Chapter 4

INTERFERENCE OF WEEDS WITH COTTON

Harold D. Coble and John D. Byrd
North Carolina State University
Raleigh, North Carolina

INTRODUCTION

The term "interference", as applied by the weed scientist, is used to define the negative influence plants exert on each other when growing in association. With respect to weeds growing in cotton, the term is most commonly used to describe the effect of weeds on the crop, although the crop certainly can have detrimental effects on weed populations as well (Street *et al.*, 1981). Weed interference in cotton can be separated into two components: competition and allelopathy.

Competition may occur when two or more plants growing in close proximity to each other draw on the same, limited-supply resource pool. The resources plants may compete for include water, nutrients, light and carbon dioxide. Under certain circumstances, oxygen and space may be considered as resources for plant growth as well. Theoretically, if all resources could be available in unlimited supply, then competition would not occur.

Allelopathy, on the other hand, results when one plant introduces into the environment a substance which is detrimental to other plants in its area of influence. Allelopathic substances are usually complex organic compounds and may be exuded from roots or leached from leaves of living plants or they may result from decaying plant residues.

In field situations, the relative contributions of competition and allelopathy to total interference are very difficult to separate, and little scientific evidence has been presented to support an allelopathic effect of weeds on cotton in the field. One weed species, unicorn-plant, has been reported as containing plant growth substances which could be removed in the laboratory by steam distillation and then applied to cotton causing growth inhibition (Riffle *et al.*, 1987). Similar effects are reported from smooth pigweed extracts (Munger *et al.*, 1984).

Production losses associated with weeds in cotton also include the disruption of management practices for other pests and crop quality reductions caused by weed residues in the harvested crop. Direct interception of insecticide and growth regulator sprays by weeds may cause reduced efficacy from these products and make additional applications necessary. Weeds present in the crop during harvest, especially grasses, contribute to cotton grade reductions through their physical presence as trash in the lint or lint staining.

COMPETITIVE EFFECTS OF WEEDS ON COTTON

The net effect of weed competition on cotton is a reduction in the quantity of marketable products, lint and seed, usually through a reduction in the number of bolls per plant (Arle and Hamilton, 1973), although occasionally boll weight and seed number per boll are affected (Arle and Hamilton, 1975). It is this effect on yield that the producer is most concerned with. However, it is sometimes important to understand how and when weed competition occurs in order to plan the most efficient management programs. Timing of control practices, especially cultivation and herbicides, may be critical with many species in order to avoid crop loss.

WEED SPECIES EFFECTS

As with other crops, the degree of competitive damage to cotton caused by a weed population is a function of the species composition, density, and duration of that population. Certain weed species are more competitive than others with cotton because of differences in growth habit. A comparison of the relative competitive abilities of 18 broadleaf weed species with cotton is presented in Table 1. Common cocklebur, with its tall growth habit and large leaves, is the most competitive weed in cotton with nearly nine percent loss in cotton yield resulting from one weed per 30 feet of crop row (Snipes *et al.*, 1982). The next most competitive group of weeds caused from 4.7 to 6.1 percent yield loss per weed per 30 row-feet and included smooth pigweed (Stuart *et al.*, 1984), wild okra and unicorn-plant (Bridges and Chandler, 1984), and tumble pigweed (Rushing *et al.*, 1985b). A group of 11 weed species were reported to cause losses ranging from 1.7 to 3.7 percent per weed per 30 row-feet (Table 1), while prickly sida was the least competitive of the species studied causing only 0.26 percent yield loss at the same weed population (Buchanan *et al.*, 1977). In this comparison, all of the weeds were allowed to compete with the crop for the entire growing season.

Most studies on weed competition have been conducted by comparing only one weed species at a time in the crop. While this information is most useful, very few fields are infested with only one weed species. More studies such as those of Snipes *et al.* (1983) and Street *et al.* (1985) should be conducted in which mixtures of weed species were evaluated with respect to their influence on the crop.

Cotton yield losses associated with certain perennial weeds are difficult to assess on a per-weed basis. Such perennials as bermudagrass and hogpotato are most often found in patches in a field, with the patches consisting of nearly total ground cover. Brown *et al.* (1985) reported losses of 60 to 80 percent resulting from full-season competition with bermudagrass at full ground cover. Hogpo-

Table 1. Relative competitive abilities of selected annual broadleaf weeds in cotton expressed as percent crop yield loss from one weed per 30 row-feet.

