12-1984

Interference and postemergence control of annual grasses in burley and dark fire-cured tobaccos

Gary K. Palmer

To the Graduate Council:

I am submitting herewith a dissertation written by Gary K. Palmer entitled "Interference and postemergence control of annual grasses in burley and dark fire-cured tobaccos." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Plant, Soil and Environmental Sciences.

Larry S. Jeffery, Major Professor

We have read this dissertation and recommend its acceptance:

Elmer L. Ashburn, David L. Coffey, Charles D. Pless

Accepted for the Council:

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INTERFERENCE AND POSTEMERGENCE CONTROL OF ANNUAL GRASSES IN BURLEY AND DARK FIRE-CURED TOBACCOS

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Gary Kevin Palmer

December 1984

ACKNOWLEDGEMENTS

The author wishes to express his sincere thanks and appreciation to Dr. Larry S. Jeffery for his advice, quidance, critical review of this manuscript, and friendship through the course of this study. Special thanks are also due the following: Dr. Elmer L. Ashburn for his suggestions and valuable assistance, Dr. David L. Coffey for his advice and friendship, and Dr. Charles D. Pless for his friendship, advice, encouragement, and for sharing his faith.

The author is especially grateful to the Philip Morris Tobacco Company for providing a research fellowship.

Special appreciation is expressed to his fellow graduate students for their assistance and friendship during the course of this study.

Appreciation is expressed to the author's mother, Alta L. Palmer, and his father-in-law and mother-in-law, Mr. and Mrs. Carl R. Hux, for their understanding and support.

The author is especially grateful for the support provided by his wife, Rhonda.

ABSTRACT

Interference studies with annual grasses were conducted in 1982 and 1983 in burley and dark fire-cured tobaccos (*Nicotiana tabacum* L.) at Greeneville and Springfield, Tennessee, respectively. Treatments consisted of annual grass-free periods of 2, 4, 6, 8, and 10 weeks from transplanting and 2, 4, 6, 8, and 10 weeks of interference followed by removal of all weeds and maintenance of weed-free conditions. A season long annual grass-free treatment and a season long annual grass-infested treatment served as controls. Annual grass-free periods were established and maintained by hand-hoeing. In 1982, the critical annual grass-free period and critical duration of interference of annual grasses for Federal grade and yield of burley tobacco and total cured plant and leaf yields of dark fire-cured tobacco were between 4 and 6 weeks after transplanting. Due to dry growing conditions and low annual grass populations yield responses in 1983 failed to indicate critical periods.

Separate studies were conducted in 1982 and 1983 at the same locations to evaluate and compare the performance of sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one} alone and with a crop oil concentrate and fluazifop-butyl {(±)-butyl 2-[4-[(5-(triflouromethyl)-2-pyridinyl)oxy]phenoxy] propanoate} plus a crop oil concentrate for control of annual grasses and tobacco response. They were compared to conventional cultivation and a widely used preplant incorporated treatment of pendimethalin

[*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine]. The above treatments were applied alone and in combination with acephate.

In 1982, the postemergence herbicides controlled annual grasses as well or better than cultivation or pendimethalin. Tobacco treated with the postemergence herbicides produced yields equal to or less than tobacco treated with pendimethalin. Dark fire-cured tobacco treated with the postemergence herbicides yielded less than did tobacco in the cultivated checks. In 1983, all treatments produced good tobacco yields. Plants from plots treated with sethoxydim applied without a crop oil concentrate produced the lowest dark fire-cured tobacco yields. Acephate in combination with annual grass control treatments did not appear to enhance tobacco growth or yield. Some crystallization of acephate occurred when tank-mixed with sethoxydim and fluazifop-butyl.

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I. INTRODUCTION

Several annual grasses are listed among the ten most common and troublesome weeds in tobacco (*Nicotiana tabacum* L.) in Tennessee (14). The critical annual grass-free period and critical duration of interference of annual grasses has not been determined for tobacco. Annual grasses reduce crop yield and quality by competing for water, nutrients, space, and light. Exudates and residue from annual grasses may also influence both yield and quality of a crop. The effects of competition and allelopathy on crop plants by annual grasses can be collectively referred to as interference of annual grasses. The length of the annual grass-free period after transplanting required to prevent significant interference in tobacco from annual grass regrowth has not been determined. The length of interference of annual grasses after transplanting that can be tolerated by tobacco without preventing significant reductions in quality and yield has not been determined. Interference studies can help determine the appropriate length of residual control activity that a preemergence or preplant incorporated herbicide should have. Interference studies can provide insight into the proper timing for application of postemergence herbicides.

Current weed control recommendations in Tennessee include cultivation and the following herbicides in combination with cultivation; diphenamid, isopropalin, napropamide, pebulate, and pendimethalin (13). No herbicide is currently labeled for postemergence control of annual grasses occurring in tobacco after transplanting.

Before a postemergence annual grass herbicide can be labeled and recommended for use in tobacco, the efficacy of the herbicide and crop tolerance to the herbicide must be determined. Timing of the application must be evaluated to achieve maximum annual grass control and to prevent significant tobacco yield and quality losses from interference of annual grasses. Determination of the compatibility of the postemergence herbicide with other pesticides is necessary where applications may coincide.

The objectives of the interference studies reported here were to determine the critical annual grass-free requirement for tobacco and the critical duration of interference of annual grasses in tobacco. The objectives of the postemergence annual grass control studies were to determine the following: a) the effectiveness of postemergence grass herbicides for control of annual grasses when compared to cultivation or to pendimethalin applied preplant incorporated; b) the tolerance of tobacco and the control of annual grasses associated with the addition of a crop oil concentrate to sethoxydim when compared to sethoxydim alone; c) the effects of the postemergence herbicides on annual grass control and tobacco response when tank-mixed with acephate; d) The compatibility of the postemergence herbicides with acephate; and e) effects of acephate on tobacco growth response.

II. LITERATURE REVIEW

INTERFERENCE OF ANNUAL GRASSES

Interference in Tobacco

Little work has been done in the area of interference of weeds in tobacco. Medlen and Worsham (79), in a study of the effects of common ragweed (*Ambrosia artemisiifolia* L.) in flue-cured tobacco, found that a ragweed density of one plant per 28 cm of row resulted in significant reductions of yield and value. An average population of six plants per square meter remaining in plots for up to 4 weeks after transplanting did not significantly reduce yield or value. Tobacco plots kept weed-free for at least 2 weeks after transplanting did not yield significantly different than tobacco kept weed-free all season.

Interference in Row Crops

Although no report of interference of annual grasses in tobacco was found, competition of annual grasses has been documented in many crops. Ambrose and Coble (2) found that fall panicum (*Panicum dichotomiflorum* Michx.) could be grown in soybeans [*Glycine max* (L.) Merr.] for up to 10 weeks before removal without significant yield reduction. If plots were maintained weed-free for 2 or more weeks no significant reduction occurred. The economic threshold appeared to be greater than the 20 plants per 3 m of row maximum used in the study. Similar results were reported by Harris and Ritter (50) in a study of the effects of a mixed population of annual grasses in soybean. The population consisted of fall panicum and giant green foxtail [*Setaria viridis* var. *major* (Gaud.) Posp.] in a ratio of three to one. Interference for 10 weeks resulted in significant losses in total soybean biomass and yield. The economic threshold was considered to be greater than 6.6 plants per linear meter of row, the maximum population density in the study. Sollazzo and Ilnicki (114) reported that late planted soybeans were more sensitive than early planted soybeans to the severe competitive nature of fall panicum which reduced yields, pod number, and branching of soybeans. Michieka and Ilnicki (80) found that soybean yields were reduced if fall panicum was allowed to compete for more than 3 weeks after emergence of soybeans. Competition within the first 3 weeks after soybean emergence did not significantly reduce soybean yields.

