (May 17), 1982. Gainesville.

Row Spacing (cm)	Treatments[†]			
	Trifluralin + Metribuzin	Alachlor + Metribuzin	Trifluralin + Metribuzin + Toxaphene	Check
25	$^{a}9.0^{d}$	$^{b}10.0^{d}$	$^{b}10.0^{d}$	$^{c}3.8^{d}$
50	$^{a}5.3^{e}$	$^{a}5.6^{e}$	$^{b}10.0^{d}$	$^{c}0.0^{e}$
75	$^{a}4.3^{f}$	$^{a}4.3^{f}$	$^{b}10.0^{d}$	$^{c}0.0^{e}$

[†] Means within a row preceded by the same letter, or means within a column followed by the same letter, are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

The effect of soybean row spacing on percent canopy closure for planting date A is shown in Table 36. There was no significant difference in canopy closure among row spacings at four weeks. At five weeks the canopy closure in the 25 and 50 cm rows was significantly greater than that of the 75 cm rows. The 25 cm rows reached 90% closure in six weeks while the 50 and 75 cm rows required seven and nine weeks, respectively. Planting date B (Table 37) canopy closure was more rapid than A. At four weeks the 25 cm rows had an 81% closure compared to only 47 and 35% for the 50 and 75 cm rows, respectively. The 25 cm rows obtained 90% closure at five weeks and the 75 cm rows required over ten weeks. Ninety percent closure was not achieved in planting date C until six weeks for the 25 cm rows, eight weeks for the 50 cm rows and nine weeks for the 75 cm rows (Table 38). Planting date D soybean canopy closure was further delayed for all row spacings (Table 39). The 25 cm rows did not achieve 90% canopy closure for seven weeks. At planting date E (Table 40) the narrow rows had 90% canopy closure at seven weeks. The 75 cm rows at ten weeks had only 81% closure. The narrow row canopy closure advantage was greatest at planting dates B and E which also is where the narrow rows yields are significantly greater than the yields of the wide rows.

TABLE 36. Effect of Soybean Row Spacing on Percent Canopy Closure. Planting Date A (May 3), 1982. Gainesville.

Row Spacing (cm)	Weeks After Planting[†]						
	4	5	6	7	8	9	10
25	59 a	74 a	90 a	97 a	98 a	98 a	99 a
50	48 a	62 ab	77 ab	91 a	97 a	98 a	98 a
75	45 a	56 b	64 b	79 b	85 b	93 a	97 a

[†] Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 37. Effect of Soybean Row Spacing on Percent Canopy Closure. Planting Date B (May 17), 1982. Gainesville.

Row Spacing (cm)	Weeks After Planting[†]						
	4	5	6	7	8	9	10
25	81 a	95 a	93 a	96 a	98 a	97 a	98 a
50	47 b	66 b	83 b	81 b	89 b	96 a	98 a
75	35 c	41 c	69 c	66 c	74 c	83 b	87 b

[†] Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 38. Effect of Soybean Row Spacing on Percent Canopy Closure. Planting Date C (May 31), 1982. Gainesville.

Row Spacing (cm)	Weeks After Planting[†]						
	4	5	6	7	8	9	10
25	67 a	69 a	92 a	89 a	98 a	98 a	98 a
50	56 b	47 b	70 b	82 b	94 a	97 a	99 a
75	36 c	43 b	65 c	67 c	74 b	94 b	97 a

[†] Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 39. Effect of Soybean Row Spacing on Percent Canopy Closure. Planting Date D (June 14), 1982. Gainesville.

Row Spacing (cm)	Weeks After Planting[†]						
	4	5	6	7	8	9	10
25	49 a	85 a	75 a	92 a	97 a	99 a	99 a
50	23 b	39 b	58 b	72 b	82 b	87 b	98 a
75	13 c	18 c	42 c	66 b	69 c	73 c	93 b

[†] Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

TABLE 40. Effect of Soybean Row Spacing on Percent Canopy Closure. Planting Date E (June 28), 1982. Gainesville.

Row Spacing (cm)	Weeks After Planting[†]						
	4	5	6	7	8	9	10
25	59 a	63 a	67 a	95 a	95 a	96 a	95 a
50	44 ab	53 a	56 a	87 b	93 a	93 a	94 a
75	31 b	30 b	38 b	62 c	73 b	76 b	81 b

[†] Means within a column followed by the same letter are not significantly different at the 5% level of probability, as determined by Duncan's new multiple range test.