Species	Cotton yield loss per weed per 30 row-ft	References
	(%)	
Common cocklebur	8.85	Snipes *et al.*, 1982
Pigweed, smooth	6.06	Stuart *et al.*, 1984
Wild okra	5.33	Bridges and Chandler, 1984
Unicorn-plant	5.03	Bridges and Chandler, 1984
Pigweed, tumble	4.66	Rushing *et al.*, 1985b
Hemp sesbania	3.68	Bryson, 1987
Buffalobur	3.43	Rushing *et al.*, 1985a
Morningglory, tall	3.43	Crowley and Buchanan, 1978
Spurred anoda	2.90	Chandler, 1977
Sicklepod	2.79	Buchanan *et al.*, 1977
Velvetleaf	2.66	Chandler, 1977
Morningglory, entireleaf	2.21	Crowley and Buchanan, 1978
Pigweed, redroot	2.16	Buchanan *et al.*, 1980
Coffee senna	1.87	Higgins *et al.*, 1986
Morningglory, ivyleaf	1.71	Crowley and Buchanan, 1978
Morningglory, pitted	1.71	Crowley and Buchanan, 1978
Jimsonweed	1.01	Oliver *et al.*, 1981
Prickly sida	0.26	Buchanan *et al.*, 1977

tato, a broadleaf perennial found in cotton in Oklahoma, has been reported to cause up to 39 percent yield loss at full ground cover (Castner *et al.*, 1987). The most widespread perennial weeds in cotton are johnsongrass and yellow nutsedge, with both weeds found over the entire cotton growing area. Johnsongrass is the most competitive of the perennial weeds studied, with yield losses of 40 percent reported from infestations of eight johnsongrass plants per 30 feet of row (Bridges and Chandler, 1987; Reynolds *et al.*, 1983). Keeley and Thullen (1981) reported cotton yield loss of nearly one percent for every johnsongrass stem per 10 square feet. Yellow nutsedge, with loss figures in the range of 0.5 percent per plant per 3 feet of row, is less competitive than johnsongrass (Keeley and Thullen, 1975, 1983; Patterson *et al.*, 1980).

WEED DENSITY EFFECTS

In general, the effect of weed density on cotton yield is linear and additive at low weed populations where weeds act independently, and becomes curvilinear at higher weed populations when intraspecific interference among weeds becomes a factor. However, in certain situations the effect of weed density on crop yield may be sigmoidal. In these circumstances, resources may not be limiting at low weed populations so that no competition can occur. As weed populations increase, resources become limiting and competition begins, in a linear and additive relationship. At high weed populations, intraspecific competition among weeds becomes a factor and the degree of crop loss per weed becomes less, thus the sigmoidal relationship. Bridges and Chandler (1987) illustrated this relationship with johnsongrass influence on cotton. The sigmoidal relationship usually occurs only with those weed species which do not compete aggressively for light with the crop. Any weed species which grows taller than the crop would limit light availability, thus causing competition even at low weed populations, resulting in the linear and additive effect on crop yield (Figure 1).

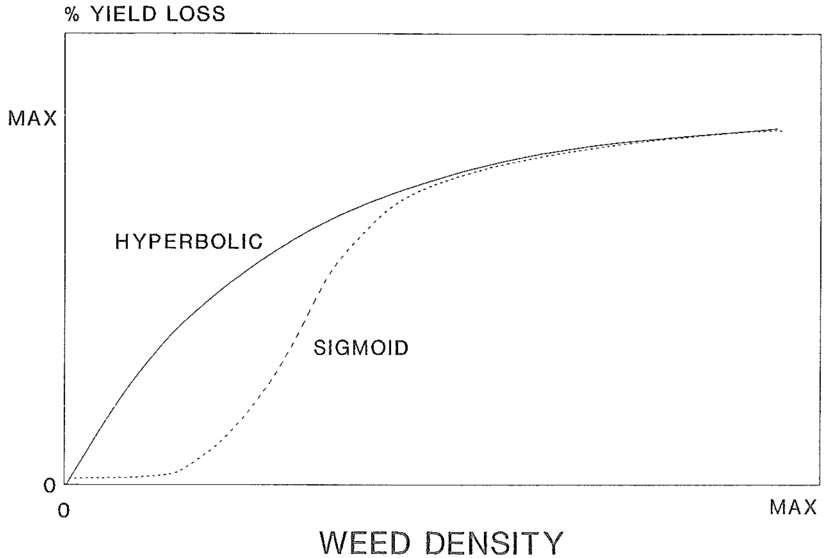

Figure 1. Comparison of the sigmoid shape curve with the hyperbolic shape showing no competitive effect at low weed populations in the sigmoid relationship versus an immediate competitive effect in the hyperbolic curve.