Fall panicum competition in corn (*Zea mays* L.) was studied by Beale and Ilnicki (16). They found that corn grain and silage yields decreased as density of fall panicum increased. Selleck (112) reported that fall panicum at a density of one to two plants per meter of row can reduce corn yield by 20 percent. He found that one fall panicum plant per 25.4 cm of row can reduce soybean and peanut (*Arachis hypogaea* L.) yields by 15 and 46 percent, respectively. In a similar study by Ritter and Lewis (102), 32 fall panicum plants per 4.9 m of row significantly reduced corn yields. Natural infestations of 15 and 25 plants per 0.3 m of row reduced yields by 15 and 17 percent, respectively. Twenty-five fall panicum plants per 0.3 m significantly reduced yields after 8 weeks of interference. If plots were maintained weed-free for 2 to 4 weeks after planting, no significant reduction of yield occurred due to fall panicum germinating after the weed-free period.

York and Coble (133), studying the effects of fall panicum on peanuts, found that interference for 2 weeks after peanut emergence reduced seed yields by an average of 28 percent over a 2 year period. One fall panicum plant per 4.9 m of row reduced peanut seed yield by 25 percent. They concluded that the economic threshold of fall panicum in peanuts was less than one weed per 4.9 m of row. Forage yield was not as sensitive to fall panicum competition as seed yield. Peanut forage yield required fall panicum control for 8 weeks or longer to prevent significant reductions.

Competition of crabgrass (*Digitaria* sp.) has been studied in many crops. Weise et al. (125) found that only one crabgrass head in 101.6 cm of row could reduce yields of grain sorghum [*Sorghum bicolor* (L.) Moench] by 24.6 kg/ha. At a row spacing of 91 cm, Wan-Yahaya and Murray (123) discovered that 31 large crabgrass [*D. sanguinalis* (L.) Scop.] plants per 10 m of row significantly reduced grain sorghum yields. The economic threshold for large crabgrass competition in grain sorghum was lower than that for barnyardgrass [*Echinochloa crus-galli* (L.) Beauv] and Texas panicum (*Panicum texanum* Buckl.). Eight weeks of competition by infestations of barnyardgrass, large crabgrass, and Texas panicum reduced grain sorghum yields by 46, 44, and 44 percent, respectively. Burnside and Wicks (24) studied the effects of a mixed population of weeds in sorghum. The predominant weed species was large crabgrass. Other weed species included green foxtail [*Setaria viridis* (L.) Beauv.], redroot pigweed (*Amaranthus retroflexus* L.) and tall waterhemp

[*Amaranthus tuberculatos* (Moq.) J. Sauer]. If the weed population was allowed to grow for 3 weeks after planting the sorghum, yield, seed head number and seed weight were significantly reduced. Yields from plots kept weed-free for 4 weeks were not significantly different from that obtained from plots maintained weed-free for the entire season.

Robinson (103) discovered that competition of annual grass in cotton (*Gossypium hirsutum* L.) can be severe. He found that large crabgrass was as competitive as spurred anoda [*Anoda cristata* (L.) Schlecht.], prickly sida (*Sida spinosa* L.), and velvetleaf (*Abutilon theophrasti* Medic.). Studies of weed placement revealed severe competition by these weeds when placed in-the-row compared to between-the-row placement or no weeds. In 1972 and 1973, in-the-row placement of all weeds studied reduced seed cotton yields to zero. Robinson's work emphasized the need for weed control beyond that achieved by cultivation alone. Buchanan and Burns (22) found that cotton grown in Alabama required a period of approximately 8 weeks from germination without weed competition to produce maximum yields. They concluded that herbicides should have sufficient residual to achieve an 8 week period of control and ideally should persist no longer than 8 weeks. They felt that by 8 weeks cotton was capable of competing successfully with the weeds. The predominant weed studied was large crabgrass. Four to six weeks of competition after emergence did not significantly reduce yields. Competition beyond the critical duration of competition due to delayed application of postemergence annual grass herbicides can result in a dramatic reduction in cotton yields.

Large crabgrass competition has been studied in other crops including corn, peanuts, and tomatoes (*Lycopersicon esculentum* Mill.). Vengris (121) reported that a weed population consisting primarily of large crabgrass and fall panicum reduced corn yields by an average of 43 percent over 3 years. These annual grasses may compete for 2 to 4 weeks without significantly reducing yields. Control of the annual grasses for 2 to 4 weeks prevented significant reductions in yield. Hill and Santlemann (55) found when large crabgrass and smooth pigweed (*Amaranthus hybridus* L.) competed for 3 weeks or more with Spanish peanuts, peanut seed yield was significantly reduced. They concluded that the use of a postemergence herbicide would be most beneficial when applied within 3 weeks after planting. Reductions in Spanish peanut forage yields did not occur until 5 weeks after planting. If plots were maintained weed-free from planting to 6 weeks, no reduction in peanut forage or seed yield occurred. Sanders et al. (106) studied the relationship between mineral content of tomatoes and weed density, but a clear relationship was not found. A population density of 55 large crabgrass plants per square meter reduced tomato fruit yields by 27,100 and 31,900 kg/ha in 1973 and 1974, respectively. Densities as low as 11 large crabgrass plants per square meter reduced yields by almost 50 percent.

Studies by Staniforth (115) led him to conclude that the annual grass, giant foxtail, (*Setaria faberi* Herrm.) was a more serious competitor than either yellow foxtail [*Setaria lutescens* (Weigel) Hubb.] or green foxtail. Giant foxtail has a more vigorous growth habit and reduced soybean yields more severely. Knake (67) found that soybeans must be kept weed-free for 2 to 3 weeks after planting to prevent significant yield reductions by competition from giant foxtail. As the number of giant foxtail plants increased, yield reduction in corn and soybeans increased. Knake and Slife (68) found that if they seeded giant foxtail the day the crop was planted, giant foxtail reduced corn and soybean yields by 13 and 27 percent, respectively. Giant foxtail seeded 3 weeks after the crop was planted did not significantly affect yields. Jorge and Staniforth (62) found that adequate soil nitrogen minimized the effects of foxtail competition in corn. However, corn yield reductions of 10 percent still occurred at the highest level of nitrogen fertilization.

In a mixed population of weeds which included foxtail, crabgrass, and smooth pigweed, a negative correlation between grain sorghum yield and weed yield was reported by Burnside and Wicks (25). If the weeds were not removed by the fourth week, sorghum yield was reduced. They suggested that effective postemergence herbicide use would require application within 3 weeks after planting. Plots maintained weed-free from the first 2 weeks yielded almost twice as much as plots with no weed control.

Allelopathic Activity of Annual Grasses

Although a large collection of evidence promotes the existence of allelopathy in many species, no single example proves that allelopathy is a significant factor involved in the interference of field crops by weeds under field conditions (85, 101). Schreiber (108) noted that greater seedling vigor and quantity of seed production of other foxtail species should give them a competitive edge over giant foxtail. The rapid dominance of giant foxtail indicates that factors other than competition are involved in the success of giant foxtail. Bell and Koeppe (17) found that as the age of giant foxtail increased the interference also increased. Corn seeded into 6 week old giant foxtail was reduced in height by 74 percent. Corn grown in the presence of mature living giant foxtail and giant foxtail residue for 1 month was dramatically reduced in height. When attempts were made to eliminate the effects of giant foxtail competition in corn, corn growth inhibition decreased from 90 percent to 35 percent. The remaining inhibition was attributed to allelopathy.

In many cases, weed residue is as allelopathic or more so than the weed growing in association with the crop. Bhowmik and Doll (20) tested the effects of broadleaf and grass weed residue on corn and soybeans. Giant foxtail and barnyardgrass residue decreased the height and shoot dry weight of corn. Six weeks after planting crop growth was reduced by 15 to 30 percent, but crops had recovered after 16 weeks. Giant foxtail and corn residue were found to increase soybean yields. Schreiber and williams (109) found that giant foxtail root residue reduced the root growth of corn. Crabgrass and yellow foxtail residue did not reduce root growth as drastically as giant foxtail, but root growth was less than in control containers. Bhowmik and Doll (19) found that water extracts of dried residues of fall panicum, giant foxtail, green foxtail, and yellow foxtail inhibited radicle elongation in corn. Fall panicum and green foxtail extracts inhibited hypocotyl elongation in soybeans. In field studies, corn yields were decreased by barnyardgrass and giant foxtail residues and soybean yields were enhanced by giant foxtail residue. Residues from timothy (*Phleum pratense* L.), corn, rye (*Lolium* sp.), and tobacco have been found to affect the respiration rate of tobacco seedlings (90, 91).