SUMMARY AND CONCLUSIONS

Competition studies between soybeans and sicklepod were conducted from 1980-1982. In 1980 and 1982 soybean yields were significantly greater in the 25 cm rows than the 75 cm rows. There was no significant difference in yield between row spacings in 1981. Soybeans in 1980 were planted late; therefore the higher soybean populations of the narrow rows were advantageous. Soybeans in 1981 were planted at the appropriate time; however, low rainfall suppressed yields and treatment differences. While narrow row soybeans did not provide a yield advantage neither did they decrease yields. Growing conditions in 1982 were excellent. In this situation, yields from the 25 and 50 cm rows were significantly higher than from 75 cm rows. From 1981 to 1982, soybean yield increased 25, 12 and 0% for the 25, 50, and 75 cm rows, respectively.

Corresponding to these yield increases, sicklepod dry weight increased only 1% for the 25 cm rows, decreased 17% for the 50 cm rows, and increased 42% in the 75 cm rows. Conceding that these values cannot be statistically compared, a trend seems apparent. With ample moisture, the soybeans in the 25 cm rows effectively utilized the additional water while in 75 cm rows, sicklepod was able to increase its biomass dramatically at the expense of the crop. Soybean yield correlated well to sicklepod dry weight in 1982 giving a curvilinear response with a coefficient of determination of 0.81. Soybean yield significantly decreased as sicklepod density increased in 1980. In

1981, low and medium weed densities contained similar soybean yields, while in 1981 zero and low densities were not significantly different.

Mean plant water use was significantly greater in the 25 and 50 cm rows than in the 75 cm rows in both 1981 and 1982. However, under stress conditions there was no difference between the narrow and wide rows at the 25 cm depth in 1981. In 1982, no significant difference between the two were found 82% of the time. This indicates that at this depth, when under water stress, narrow rows do not use more water than wide rows. When water is plentiful, the narrow rows are utilizing more water and therefore are producing more photosynthate. At the 15 cm depth in 1982 narrow rows used more water in all conditions. The difference in row spacing water use is greater at the 15 cm depth than at the 25 cm depth. Soil evaporation plays a more important part in drying out at the 15 cm depth than at the 25 cm depth. Later in the growing season when soybean roots can utilize water at and below the 25 cm depth, soil evaporation may not be as important.

One of the most important aspects of narrow row soybeans may be the reduction of sicklepod seed production. The 25 cm rows reduced the sicklepod seed number per hectare 76% compared to 50 cm rows and 60% compared to 75 cm rows in 1981. The reduction in 1982 was similar with a 66% drop in seed from 25 to 75 cm rows. The average number of sicklepod seed per plant in 1982 was 2396. These results show that if one plant was allowed to mature and produce seed, yields would not suffer but sicklepod seed reserves in the soil would increase. In the 75 cm rows, there were over 15 million sicklepod seed per hectare produced at the low sicklepod density. Even if only 1% germinated the following year, there would be over 15,000 sicklepod plants per hectare to contend with. Since toxaphene will no longer be an option in the future, full season control would be a difficult task. Long term weed control needs to be examined further.

Along with water, one of the major growth factors in plant competition is light. In 1982, sicklepod in the 75 cm rows intercepted 78% more light than those in the 25 cm rows. Similar results were obtained in 1981 with 75% more light being intercepted. Sicklepod biomass was reduced dramatically by competition of the soybeans in the 25 cm rows. Not only would these small sicklepod plants intercept less light, but they present fewer problems at harvest than larger plants.

When herbicide treatments were evaluated, weed control improved as row spacing decreased. Trifluralin + metribuzin ppi gave 90% control of sicklepod in the 25 cm rows during 1982 compared to 53 and 43% control in the 50 and 75 cm rows, respectively. Alachlor + metribuzin created similar results with 100% control in the 25 cm rows compared to 56 and 53% in the 50 and 75 cm rows, respectively. Two applications of toxaphene gave 100% control at all row spacings. In the 25 cm row check, sicklepod was reduced 39% due to competition of the soybeans. Over 90% canopy closure was achieved in the 25 cm rows five weeks after planting at the recommended planting date. If the preplant or preemergence herbicides will suppress sicklepod emergence for four to five weeks, the soybean canopy in the 25 cm rows is capable of preventing serious competition.

This research indicates that soybeans planted in narrow rows may be beneficial in the management of weeds such as sicklepod. Future investigations into water use efficiency and light competition should be intensified. The low water holding capacity of Florida's sandy soils increases critical competition between crops and weeds for moisture. The effect of narrow rows on other weeds needs to be evaluated. Seldom does a grower only have a single weed species present. A multiple spectrum of weed populations is usually evident. Another area of research for the future might involve the evaluation of soybean cultivars for variation in competitive ability. Florida's climate is unique in that soybeans could be planted much earlier than in other states. Extreme early planting with early maturing varieties could possibly get a head start on emergence of some weeds.

In today's economy, only the efficient farmer will be successful. Narrow row soybeans may be one alternative for more efficient soybean production.