WEED DURATION EFFECTS

The duration of a weed population is probably as important in determining the degree of crop loss caused by weeds as is density. Weeds that emerge at the same time or before the crop are more competitive and cause greater crop loss than those that emerge later (Chandler, 1977; Buchanan *et al.*, 1980; Keeley *et al.*, 1986). Generally, cotton must be kept weed-free for 4 to 8 weeks after emergence in order to avoid crop loss. The more competitive the weed species, the longer the crop must be kept weed-free. Cotton kept free of prickly sida and velvetleaf or spurred anoda for 4 weeks yielded as well as that kept free of weeds for the entire growing season(Chandler, 1977). However, weed-free periods of at least 8 weeks were required to prevent losses from morningglory (Keeley *et al.*, 1986) and johnsongrass (Bridges and Chandler, 1987).

In situations where weed control is to be practiced postemergence, the length of time that a weed population can remain in the crop without causing a yield reduction depends on the weed species and density. The more competitive species and higher densities must be removed earlier in the crop cycle than less competitive species and lower weed densities. As little as 3 to 4 weeks of johnsongrass competition caused significant yield loss (Bridges and Chandler, 1987), whereas 6 to 7 weeks of prickly sida competition could be tolerated without yield loss (Buchanan *et al.*, 1977).

COMPETITION FOR RESOURCES

Environmental resources for which plants may compete include light, water, nutrients, carbon dioxide, oxygen and space. In a cropping situation such as cotton culture, space is usually not considered a limiting factor since the crop stand is optimized for yield and not number of plants per unit area. In addition, weed control is usually sufficient to keep weed numbers far below the theoretical maximum for the area. In waterlogged soils, oxygen is sometimes limited temporarily. However, soil oxygen levels are usually considered not limiting for plant growth. Likewise, in a field setting, carbon dioxide levels are usually held fairly constant by natural air movements. Therefore, the main environmental resources which are likely to be limiting for plant growth in a cotton/weed association are water, nutrients and light.

Water—At some point during the growing season, water is usually limiting for plant growth except on adequately irrigated fields. Wells *et al.* (1984) found that common cocklebur growing in competition with cotton caused reduced cotton leaf water potential in non-irrigated plots but not in irrigated plots. In that same study, cotton lint yield was reduced 81 percent in dry plots compared to 62 percent reduction in irrigated plots. This study indicates that water was not the only factor involved in the competitive relationship, but certainly played a significant role in the crop yield reduction caused by the weed. In previous studies, Stuart *et al.* (1984) examined the influence of smooth pigweed on cotton water relations and found reduced cotton leaf water potential at weed populations as low as one weed per 2.4 feet of row in non-irrigated fields. In this study, smooth pigweed was able to extract water from deeper in the soil profile than was cotton, thus making the weed a better competitor for limited water than cotton. James *et al.* (1977), found no competition for water between cotton and four species of morningglories under well-watered conditions. Thus it appears that weeds compete effectively with cotton for water under conditions in which water is in limited supply.

Nutrients—In most cropping situations where fertilizer is applied on a regular basis, plant nutrients are usually not limiting with respect to crop yield potential. In cotton production, nitrogen applications are limited to some degree in order to avoid excessive vegetative plant growth. Under these conditions of limited fertilizer applications, weeds have been shown to compete for nitrogen. Robinson (1976a) showed that the effect of high weed populations (100 percent ground cover) could be offset to some degree by adding additional nitrogen above the recommended rate for the area. Likewise, adding twice the normal rate of nitrogen overcame the yield loss caused by a weed population at one-half the natural population. On the other hand, Buchanan and McLaughlin (1975) found that nitrogen levels had no effect on the cotton/weed relationship. Whether or not competition for nutrients occurs between cotton and weeds probably depends on a number of factors, including weed species, soil moisture status, weed population level, relative emergence dates of the crop and weeds and placement of weeds relative to the crop row (Robinson, 1976b).