Allelopathic activity may be due to the release of substances by microbial breakdown (18). Proof of the occurrence of allelopathic activity has been difficult and has centered more on disproving arguments against allelopathy. The final analysis remains incomplete, but indications are that allelopathy may either inhibit or stimulate crop yields under field conditions depending on the species involved (17, 20). The agronomic practice of incorporation of weed plant residue may need careful evaluation.

PESTICIDE REVIEW

Sethoxydim

Sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one} is an amber, oily liquid discovered in the laboratories of Nippon Soda and developed by BASF Wyandotte Corporation as a postemergence grass herbicide (9, 77, 124). Kukas (69) refered to sethoxydim as a true gramicide due to the extensive number of susceptible grass species and high tolerance of all broadleaf species tested. Broad spectrum control of both annual and perennial grass weeds has been well documented (9, 15, 77, 126). The list of highly susceptible annual grasses includes barnyardgrass, crabgrass species, broadleaf signalgrass, panicum species, foxtail species, goosegrass [*Eleusine indica* (L.) Gaertn.], and others (9, 15, 47, 69, 77, 78, 84, 111).

Hosaka et al. (58) evaluated the susceptibility of 27 temperate and 28 tropical grasses to postemergence applications of sethoxydim. They found that only rattail fescue (*Festuca myuros* L.) and annual bluegrass (*Poa annua* l.) were tolerant at 0.25 and 0.5 kg/ha. Both species are temperate grasses and of the tribe festuceae. A second study of grasses in the genus *Festuca* revealed tolerance in other *Festuca* species. Red fescue (*Festuca rubra* L.) was slightly less tolerant than hard fescue (*Fescue longifloria* Thuills). Annual bluegrass was less tolerant than hard fescue.

All broadleaf plants and sedges tested have been found to be highly tolerant to applications of sethoxydim (9, 69, 77, 110, 118). Over fifty vegetable and agronomic crops including tobacco have been reported to be tolerant to applications of sethoxdyim (9). Kukas (69) reported an extensive list of tolerant broadleaf crops which included tobacco. Worsham (128, 129, 131, 132) reported excellent crop tolerance to sethoxydim in flue-cured tobacco over a 4 year period. Hagood (47) and Zilkey and Capell (135) also found excellent crop tolerance in tobacco. Excellent tolerance in soybean was reported by Chernicky et al. (30), Cranmer and Nalawaja (34), Sciarappa (110), and Veenstra et al. (118). Sciarappa and McAvoy (111) reported excellent crop safety at 0.11 to 1.12 kg/ha of sethoxydim plus oil in alfalfa (*Medicago sativa* L.). Other legumes tested were found to be equally tolerant. Peters (92) reported similar crop tolerance and a significant increase in alfalfa yield due to control of large crabgrass. McAvoy (77) and Johnson and Hopen (61) reported crop tolerance to sethoxydim in onions (*Allium cepa* L.) and asparagus (*Asparagus officinalis* L.). Johnson and Hopen (60) reported sethoxydim injury to tomato plants in the four-leaf stage at rates of 0.8 to 1.1 kg/ha. Addition of oil or surfactant increased injury at the two-leaf stage, but injury was considered minimal and was outgrown rapidly. Peters (92) noted an initial crinkling and straplike appearance of clover (*Trifolium* sp.) leaflets which was eventually outgrown.

When sethoxydim is applied to the foliage of susceptible grasses, absorption occurs rapidly (9, 44, 120, 124). McAvoy (77) reported that within an hour the majority of sethoxydim had been absorbed by the plant. Campbell and Penner (27) found that 90 percent of sethoxydim applied was absorbed within 12 hours. The absorption of sethoxydim has been reported to be as rapid in tolerant plants as in susceptible plants (77). Swisher and Corbin (117) found that absorption of sethoxydim was initially more rapid in soybeans than in johnsongrass [*Sorghum halepense* (L.) Pers.]. Absorption in johnsongrass, although initially slower than in soybeans, was more persistant. Addition of an oil concentrate was found to increase the absorption of sethoxydim (77). Although primarily foliarly absorbed (27), to a lesser extent sethoxydim can enter through the roots if ample soil moisture is available (77).

Sethoxydim is translocated rapidly both acropetally and basipetally (9, 77, 120). Swisher and Corbin (117) studied the translocation of sethoxydim in johnsongrass and suggested that sethoxydim is primarily a phloem-mobile compound translocated with photosynthates following application. Accumulation occurs in meristems, new leaves, and roots (27, 77, 121). Veerasakaran and Catchpole (119) reported similar characteristics of translocation for the chemically related compound alloxydim-sodium. As cells within the metabolic sink rapidly die, translocation of sethoxydim is disrupted, decreasing movement to apical untreated leaves (117). Swisher and Corbin (117) found that sethoxydim translocation in soybeans was twice that found in johnsongrass. They discounted translocation as a means of selectivity. Veerasakaran and Catchpole (119) did not find significant differences in translocation between resistant broadleaf crop plants and susceptible grasses treated with alloxydim-sodium.

Rapid inhibition of plant growth is the initial symptom of sethoxydim injury in annual grasses (30, 77, 117, 120). Gealy and Slife (43) found that the onset of growth inhibition and electrolyte leakage from stem-base cells coincided with sethoxydim translocation. When applied to either the second or fourth leaf whorl of a susceptible annual grass, growth inhibition occurred within 24 hours. Asare-Boamah and Fletcher (12) reported inhibition of growth in corn seedlings by sethoxydim 4 days after application. As the concentration of sethoxydim increased, the growth became more retarded 96 hours after treatment. Cessation of growth is followed by a failure of new leaves to emerge (117). Failure of new leaf emergence is due to the reaction of the meristematic region to sethoxydim (9, 44, 77, 120). Swisher and Corbin (117) reported injury to shoot apices within 24 hours after application. Within 3 days after application shoot apices were disorganized and necrotic. Leaves expanding at the time of treatment could be pulled easily from the shoot within 3 to 5 days after treatment. Newly expanded leaves of large crabgrass were bleached even at low rates (12). Initially the mature leaves appeared green and healthy, but later became chlorotic and necrotic (77, 120). Leaves and stems often have a red or purple tint which Asare-Boamah and Fletcher (12) attributed to the accumulation of anthocyanins and a decrease in chlorophyll level (30, 77). They found that chlorophyll content declined with increasing rates of sethoxydim. Chlorophyll reduction was thought to be due to either disruption of the chloroplast or inhibition of carotenoid synthesis with photodestruction of chlorophyll. As concentrations of sethoxydim increased from 1 to 100 ppm, percent reduction increased from 7 to 90 percent, respectively. An increase in total sugar content occurred as the concentration of sethoxydim increased. Anthocyanin levels increased at all concentrations tested. Swisher and Corbin (117) also reported discoloration in nodal regions above and below the node due to an increase of anthocyanin in those zones.

Swisher and Corbin (117) found a zone of necrosis in roots of plants harvested 24 hours after application. Massive root tissue destruction was evident 3 to 5 days after treatment. Asare-Boamah and Fletcher (12) reported a swelling of the primary roots immediately behind the meristematic zone. As concentrations of sethoxydim increased, seminal adventitious roots were shorter and thicker. At rates higher than 0.02 kg/ha, roots were significantly shorter. Fresh and dry weights decreased at rates higher than 0.04 kg/ha.