APPENDIX A

RAINFALL DATA
ARC, QUINCY, FLORIDA, 1980

DAY	MAY	JUNE	JULY	AUGUST	SEPTEMBER
1					.31
2	.05				
3					
4	.01			1.21	.18
5					.12
6					
7			.73		1.17
8	.23				
9	.40				
10	.19				
11					.37
12	.01			.01	
13					
14			.02	.26	
15	3.03			.42	
16	.55			.11	
17				.02	
18	.04				.34
19	.01				.52
20	.74	1.00	.36		
21					
22	.01	1.71		.03	
23	.87				
24	1.01	.18	.27		.51
25		.46	2.43		.01
26	.40	.87	1.88		
27			.36	.02	
28		.25	.63	.06	
29		.77	.07		.01
30			.08		.41
31				.01	
TOTAL	7.55	5.24	6.82	2.15	4.95

APPENDIX B

RAINFALL DATA
GAINESVILLE, FLORIDA, 1980

DAY	MAY	JUNE	JULY	AUGUST	SEPTEMBER
1	T				.11
2			T		T
3					.44
4	.02		.59		T
5	.30				
6					
7			.12		
8	.90		.04		.06
9	1.09				.18
10	T	.21		.38	T
11				.06	
12					.14
13			.54		
14					
15	T		.45	.29	
16	.48			.64	.04
17	.40				.23
18	.02	.06		.04	.55
19		.13	.21	.04	T
20		.03		T	
21	.16	.03		.52	
22	.59	.44	T		.01
23	.53	.02	.58	.72	.04
24		.15	1.57	.01	
25	.56	.16	2.51	.08	
26	.03	.59	.87	.09	
27		.01	.21		
28		.12			.60
29		.15	.97	.31	
30		.19			1.31
31					
TOTAL	5.08	2.29	8.66	3.18	3.71

APPENDIX C

RAINFALL DATA
GAINESVILLE, FLORIDA, 1981

DAY	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.
1				.03		
2		.75				
3		.01		.40		
4						
5		.40		1.19		
6	.05	.21			.03	
7			.01	.12	.04	
8			.56		.05	.05
9			.32	.10		
10						
11		1.35		.06	.32	.08
12				.14		
13		.57	.27			
14			.57	.02		
15						
16					.45	
17			.40		.05	
18		1.20		.04	.16	
19		.66				.12
20		.90		.49		
21		.01	.02			
22						
23			.03	.25		
24						.03
25						.50
26		.70				T
27	.78	.03				.03
28				1.04		
29				.05		
30			.55	.80		T
31				.25		
TOTAL	.83	6.79	2.73	4.98	1.10	.81

APPENDIX D

RAINFALL DATA
GAINESVILLE, FLORIDA, 1982

DAY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1				.60		
2						.51
3				.07		.79
4						
5	.33					.16
6	1.38	T			.16	.01
7	.56	1.89	.04		.19	
8		3.89			.05	.05
9		.14			.28	
10					.05	T
11		1.68				.01
12				2.00	.09	.03
13						
14						.03
15					2.20	
16					.04	.54
17		.02		.32		.13
18		.02		2.76	.10	.80
19	.07				1.18	T
20					.82	.20
21				.13	.06	.05
22	.01		.08	.08	.01	2.54
23	.37	T	1.38	1.06	.63	.05
24	.17	T	.14	.25	.16	
25	1.03	.17	.10	.43		
26	.11	.91	.04	.92	.03	
27		.01		.07	.42	.14
28	.38		.17		.29	
29	1.01				T	.14
30			.22			
31			.94			
TOTAL	5.42	8.73	3.11	8.69	6.76	6.18

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BIOGRAPHICAL SKETCH

Jerry Holland Jordan, Jr., was born August 1, 1956, in Tupelo, Mississippi. He graduated from Tupelo High School in June, 1974. In September 1974, he entered Itawamba Junior College, Fulton, Mississippi, and received his Associates of Arts degree in May, 1976.

In September 1976, he entered Mississippi State University and received the Bachelor of Science degree in plant pathology and weed science in 1978. He received his Master of Science degree in weed science from Mississippi State University in 1980. Since that time he has been enrolled in the Graduate School of the University of Florida to pursue the degree of Doctor of Philosophy with a major in agronomy.

J. Holland Jordan is married to the former Lisa Griffin and they have two children, April Michelle and Brett Holland.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Wayne L. Currey

W. L. Currey, Chairman
Associate Professor of Agronomy

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

David H. Teem

D. H. Teem
Associate Professor of Agronomy

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

B J Brecke

B. J. Brecke
Associate Professor of Agronomy

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

D. C. Herzog
Associate Professor of Entomology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

D. H. Hall

D. H. Hall
Associate Professor of Botany

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

C. K. Hiebsch

C. K. Hiebsch
Assistant Professor of Agronomy

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

April, 1983

Jack L. Fry

Dean, College of Agriculture

Dean for Graduate Studies and Research