Light—Since sunlight is a limited resource, any weed that grows taller than cotton will shade the crop, thus effectively competing for available light. Cotton has been shown to be relatively intolerant to shade, with even high numbers of cloudy days leading to shedding of squares and bolls (Goodman, 1955; Mason, 1922). Shading by tall-growing weeds has been highly correlated with square and boll abscission as well (Hearn, 1976; Guinn, 1982). In a study aimed primarily at elucidating competitive relationships for water, Stuart *et al.* (1984) found that late in the growing season, smooth pigweed reduced the total light reaching the cotton canopy by 90 percent, resulting in a 62 percent lint yield reduction. This yield reduction was attributed to light interference since the plots were irrigated to avoid competition for water. Additional evidence of light competition has been presented by Andries *et al.* (1974) when they showed that normal leaf cotton was more competitive with weeds than okra-leaf or super okra-leaf cultivars. These narrow-leaf types allowed more light to reach the weeds resulting in more weed growth, especially at wide row spacings.

Several weeds have been shown to utilize light more efficiently than cotton (Patterson *et al.*, 1978), and are able to gain a height advantage over the crop in a relatively short time. Chandler (1977) showed that velvetleaf and spurred anoda were both nearly 50 percent taller than cotton by 10 weeks into the growing season, thus competing very effectively with the crop for light. Both weed species caused significant yield reductions in the crop. Venice mallow, however, never grew as tall as the cotton and caused no yield reduction. The growth and development of yellow nutsedge has been shown to be reduced due to light interception by cotton if the crop emerges before the weeds (Keeley and Thullen, 1978). Most studies have shown that removal of weeds by 6 to 8 weeks after crop emergence in cotton will eliminate yield losses. This seems to be sound evidence that light is the most important resource in plant competition.

ENVIRONMENTAL AND CULTURAL EFFECTS ON COMPETITION

The relative competitive abilities of both crops and weeds may be influenced to a great extent by environmental conditions. Temperature, even within the range of normal crop growth, can influence resource capture and utilization by all plants. Cotton is particularly suited to warm weather, and often grows very slowly early in the season because of cool weather. Several studies have shown most weeds to be more tolerant of cool weather than cotton, with the crop growth rate reduced far more than that of the weeds at lower temperatures (Flint *et al.*, 1983; Patterson and Flint, 1979; Potter, 1976). This differential growth rate between the crop and weeds allows the weed population to gain a competitive advantage earlier in the growing season, thus becoming even more competitive than it otherwise might be. Soil type is another factor affecting the expression of weed competition in cotton. Coarse textured soils with inherently low water and nutrient holding capacities obviously lead to competition for these two resources more readily than the finer textured soils. Also, soils which tend to form hardpans may alter the competitive relationships by severely restricting root growth.

Geographic region has been shown to exert an effect on relative competitive abilities of weeds in cotton (Oliver *et al.*, 1981). The effect of geographic region is usually one of differential weather and soil patterns. However, it is certainly possible that weeds may grow more aggressively in one latitude than in another simply due to daylength.

Changing cultural practices such as row spacing and crop cultivar may alter the competitive relationship between cotton and weeds. Several studies have shown that narrow row spacings will lead to decreased weed competition late in the season if weeds are kept out of the field for the first 3 to 4 weeks of the crop cycle (Andries *et al.*, 1974; Rogers *et al.*, 1976; Street *et al.*, 1981). Narrow rows lead to a full crop canopy sooner and shifts the competitive edge for light in favor of the crop. Unless weeds are kept out of the crop with some early-season control measure, there is no advantage to the narrow rows. Cotton cultivars that either grow taller or have more dense foliage are better competitors for light than other types (Chandler and Meredith, 1983). However, regardless of the cultivar, early-season weed control is necessary since the cultivar effect of increased shade is effective only after light competition begins, usually around 8 to 10 weeks after emergence. In general, any cultural practice which leads to a faster growing crop will give the crop a competitive advantage over weeds. Cotton is especially sensitive in this respect since it grows very slowly early in the season unless conditions are very favorable, and weeds most often have the advantage.