Swisher and Corbin (117) suggested that sethoxydim is converted biologically in a similar manner to that of the chemically related alloxydim-sodium. Alloxydim-sodium is subject to oxidation of sulfur to sulfoxide and sulfone. Metabolism of sethoxydim followed a similar pattern in both johnsongrass and soybeans. Transformation products are nearly identical, but transformation is faster in soybeans than johnsongrass. Apical johnsongrass leaves contained proportionally greater amounts of unchanged sethoxydim than did apical soybeans leaves. Reduced ability of johnsongrass to transform sethoxydim was suggested. Campbell and Penner (29) studied the metabolism of sethoxydim in navy beans, alfalfa, barnyardgrass, and quackgrass [*Agropyron repens* (L.) Beauv.]. Metabolism to an inactive desethoxy derivative was rapid in all plants studied. In soybeans, the parent molecule is quickly oxidized and structurally rearranged. Metabolites are eventually conjugated or degraded (9, 44, 77). Accumulation of sethoxydim in roots of johnsongrass and soybeans was similar within the first day following application (117). Johnsongrass roots contained greater amounts of sethoxydim 4 to 8 days after treatment. Rapid degradation was thought to be partially responsible for selectivity (119).

Veerasekaran and Catchpole (119) studied differential spray retention of alloxydim-sodium in tolerant and susceptible plants. Resistant broadleaf crop plants retained similar or greater amounts of spray than did the susceptible grasses. They concluded that differential spray retention was not a factor controlling selectivity of alloxydim-sodium. Swisher and Corbin (117) found higher concentrations of sethoxydim in uninjured leaves of johnsongrass. They felt that the herbicide may be affecting areas of high metabolic activity within meristematic regions of susceptible species. Susceptibility was thought to be due to greater sensitivity of those areas rather than higher concentrations of the chemical. Gealy and Slife (43) studied the differential response of corn-leaf and soybean-leaf photosynthesis to sethoxydim as the potential mode of action. Corn-leaf photosynthesis was initially inhibited less than soybean-leaf photosynthesis. Inhibition of photosynthesis with three times the field rate of sethoxydim was moderate. They found no inhibition of photosynthesis 24 hours after application of sethoxydim, but growth was inhibited by 66 percent. The herbicide was translocated to the leaf growing point and only after the tissue in that area was disrupted to the point of growth inhibition was photosynthesis depressed in older leaves. Cell disruption at the stem base was suggested as the possible mode of action. When Asare-Boamah and Fletcher (12) studied the mode of action of sethoxydim they noted disorientation of daughter nuclei in respect to the longitudinal axis of the cell. They attributed this effect to the malfunction of the microtubules. Sethoxydim was thought to interfere with cytokinesis and not karyokinesis. They found in corn that sethoxydim inhibited growth, chlorophyll accumulation, and respiratory activity while increasing sugar and anthocyanin levels. Interference with cell wall formation during mitosis resulted in binucleate cells. The nuclei of daughter cells often failed to migrate to opposite poles. The physiological and cytological effects of sethoxydim are thought to be the basis of its phytotoxicity (12). Absorption, translocation, rate of metabolism, and the nature of the products formed are not thought to impart the observed selectivity of sethoxydim.

The most consistent control of annual grasses with sethoxydim has been achieved with a spray volume of 187 to 234 L/ha and a spray pressure of 2.8 to 4.2 kg/cm^2 (66, 77). Suggested rates for control of annual grasses range from 0.11 to 0.56 kg/ha (9). Atwell and Sciarappa (15) found that 97 percent control of annual grasses could be achieved with a rate of 0.22 kg/ha of sethoxydim. Cranmer and Nalewaja (34) found that better control of annual grasses could be achieved if rates were increased to 0.24 to 0.47 kg/ha. Excellent control of annual grasses has been reported using a rate of 0.22 kg/ha of sethoxydim (36, 46, 111). Vesecky et al. (122) achieved 80 to 100 percent control of annual grasses that were less than 80 cm in height with a rate of 0.14 kg/ha of sethoxydim.

Stage of annual grass growth at the time of sethoxydim application has been shown to influence percent control in some annual grass species. Mosier et al. (83) found that all grasses tested were controlled at the 2 to 4 leaf stage. Fall panicum and large crabgrass were controlled at the 5 to 15 leaf stage. However, Chernicky et al. (31) were able to achieve better control of large crabgrass when the plants were between 9 and 14 cm tall. They also found that goosegrass could be controlled better at a height of 13 cm than at 35 cm. Grichar and Boswell (46) found that at a rate of 0.11 kg/ha significantly less control was achieved in grasses at 15 to 46 cm compared to 0 to 15 cm. Increasing the rate to between 0.56 and 1.12 kg/ha gave 100 percent control of large crabgrass and broadleaf signalgrass [*Brachiaria platyphylla* (Griseb.) Nash] if they were 30.5 to 45.7 cm in height. Monaco (81) reported that control of large crabgrass became increasingly difficult with rates of 0.15 to 0.56 kg/ha as the large crabgrass increased in height. Goosegrass could be controlled up to tillering. Kells et al. (64) achieved excellent control of giant foxtail and barnyardgrass when they were 7 to 9 cm or 17 to 22 cm in height, respectively. Rosser and Witt (104) reported 93 percent control of giant foxtail with sethoxydim plus oil applied either early or late postemergence. Wilson and Hines (126) reported effective control of all grasses tested at the eight leaf stage. Highest yields are most often achieved when applied early postemergence. Edwards and Hurst (38) found better soybean yields could be achieved by applying sethoxydim to broadleaf signalgrass before it reached a height greater than 8 cm. They achieved 90 percent control which lasted throughout the season. Himmelstein and Peters (56) achieved highest yields of alfalfa when early postemergence applications were made. However, large crabgrass regrowth was greatest when applications were made to 10 cm grass plants. Control may be reduced if applications are made before most of the grass weeds have emerged (88, 120). If applications are made too late the crop canopy may interfere with spray coverage, thereby reducing control (9). A high density of broadleaf plants can also prevent effective coverage and thus reduce control.

Adjuvants have been found to increase the activity of sethoxydim (30). An extensive list of oil concentrates are recommended for use with sethoxydim. The increase in sethoxydim efficacy with the addition of an oil concentrate has been reported to be due to increased uptake (9, 124). Hartzler and Foy (52, 53) found the increase in control with the addition of an adjuvant decreased as the rate of sethoxydim increased. At highest rates, excellent grass control was achieved with or without an adjuvant. No significant difference in response to the addition of different adjuvants was reported. Kukas (69) found that at minimum rates an oil concentrate was required for consistent results. Veenstra et al. (118) found that a rate of 0.28 kg/ha of sethoxydim plus oil concentrate controlled annual grasses as well as 0.56 kg/ha without oil.

Optimum environmental conditions for control of annual grasses with sethoxydim are good soil moisture, high temperatures, and high humidity (30, 69, 77). Cranmer and Nalewaja (33) found that control of wild oats at the two-leaf stage was higher at 10 or 30 C than at 20 C. At the four-leaf stage, control increased as temperature increased. The effect of temperature was overcome by the addition of an adjuvant. In general, high temperatures associated with rapid growth favored the development of injury symptoms (52). Cranmer and Nalewaja (33), however, found that if the humidity was low, yellow foxtail control was best at 10 C. At high humidity control was best at 20 C. The effect of humidity could be overcome by the addition of an adjuvant. Simulated rainfall of 2 mm applied 30 minutes after application of sethoxydim did not reduce control of wild oats. More than 2 mm decreased control by 17 percent. An average rainfree period of 8 hours was required to prevent reduction in control of wild oats (*Avena fatua* L.). The addition of an adjuvant decreased the period to 2 hours. A more widely accepted rainfree period is from 4 to 5 hours (9, 44, 124). Sethoxydim has been found to be thermal and light labile (29). Some degradation occurs in UV and sunlight (124). Campbell and Penner (29) reported a transformation of sethoxydim after 5 minutes in light to phytotoxic and nonphytotoxic decomposition products.

Tank mixing of sethoxydim and broadleaf herbicides has been studied to determine the efficacy of the mix. Sciarappa and McAvoy (111) reported minimal grass antagonism and excellent efficacy of sethoxydim tank-mixed with 2,4-DB for use in legumes. Problems with antagonism were reported when sethoxydim was tank-mixed with dinoseb and bromoxynil. Cranmer and Nalewaja (34) reported decreased control of annual grasses when sethoxydim was tank-mixed with bentazon, 2,4-DB, or acifluorfen. Separate application or higher rates of sethoxydim may be required to achieve satisfactory control of annual grasses (9).