ALLELOPATHIC EFFECTS OF WEEDS ON COTTON

Certain weeds seem to cause greater crop yield loss than can easily be accounted for by competition. One such weed, unicorn-plant, has been found to contain compounds which can be extracted by laboratory procedures that are very inhibitory to cotton growth (Riffle *et al.*, 1987). Whether or not these same compounds are effective under field conditions has not yet been determined, but the mere existence of such allelopathic chemicals in weeds certainly holds open the possibility. Additional evidence that allelopathy might exist in the field comes from studies by Munger *et al.* (1984) in which smooth pigweed extracts were found to be toxic to field grown cotton.

In a study designed to establish optimum cover crop levels, lupine was found to have a stimulatory effect on cotton at low rates of application but at high rates was inhibitory (Lehle and Frans, 1974). This reversal of effect at increasing application levels is typical of some of the identified allelopathic chemicals. Additional research work is needed to determine which weeds may contain allelopathic compounds and if allelopathy is an effective interference mechanism in the field.

PRODUCTION LOSSES ASSOCIATED WITH WEED INTERFERENCE

Weeds may interfere with harvest operations by slowing the speed of harvest equipment. However, high populations of weeds are usually required before an effect on harvester speed occurs, and yield losses would already be so high in these cases that harvest speed is probably secondary. Some weeds are known to interfere with harvest through physically interfering with lint removal by the picker. Such species as unicorn-plant and jimsonweed have seed pods with hooked spines that may trap a significant amount of lint, thus reducing the effective yield.

Cotton quality reductions caused by trash and lint staining are common weed effects. Annual and perennial grasses may still be green at cotton harvest unless they have been desiccated chemically or by frost. The harvest operation may crush the green leaves and stems of the grass plants and release enough chlorophyll to cause significant green staining of the lint, thus leading to grade reductions (Garner and Bowen, 1961).

Significant weed populations late in the growing season may contribute to increased damage from other pests. The dense foliage of late-season weeds will cause moisture levels within the cotton canopy to be higher, creating an ideal environment for development of diseases such as boll rot. Many growers use growth regulators to keep the crop from developing excessive vegetative growth, which is also associated with boll rot. Weeds interfere with the application of growth regulators through physically intercepting the chemical spray. In addition to increasing disease incidence, weeds also interfere with control practices for insects and mites by interfering with pesticide spray applications and by serving as alternate hosts for some of the insect pests that infest cotton. Pest management practices such as stalk cutting are also made more difficult by the presence of weeds.

SUMMARY

Weeds may interfere with cotton through competition for available resources including water, nutrients and light. The degree of competition is a function of the weed species composition of the population, the weed population density and the duration of the population. In addition, competition for these resources is regulated by the availability of the resource being competed for, the level of environmental conditions such as temperature, and cultural practices such as row spacing and cotton cultivar. The consequence of competition that is of major concern is the crop yield loss, usually as a result of fewer bolls per plant in weed-infested areas. Allelopathy, another component of interference, may also be important, although limited evidence exists for this phenomenon in the field. Production losses associated with weed interference may occur at harvest or through disruption of other management operations. Studies on weed interference have been conducted in all areas of the Cotton Belt, but more research is necessary in all areas in order to have a full understanding of the effects of weed interference.

LITERATURE CITED

Andries, J. A., A. G. Douglas, and A. W. Cole. 1974. Herbicide, leaf type, and row spacing response in cotton. Weed Sci. 22:496-499.

Arle, H. F. and K. C. Hamilton. 1973. Effect of annual weeds on furrow irrigated cotton. Weed Sci. 21:325-327.

Arle, H. F. and K. C. Hamilton. 1975. Rates of herbicides on irrigated cotton. Weed Sci. 23:179-181.

Bridges, D. C. and J. M. Chandler. 1984. Devilsclaw and wild okra competition with cotton. Proc. So. Weed Sci. Soc. 37:312

Bridges, D. C. and J. M. Chandler. 1987. Influence of johnsongrass (*Sorghum halepense*) density and period of competition on cotton yield. Weed Sci. 35:63-67.

Brown, S. M., T. Whitwell, and J. E. Street. 1985. Common bermudagrass (*Cynodon dactylon*) competition in cotton (*Gossypium hirsutum*). Weed Sci. 33:503-506.

Bryson, C. T. 1987. Interference of hemp sesbania (*Sesbania exaltata*) with cotton. Weed Sci. 35:314-318.

Buchanan, G. A., and R. D. McLaughlin. 1975. Influence of nitrogen on weed competition in cotton. Weed Sci. 23:324-328.

Buchanan, G. A., R. H. Crowley, and R. D. McLaughlin. 1977. Competition of prickly sida with cotton. Weed Sci. 25:106-110.

Buchanan, G. A., R. H. Crowley, J. E. Street, and J. A. McGuire. 1980. Competition of sicklepod (*Cassia obtusifolia*) and redroot pigweed (*Amaranthus retroflexus*) with cotton (*Gossypium hirsutum*). Weed Sci. 28:258-262.

Buchanan, G. A., J. E. Street, and R. H. Crowley. 1980. Influence of time of planting and distance from the cotton (*Gossypium hirsutum*) row of pitted morningglory (*Ipomoea lacunosa*), prickly sida (*Sida spinosa*), and redroot pigweed (*Amaranthus retroflexus*) on competitiveness with cotton. Weed Sci. 28:568-572.

Castner, E. P., N. M. Hackett, D. S. Murray, and L. M. Verhalen. 1987. Effects of hogpotato on the growth and development of cotton. Proc. So. Weed Sci. Soc. 40:299.

Chandler, J. M. 1977. Competition of spurred anoda, velvetleaf, prickly sida, and venice mallow in cotton. Weed Sci. 25:151-158.

Chandler, J. M. and W. R. Meredith, Jr. 1983. Yields of three cotton (*Gossypium hirsutum*) cultivars as influenced by spurred anoda (*Anoda cristata*) competition. Weed Sci. 31:303-307.

Crowley, R. H. and G. A. Buchanan. 1978. Competition of four morningglory (*Ipomoea* sp.) species with cotton (*Gossypium hirsutum*). Weed Sci. 26:484-488.

Elmore, C. D., M. A. Brown, and E. P. Flint. 1983. Early interference between cotton (*Gossypium hirsutum*) and four weed species. Weed Sci. 31:200-207.

Flint, E. P., D. T. Patterson, and J. L. Beyers. 1983. Interference and temperature effects on growth of cotton (*Gossypium hirsutum*), spurred anoda (*Anoda cristata*) and velvetleaf (*Abutilon theophrasti*). Weed Sci. 31:892-898.

Garner, T. H. and H. D. Bowen. 1961. Influence of crabgrass on the quality of mechanically harvested cotton. Trans. ASAE 4:210-214.

Goodman, A. 1955. Correlation between cloud shade and shedding in cotton. Nature 176:39.

Guinn, G. 1982. Causes of square and boll shedding in cotton. U. S. Dep. Agric., Agric. Res. Serv. Tech. Bull. 167. 22 pp.

Hearn, A. B. 1976. Crop Physiology. Pages 77-122 *in* D. M. A. Arnold, ed. Agricultural Research for Developments. Cambridge Univ. Press, Great Britain.

Higgins, J. M., R. H. Walker, and T. Whitwell. 1986. Coffee senna (*Cassia occidentalis*) competition with cotton. Weed Sci. 34:52-56.

James, T. A., L. R. Oliver, and J. M. Chandler. 1977. Soil moisture competition between four morningglory species and cotton. Proc. So. Weed Sci. Soc. 30:363.

Keeley, P. E. and R. J. Thullen. 1975. Influence of yellow nutsedge competition on furrow-irrigated cotton. Weed Sci. 23:171-175.

Keeley, P. E. and R. J. Thullen. 1978. Light requirements of yellow nutsedge (*Cyperus esculentus*) and light interception by crops. Weed Sci. 26:10-16.

Keeley, P. E. and R. J. Thullen. 1981. Control and competitiveness of johnsongrass (*Sorghum halepense*) in cotton (*Gossypium hirsutum*). Weed Sci. 29:356-359.

Keeley, P. E. and R. J. Thullen. 1983. Influence of yellow nutsedge (*Cyperus esculentus*)-free periods on yield of cotton (*Gossypium hirsutum*). Weed Sci. 31:803-807.

Keeley, P. E., R. J. Thullen, and C. H. Carter. 1986. Influence of planting date on growth of ivyleaf morningglory (*Ipomoea hederacea*) in cotton (*Gossypium hirsutum*). Weed Sci. 34:906-910.