Grichar and Boswell (46) indicated that sethoxydim could be important in broadleaf crops where the major problem is a lack of effective control for grass species which escape initial preemergence herbicide treatments. Sethoxydim helps remove the need for post-directed application due to excellent tolerance of broadleaf crops and has great potential in no-till cropping situations (69, 92).

Fluazifop-butyl

Fluazifop-butyl {(±)-butyl 2-[4-[(5-(trifluoromethyl)-2-pyridinyl) oxy]phenoxy]propanoate} is a light straw colored, odorless liquid developed worldwide by the Plant Protection Division of ICI Ltd. and in the United States by the Agricultural Chemicals Division of ICI Americas Inc. It is a selective postemergence herbicide for the control of grass weeds (5, 95). Fluazifop-butyl, the butyl ester of the parent acid fluazifop, is a highly active herbicide controlling most grass weeds in broadleaf crops. Over a 3 year period, Worsham (128, 129, 131) reported excellent tobacco crop tolerance to fluazifop-butyl. Other researchers have reported excellent crop tolerance and grass control in tobacco (47, 135). Tolerance in soybeans and many vegetable crops has been reported (39, 81). However, Harkins and Bates (49) reported negligible phytotoxicity in soybeans treated at the third trifoliolate. However, these symptoms were quickly outgrown. Corn, sorghum, and small grains have been reported to be highly susceptible to fluazifop-butyl (93). Fluazifop-butyl is not active on broadleaf weeds and sedges (7, 32, 95, 96).

Fluazifop-butyl is selective as a preemergence herbicide, but rates two to four times higher than needed for postemergence applications are required to obtain adequate grass control. Actual rates will depend on the soil type. Although current emphasis is on postemergence applications only, potential benefit from soil activity following postemergence application of fluazifop-butyl could be of significant importance (5).

Fluazifop-butyl is rapidly absorbed through leaf surfaces following application (124). Kells et al. (64) reported that fluazifop-butyl is absorbed by both tolerant soybeans and susceptible quackgrass. Six hours after treatment, soybeans contained 75 percent of ^{14}C-labeled material compared to 44 percent in quackgrass. After 144 hours, 94 percent and 92 percent were recovered from soybeans and quackgrass, respectively. Later research by Kells et al. (63) produced similar results. Indications are that differential absorption is not a selective mechanism for fluazifop-butyl (63, 105).

Fluazifop-butyl is a systemic herbicide which is translocated rapidly acropetally and basipetally (5, 44, 63, 95, 124). Rosser et al. (105) indicated that translocation is not a basis for selectivity. They were able to recover 31 percent of ^{14}C-fluazifop from 30 to 60 cm johnsongrass after 72 hours. Significantly more ^{14}C-labeled fluazifop was translocated in 90 cm johnsongrass and sunflower. Kells et al. (63, 64) reported that translocation of fluazifop-butyl occurred in both tolerant soybeans and susceptible quackgrass. Translocation of 13 percent was discovered in quackgrass compared to 16 percent in soybeans. They agreed with Rosser et al. that translocation is not a major factor in selectivity between tolerant and susceptible plants. Radioautographs indicated an accumulation of ^{14}C in meristematic areas of both plants. Rosser et al. (105) also reported accumulation in meristematic regions, but indicated that translocation occurred throughout the plant. Other areas of accumulation reported were young johnsongrass tillers, meristematic areas above treated leaves, rhizomes, and secondary shoots from rhizomes connected to treated plants. Even though absorption and translocation occurs in broadleaf plants, Zilky and Capell (135) reported that fluazifop-butyl had no effect on alkaloids and reducing sugars in tobacco.

The first visible symptom of fluazifop-butyl on susceptible grasses is a cessation of growth that occurs within 48 hours after application (5, 7, 44, 93). More noticeable injury can take 7 to 10 days to appear. Control is evident by leaf burn, reddening, and burnback of foliage which first appears in the nodes and buds before progressing to younger leaves. Complete death of the plant may take 2 to 4 weeks depending on environmental conditions but competition with the crop ceases earlier.

The first degradation reaction of fluazifop-butyl in broadleaf species removes the butyl group by rapid hydrolysis leaving behind the fluazifop moeity (44, 124). Rosser et al. (105) reported that only trace amounts of fluazifop-butyl were translocated. The free acid fluazifop accounted for 20 and 35 percent of the ^{14}C recovered in treated leaves and translocated materials, respectively. Selectivity is thought to be associated with the rapid degradation of fluazifop-butyl followed by conjugation in broadleaf species (44). In grass species fluazifop-butyl is thought to interfere with adenosine triphosphate (ATP) production.

Porter et al. (93) reported that rates of fluazifop-butyl from 0.28 to 0.56 kg/ha in 94 to 374 L/ha controlled annual grasses. A minimum spray volume of 47 L/ha should be used to adequately cover the foliage (7). This optimum range for fluazifop-butyl is consistent with that reported by others (26, 32, 44, 83). Lunsford (70) reported that a range of 0.28 to 0.42 kg/ha of fluazifop-butyl gave 93 to 96 percent control of Texas panicum in onions. He found that a rate of 0.28 kg/ha plus oil concentrate controlled 97 percent of Texas panicum in peanuts. Volunteer corn and shattercane are also extremely sensitive to fluazifop-butyl (5). Rates of 0.07 to 0.25 kg/ha can give optimum control. Elevated rates may injure broadleaf plants causing stunting, necrotic specks, and chlorotic leaf margins. At low rates fluazifop-butyl may act as a grass retardant (124).

Control of annual grasses is reported to be significantly better when applied at the two to three leaf stage than at the five to six leaf stage (5, 63, 83). Monaco (81) found that large crabgrass becomes more difficult to control with age. Lunsford (70) reported that if Texas panicum was allowed to reach 10 to 20 cm in height with 6 to 12 tillers, higher rates and a longer duration were required to achieve effective control. Kells et al. (63) found that total translocation was similar at different leaf stages, but distribution was more extensive at the two to three leaf stage. When plants were treated at the five to six leaf stage a large amount of ^{14}C-coumpond was translocated to proximal untreated portions of leaves, but not to portions of the plant below the point of treatment. They suggested that these differences could explain the reduced control of plants treated at the five to six leaf stage. Although early applications will optimize control of grasses, applications made too early miss the first flush of annual grasses thus reducing control (5, 7, 51). Harkins and Bates (49) found that applications 3 weeks prior to the point when soybeans had canopied increased soybean yields in all plots treated with fluazifop-butyl. Highly competitive crops can enhance grass control by fluazifop-butyl (5). Foresman et al. (39) reported good late-season control of giant foxtail, but yields had already been reduced by early-season competition. Heavy weed densities may require increased spray pressure and/or higher rates (5). Actively growing, taller grasses or those under drought stress may require higher herbicide rates (93). Cultivation 14 to 21 days after herbicide application may also enhance control.

Addition of either a crop oil concentrate or a nonionic surfactant to fluazifop-butyl is recommended to achieve optimum results (5, 7). Kells et al. (63) found no significant difference in control with fluazifop-butyl plus either X-77 or a crop oil concentrate as spray additives. Lunsford (70) reported that addition of an oil concentrate increased the fluazifop-butyl activity. Increases were more dramatic when lower rates of fluazifop-butyl were used. Other researchers have reported similar results (32, 39, 93, 96).

Fluazifop-butyl should be applied to actively growing grasses (7). Kells, et al., (63) found that fluazifop-butyl applied at 0.56 kg/ha was more active when plants were maintained under adequate moisture. Radioautographs of treated plants indicated a greater distribution of material in plants grown under adequate moisture conditions. Ready and Wilkerson (97) found that transport was also less rapid in stressed plants. In general, high temperature and low moisture stress decreased control of annual grasses. Higher rates of fluazifop-butyl may be required to achieve adequate control of annual grasses under low soil moisture and relative humidity (5, 7, 97, 124). The influence of plant growth stage, temperature, light, and moisture on control can be partially explained by their effect on absorption, translocation, and distribution of fluazifop-butyl (63). Rainfall has little influence on control unless it occurs within the first hour after application (5, 7, 124). No reduction in control resulted from rainfall 2 to 4 hours following application.