Lehle, F. and R. Frans. 1974. Effects of incorporated lupine on growth of selected weed and crop species. Proc. So. Weed Sci. Soc. 27:46.

Mason, T. G. 1922. Growth and abscission in Sea Island cotton. Ann. Bot. 36:457-483.

Munger, P. H., J. R. Abernathy, and J. R. Gipson. 1984. The influence of selected plant residues on cotton and sorghum establishment. Proc. So. Weed Sci. Soc. 37:320.

Oliver, L. R., J. M. Chandler, and G. A. Buchanan. 1981. Influence of geographic region on jimsonweed (*Datura stromonium*) competition in soybeans and cotton. Proc. So. Weed Sci. Soc. 34:260.

Patterson, D. T., C. R. Meyer, and P. C. Quimby. 1978. Effects of irradiance on relative growth rates, net assimilation rates, and leaf area partitioning in cotton and three associated weeds. Plant Physiol. 62:14-17.

Patterson, D. T. and E. P. Flint. 1979. Effects of chilling on cotton (*Gossypium hirsutum*), velvetleaf (*Abutilon theophrasti*), and spurred anoda (*Anoda cristata*). Weed Sci. 27:473-479.

Patterson, M. G., G. A. Buchanan, J. E. Street, and R. H. Crowley. 1980. Yellow nustedge (*Cyperus esculentus*) competition with cotton (*Gossypium hirsutum*). Weed Sci. 28:327-329.

Potter, J. R. 1976. Temperature effects on relative growth rates of six weeds and three crop species. Proc. So. Weed Sci. Soc. 29:68.

Reynolds, D. B., L. R. Oliver, and R. H. Crowley. 1983. Johnsongrass (*Sorghum halepense*) interference with cotton. Proc. So. Weed Sci. Soc. 36:347.

Riffle, M. S., G. R. Waller, and D. S. Murray. 1987. Plant growth inhibitors extracted and steam distilled from unicorn-plant (*Proboscidea louisianica*). Proc. So. Weed Sci. Soc. 40:315.

Robinson, E. L. 1976a. Yield and height of cotton as affected by weed density and nitrogen level. Weed Sci. 24:40-42.

Robinson, E. L. 1976b. Effect of weed species and placement on seed cotton yields. Weed Sci. 24:353-355.

Rogers, N. K., G. A. Buchanan, and W. C. Johnson. 1976. Influence of row spacing on weed competition with cotton. Weed Sci. 24:410-413.

Rushing, D. W., D. S. Murray, and L. M. Verhalen. 1985a. Weed interference with cotton (*Gossypium hirsutum*). I. Buffalobur (*Solanum rostratum*). Weed Sci. 33:810-814.

Rushing, D. W., D. S. Murray, and L. M. Verhalen. 1985b. Weed interference with cotton (*Gossypium hirsutum*). II. Tumble pigweed (*Amaranthus albus*). Weed Sci. 33:815-818.

Snipes, C. E., J. E. Street, and G. A. Buchanan. 1983. Determination of cotton yield loss from mixed populations of sicklepod and pigweed. Proc So. Weed Sci Soc. 36:342.

Snipes, C. E., G. A. Buchanan, J. E. Street, and J. A. McGuire. 1982. Competition of common cocklebur (*Xanthium pensylvanicum*) with cotton (*Gossypium hirsutum*). Weed Sci. 30:553-556.

Street, J. E., G. A. Buchanan, R. H. Crowley, and J. A. McGuire. 1981. Influence of cotton (*Gossypium hirsutum*) densities on competitiveness of pigweed (*Amaranthus spp.*) and sicklepod (*Cassia obtusifolia*). Weed Sci. 29:253-256.

Street, J. E., C. E. Snipes, J. A. McGuire, and G. A. Buchanan. 1985. Competition of a binary weed system with cotton (*Gossypium hirsutum*). Weed Sci. 33:807-809.

Stuart, B. L., S. K. Harrison, J. R. Abernathy, D. R. Krieg, and C. W. Wendt. 1984. The response of cotton (*Gossypium hirsutum*) water relations to smooth pigweed (*Amaranthus hybridus*) competition. Weed Sci. 32:126-132.

Wells, J. W., J. R. Abernathy, and J. R. Gipson. 1984. The effect of common cocklebur interference on cotton water relations. Proc. So. Weed Sci. Soc. 37:313.