Attempts to tank-mix fluazifop-butyl with broadleaf herbicides have uncovered potential problems (5). Increased soybean injury with reduced grass control has been observed. Monaco (81) reported injury to asparagus from a tank-mix of fluazifop-butyl and linuron which has not been observed when either was applied alone. He speculated that injury was due to increased linuron retention on the foliage by the crop oil concentrate.

Although fluazifop-butyl is used primarily as a postemergence herbicide, some degree of residual activity can occur (5, 70, 124). New flushes of annual grasses may be controlled for up to 6 or 7 weeks depending on soil type. Coarse textured soils that are low in organic matter have greater residual activity. Because of the potential residual toxicity, susceptible crops should not be planted within 60 days after application of fluazifop-butyl (7, 124). If rates between 0.56 and 1.12 kg/ha are used, injury may occur if susceptible crops are sown within 3 months after application.

Pendimethalin

Pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] is a dinitroaniline herbicide developed by the American Cyanamid Company. It controls most annual grasses and certain broadleaf weeds (6, 11, 124). Control of large crabgrass, goosegrass, giant foxtail, fall panicum, broadleaf signalgrass, and barnyardgrass has been well documented (6, 37, 40, 41, 59, 72, 73, 100, 127, 131, 134). In addition to annual grass control, pendimethalin gives varying degrees of control of certain broadleaf weeds(40, 41, 100, 134). Pendimethalin controls most weeds found in tobacco with minimal crop injury when recommended rates and incorporation practices are followed (40, 71, 100, 127, 131). Pendimethalin has been reported to give fair control of morningglories which are hard to control in tobacco (13, 100). Weeds that develop following application can be controlled with shallow cultivation.

During cold and wet or hot and dry weather, pendimethalin may stunt tobacco, but the tobacco eventually recovers (6). Excessive rates or improper incorporation can cause early-season stunting and irregular tobacco growth later in the season. Lunsford (71) found that pendimethalin at rates equal to 1.5 to 2 times that recommended for the soil type caused excessive root pruning in tobacco. The root pruning was thought to be responsible for the non-uniform tobacco growth. Six weeks after transplanting recommended rates caused 20 to 30 percent root pruning but by bloom stage had little or no effect on tobacco growth. Rates of 1.68 to 2.24 kg/ha caused excessive root pruning. Lunsford felt that inadequate incorporation could result in areas within the tobacco field having rates within the range of 1.68 to 2.24 kg/ha. Early-season root pruning of 30 to 60 percent reduced tobacco growth uniformity by 10 to 30 percent. Worsham (130) attributed the increase in root pruning to the use of larger disks for incorporation. Incorporation of pendimethalin by one pass of a cutting disk reduced crop vigor by 11 percent 3 weeks after transplanting. A rotary cultivator significantly reduced crop stunting and did not delay maturity when compared to all one pass disk treatments. Cross-disking with either a combination disk or finishing disk was recommended to achieve uniformity of incorporation. Worsham maintained that, although early-season vigor reduction does not normally reduce yields, an irregular tobacco crop can prevent uniform application of late-season pesticides such as insecticides and sucker control materials.

Pendimethalin rates recommended for weed control in tobacco range from 0.84 to 1.68 kg/ha depending on soil type (6, 11, 13). Recommended rates for coarse soil in Tennessee are 0.84 to 1.12 kg/ha and 1.4 to 1.68 kg/ha for medium and fine textured soils. The highest rates are recommended in areas where utilization of manure is high and where a history of heavy weed infestation is known. Due to absorption, activity of pendimethalin has been poor on soils high in organic matter or clay content (11). Pendimethalin persistance averages about 3 months depending on climatic conditions. A period of 120 days after pendimethalin application should be allowed before planting a winter wheat or barley crop (11).

Parka and Soper (87) discovered that the shoots of monocots and hypocotyl of dicots are the primary site of uptake of dinitroanilines from soil. Although absorption and translocation has not been demonstrated in tobacco, it has been found to occur in seedlings of certain crops. In general, dinitroanilines in close proximity to roots will be either absorbed or adsorbed, but translocation will be minimal. Malefyt and Duke (76) reported that pendimethalin applied only to the shoot zone of velvetleaf stopped all shoot growth. When applied to the root zone only, root growth was stopped. The shoots above the treated zone remained healthy and produced an extensive adventitious root system in the shoot zone. Lateral or secondary root inhibition is characteristic of dinitroanilines and actual seed germination is affected very little (87). Shoots tend to be reduced in length or stunted. Cotyledons are often swollen and the stem or hypocotyl becomes brittle. Monocots emerge prostrate, twisted, stunted, and appear reddish purple in color. Malefyt and Duke (75) found that a concentration of .0001 M pendimethalin was sufficient to induce characteristic root pruning symptoms. Plant parts least affected were those with the least cell division. The toxic effect takes place between emergence of the radicle and shoot from the seed and the emergence of the seedling from the soil (87). Disruption of cell division during mitosis causes multinucleate cells in both shoot and root meristems. Pendimethalin is considered to be a mitotic poison (87).

Application of pendimethalin should be in a minimum of 94 L/ha by ground equipment (6). Application pressure should be between 1.4 and 2.8 kg/cm^2. Pendimethalin is considered a moderately persistent herbicide compared to other dinitroaniline herbicides. Goddard et al. (45) were able to achieve excellent control of several annual grasses and broadleaf weeds with pendimethalin regardless of whether the incorporation time was immediate or delayed from 5 to 8 days. Kennedy and Talbert (65) found that if the delay was only one day, more than 90 percent of the original activity was achieved with little reduction in control (89). Delaying pendimethalin incorporation for 3 days or more allowed dramatic losses in control to occur. Parochetti and Burt (89) found that control by pendimethlin was not improved by rainfall 5 days after application with no incorporation. They suggested that volatility and/or photodecomposition had already reduced persistence of pendimethalin to the extent that weed control was reduced.

Acephate

Acephate (O,S-dimethyl acetylphosphoramidothioate) is a white, solid insecticide introduced by Chevron Chemical Company in 1971 as a second-generation improvement on methamidophos (10, 74). Acephate is an organic phosphate insecticide of moderate persistence with residual activity of from 5 to 10 days at recommended rates. Rates ranging from 0.56 to 0.84 kg/ha are recommended in Tennessee for the control of aphids, tobacco budworms, flea beetles, hornworms, and cutworms in tobacco (8, 23). Acephate is effective against green peach aphids and tobacco budworms which have exhibited resistance or tolerance to other organic phosphates (10, 74). Acephate has excellent plant safety in a wide range of crops including tobacco. Pless[1] observed an apparent increase in late-season maturity in plots treated with acephate. He expressed the possibility of growth enhancement activity associated with the use of acephate.

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[1]Pless, C. D. 1982. Personal Communication.

TOBACCO GRADES

Burley Tobacco

Leaves from cured burley tobacco plants are hand graded starting from the bottom of the plant and proceeding to the top on the basis of quality and color characteristics (99). Leaves are usually grouped into one of four farm grades. However, one or more grades may be combined or subdivided depending on the degree of difference in color and quality that can be detected by the farmer. The lower leaves which are usually thin in body are placed in the first or flyings grade. These leaves usually receive more damage during the growing season or when the tobacco is harvested and housed. Ground leaves are also included in the flyings grade. The next group of leaves on the plant are the largest and often the most valuable leaves. Leaves in this grade are called lugs. Grade 3 is called the leaf grade. The leaf grade contains leaves that have larger stems. This group may be subdivided into bright and red leaf. The uppermost leaves on the plant that are under 40 cm in length are called tips. A tobacco crop may or may not have a tips grade depending on how low plants are topped and the quality of the crop in general. Federal Graders use a similar designation for burley tobacco grades or groups as that used by the tobacco farmer, but more distinctions are made on the basis of quality and color. In addition to the grades used by the tobacco farmer the Federal grading system includes mixed, nondescript, and scrap grades.

Each grade is given one of five quality ratings and one of thirteen color ratings. However, some grades are restricted to certain quality and color ratings.

Dark Fire-cured Tobacco

Leaves from dark tobacco that have been fire-cured are hand graded starting from the bottom of the plant and proceeding into the top on the basis of quality and color characteristics (98). Although methods of fire-curing of dark tobacco varies, the leaf is subjected to wood smoke at some time during the curing process regardless of the method used (1). Characteristics of dark fire-cured tobacco depends on environmental conditions, but are also influenced by the type of wood used to produce the smoke and the intensity of the exposure. Since the fire-curing process relies more on smoke than heat, the process is more similar to the air-curing process used for burley tobacco than the flue-curing process. Dark fire-cured leaves are usually grouped into one of the following farm grades: lugs, seconds, or leaf. Leaves from the seconds and leaf grades which contain green areas after curing are grouped into a grade called out leaf. Grades may be combined or subdivided depending on quality and color differences. The bottom leaves or lugs are thin in body and may be damaged or dirty. Grade 2 or seconds may have the same color and finish as the leaf grade but can be separated by a difference in body. The leaf grade will contain the top leaves which have good body, elasticity, and finish.

III. MATERIALS AND METHODS

INTERFERENCE OF ANNUAL GRASSES IN TOBACCO

Burley Tobacco

Two field studies were conducted at the University of Tennessee Tobacco Experiment Station, Greeneville, Tennessee, in 1982 and 1983. Both studies were arranged in a randomized complete block design with five replications in 1982 and four in 1983. Individual treatments were assigned to plots four rows (107 cm spacing) wide and 6 m long. Plant spacing was 51 cm in 1982 and 43 cm in 1983. Treatments used to determine critical weed-free requirements consisted of different periods of time in weeks that plots were maintained weed-free after transplanting. Weed-free periods were 2, 4, 6, 8, and 10 weeks. Treatments used to determine the critical duration of interference of annual grasses consisted of different periods of time in weeks from transplanting that annual grasses were allowed to grow before removal and subsequent maintenance of weed-free conditions. Periods of interference of annual grasses were for 2, 4, 6, 8, and 10 weeks after transplanting. A season long weed-free treatment and a season long annual grass infestation served as controls. Annual grass removal and maintenance of weed-free conditions were accomplished by hand-hoeing. Necessary broadleaf weed removal in all treatments was by hand-hoeing.

On June 4, 1982, and June 8, 1983, the burley tobacco variety 'Virginia 509' was transplanted in fields prepared for optimum growth of burley tobacco. No herbicides were applied at any time during the growing season. The soil type in 1982 was a Waynesboro loam with 2 to 5 percent slope. Corn had been grown on the area for the previous 3 years. The soil type in 1983 was a Hermitage silt loam with 5 to 12 percent slope. Previous crops on the area were tobacco, fallowed, and corn in 1982, 1981, and 1980, respectively. Both areas had a history of heavy annual grass populations. In 1982, a natural infestation of fall panicum was allowed to grow or was removed by hand-hoeing where appropriate. The population density was approximately 100 plants/m^2. In 1983, which was a very dry year, a natural infestation consisting of a combination of fall panicum, giant foxtail, goosegrass, and large crabgrass was allowed to grow or removed by hand-hoeing where appropriate. The population density was approximately 10 plants/m^2. The low population density was attributed to dry weather conditions. The order of dominance was fall panicum>giant foxtail>goosegrass>large crabgrass.

In 1982, the length of the tobacco leaf at the eighth node was recorded 12 weeks after transplanting from three plants randomly selected from the two center rows of each plot. Since leaf length measurements vary with position, leaf measurements were taken at a constant position to standardize measurements. In 1983, leaf length and width at the broadest part were recorded in the same manner. Plant numbers per plot were recorded each year. All yields were adjusted to a uniform plant number. The two center rows of each plot were harvested on September 21, 1982 and September 14, 1983. Tobacco from each plot was cured, stripped, and hand graded into three grades in 1982 and four in 1983. In 1982, only the flyings, lugs, and tips grades were used. Separation of a leaf grade from the lugs could not be justified based on quality and color characteristics. Each grade was weighed, given a Federal grade, and assessed a numerical grade index based on the Federal grade as a fraction of the Federal grade C1L (Table A-1, Appendix). Yields were calculated and adjusted to reflect a uniform plant number. A crop index based on the Federal grade times yield was calculated to give a net worth comparison for the tobacco from each treatment. Arcsine transformations of all percentage data were computed before statistical analysis. The final means were transformed back to percentages. Data were analyzed by the General Linear Models (GLM) procedure in the Statistical Analysis System (SAS) employing Duncan's multiple range test (107).

Dark Fire-cured Tobacco

In 1982 and 1983, field studies were conducted at the University of Tennessee Highland Rim Experiment Station, Springfield, Tennessee. Both studies were arranged in a randomized complete block design with four replications. Treatments and plot size were as described for the burley tobacco interference studies with the exception of plant spacing. The plant spacing was 61 cm for both years.

On June 8, 1982 and June 13, 1983 the dark fire-cured tobacco variety 'Madole' was transplanted in fields prepared for optimum growth of dark fire-cured tobacco. No herbicides were applied at any time during the growing season. In 1982 the soil type was a Dickson silt loam with 2 to 5 percent slope and a Sango silt loam with 2 to 5 percent slope in 1983. The areas were known to have heavy annual grass populations. In 1982, a natural infestation consisting of a combination of large crabgrass and giant foxtail was allowed to grow or was removed where appropriate. The population density was approximately 70 plants/m^2 in a ratio of 2.5 to 1. Large crabgrass was the predominant species. In 1983, a natural infestation consisted primarily of fall panicum with sporadic, minor populations of stinkgrass [*Eragrostis cilianensis* (All.) Lutati], goosegrass, and smooth crabgrass [*Digitaria ischaemum* (Schreb.) Muhl.].

Twelve weeks after transplanting leaf length at the eighth node was recorded from three plants randomly selected from the two center rows of each plot in 1982. In 1983, leaf length and width were recorded. Plant numbers per plot were recorded. The two center rows of each plot were harvested on September 16, 1982 and September 22, 1983 respectively. The tobacco plants from each plot were fire-cured and total cured plant weight was recorded. Leaves were stripped, hand graded, and the cured leaf weights were recorded for each grade within each plot. In 1982, dark fire-cured tobacco leaves were graded into four grades. Lugs were subdivided into two grades. Grades 3 and 4 were the seconds and leaf grades. In 1983, lugs and leaf grades were subdivided into two grades each. A seconds grade made a total of five grades. The use of an out leaf grade was not necessary either year. Yields were calculated and adjusted to reflect a uniform plant number. Arcsine transformations of all percentage data were computed before statistical analysis. The final means were transformed back to percentages. Data were analyzed by the GLM procedure in SAS employing Duncan's multiple range test (107).

POSTEMERGENCE ANNUAL GRASS CONTROL IN TOBACCO

Burley Tobacco

Field studies were conducted at the University of Tennessee Tobacco Experiment Station, Greeneville, Tennessee in 1982 and 1983. Both studies were arranged in a randomized complete block design with four replications. Plots consisting of individual treatments were four rows spaced 107 cm apart and 6 m long. Plant spacing was 51 cm in 1982 and 43 cm in 1983. Treatments consisted of a cultivated check and four herbicide treatments (Table 1). The herbicide treatments included the following: pendimethalin applied pre-plant incorporated, sethoxydim plus Agridex® crop oil concentrate (COC) applied postemergence, sethoxydim applied postemergence, and fluazifop-butyl plus COC applied postemergence. The above treatments were applied alone and in combination with acephate. All plots not receiving acephate were treated with malathion to reduce the damage from insects. Cultivated check plots were cultivated twice, approximately 2 and 4 weeks after transplanting. All herbicide and insecticide treatments were applied with a CO_2 backpack sprayer in 187 L/ha. Acephate and treatments with either sethoxydim or fluazifop-butyl were applied at a pressure of 2.8 kg/cm^2 in 1983. All other treatments were applied at 2.1 kg/cm^2. Pendimethalin was applied immediately before transplanting and

Table 1. Conventional and Postemergence Annual Grass Control Treatments Used in this Study.[a]

Treatment	Rate
Cultivated Check	--
Pendimethalin (PPI)	1.68 kg/ha
Sethoxydim (POST)	0.56 kg/ha
+ Crop Oil Concentrate	0.95 L/ha
Sethoxydim (POST)	0.56 kg/ha
Fluazifop-butyl (POST)	0.56 kg/ha
+ Crop Oil Concentrate	0.95 L/ha

[a]Treatments were evaluated alone and in combination with acephate at a rate of 1.12 kg/ha.

PPI = Preplant incorporated; POST = Postemergence; Crop Oil Concentrate = Agridex®.

incorporated with two passes of a finishing disk. Postemergence herbicide treatments were applied at approximately 5 weeks after transplanting. All early-season applications of acephate were made to coincide with application of the postemergence herbicides. Acephate was applied as a tank-mix with the postemergence herbicides. Late-season applications of acephate were made to all treatments at approximately 9 and 12 weeks after transplanting.

The burley tobacco variety 'Virginia 509' was transplanted on June 4, 1982 into a field prepared for optimum burley tobacco growth. The soil type was a Waynesboro loam with 2 to 5 percent slope. The field had been planted in corn for the 3 years prior to this study. The same variety was transplanted on June 8, 1983. The soil type was a Hermitage silt loam with 5 to 12 percent slope. Previous crop history included tobacco, a fallow year, and corn in 1982, 1981, and 1980, respectively.

In 1982, annual grass control and tobacco vigor reduction were evaluated 8 weeks after transplanting or 3 weeks after postemergence herbicide application. Bloom and plant number percentages were recorded 11 weeks after transplanting. In 1983, annual grass control and tobacco vigor reduction were evaluated approximately 7, 9, and 12 weeks after transplanting or 2, 4, and 7 weeks after postemergence herbicide application. Bloom and plant number percentages were recorded 9 weeks after transplanting.

The two center rows of each plot were harvested on September 14, 1982 and September 21, 1983. Plants from each plot were cured, stripped, and hand graded. Cured leaves in each grade from each plot were weighed, given a Federal grade, and assessed a numerical grade index based on the Federal grade as a fraction of the Federal grade C1L (Table A-1, Appendix). Yields were adjusted to reflect a uniform plant number. A crop index based on the Federal grade times yield was calculated to give a net worth comparison for each treatment. Arcsine transformations of all percentages were computed before statistical analysis. Final means were transformed back to percentages. Data were analyzed by GLM procedure in SAS employing Duncan's multiple range test (107).

Samples of cured tobacco leaves were taken from the bottom, middle, and top positions of plants from each plot. The samples were dried and ground to 40 mesh for analysis of reducing sugar. The extraction reagent was prepared by adding 200 ml glacial acetic acid and 800 ml methanol to 3 l of water (42, 54). An activated carbon suspension was prepared with 900 ml of 50 percent aqueous glycerol. Reducing sugars standards of 5, 10, 15, 20, and 25 percent were prepared as described by Gaines (42). A 1 g sample of 40 mesh cured tobacco leaf material from each plot was weighed into 125 ml Erlenmeyer flasks and diluted to 85 ml with extraction reagent. A 15 ml aliquot of carbon suspension was added to the 85 ml solution. The flasks were stoppered and placed on an automatic shaker for 30 minutes. Carbon was removed from each sample by gravity filtration through No. 1 Whatman filter paper. Samples were analyzed with a Technicon Auto-analyzer. Percentage data obtained were corrected for a five-fold concentration and transformed by arcsine transformation before analysis. Final means were transformed back to percentages. Data were analyzed by GLM in SAS employing Duncan's multiple range test (107).

Dark Fire-cured Tobacco

Field studies were conducted at the University of Tennessee Highland Rim Experiment Station, Springfield, Tennessee. Experimental design, plot dimensions, treatments, and treatment applications were as described for the burley tobacco postemergence studies with the following exceptions: row length was 8 m in 1982, plant spacing was 61 cm both years, and incorporation of pendimethalin was with one pass of a power take-off driven rotary cultivator.

The dark fire-cured variety 'Madole' was transplanted on June 8, 1982 and June 13, 1983. The soil types were a Dickson silt loam with 2 to 5 percent slope in 1982 and a Sango silt loam with 2 to 5 percent slope in 1983.

In 1982, annual grass control and tobacco vigor reduction were evaluated 8 weeks after transplanting or 3 weeks after application of the postemergence herbicides. In 1983, annual grass control and tobacco vigor reduction were evaluated approximately 7, 9, and 12 weeks after transplanting or 2, 4, and 7 weeks after postemergence herbicide applications. Plant number was recorded 9 weeks after transplanting both years. Arcsine transformations of all percentage data were computed before statistical analysis. Final means were transformed back to percentages.

The two center rows of each plot were harvested on September 16, 1982 and September 22, 1983. Plants from each plot were fire-cured and total cured plant weight was recorded. Leaves were stripped from stalks, hand graded, and a weight taken for each grade. Yields were adjusted to reflect a uniform plant number. Data were analyzed by the GLM procedure in SAS employing Duncan's multiple range test (107).

IV. RESULTS AND DISCUSSION

INTERFERENCE OF ANNUAL GRASSES IN BURLEY TOBACCO

Critical Annual Grass-free Period

The critical weed-free period for burley tobacco was considered to be at the point between a non-significant and a significant treatment period when compared to the weed-free check. In 1982, fall panicum reduced tobacco plant vigor if plots were maintained weed-free for 4 weeks after transplanting or less (Table 2). Tobacco maintained free of fall panicum for 6 weeks or longer exhibited no significant reduction in vigor. The critical fall panicum free period to prevent a reduction in burley tobacco vigor was considered to be between 4 and 6 weeks. As annual grasses were allowed to grow for longer periods by decreasing the weed-free period to below 4 weeks after transplanting, a more drastic decline in tobacco vigor occurred. Interference of fall panicum following a 4 week weed-free period decreased leaf length by more than 15 cm. Interference following a 6 week weed-free period did not affect tobacco leaf length. Leaf length alone may not be as sensitive an indicator of leaf response as leaf length, width, area, and length/width ratio measurements (94, 116).

Plant number differences were not due to treatment effect, but were due to planter inconsistencies which caused a variation in plant number per plot by no more than one or two plants. Individual grade yields indicated that leaves falling into grade 1 were less responsive to

Table 2. Response of Burley Tobacco to Different Fall Panicum-free Periods Following Transplanting in 1982.[a]

Weed-free Period	Vigor Reduction[b]	Leaf Length[c]	Individual Grade Yields			Total Cured leaf Yield	Federal Grade[d]	Crop Index[e]
			Grade 1	Grade 2	Grade 3			
(weeks)	(%)	(cm)	(kg/ha)					
0	51x	46.7x	98x	154w	111v	363x	.246x	89x
2	50x	49.4x	166x	113w	77v	356x	.230x	82x
4	14y	63.7y	417y	612x	356w	1385y	.360xy	500y
6	10yz	68.6z	497y	884xy	480wxy	1861yz	.455yz	847yz
8	4z	65.6yz	500y	1314z	668z	2482z	.482z	1196z
10	6z	68.2z	509y	1160yz	605yz	2274z	.445yz	1012z
15	7z	68.6z	608y	1180yz	542xyz	2330z	.474z	1104z

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Ratings were taken 8 weeks after transplanting.

[c]Measurements were taken 12 weeks after transplanting.

[d]Values are based on a value of 1.000 for the Federal grade C1L.

[e]Crop index equals total cured tobacco leaf yield times the Federal grade.

interference from regrowth of annual grasses than leaves falling into the other two grades. Regrowth of annual grasses occurring after weed-free periods of 4 weeks or longer did not significantly reduce yields of grade 1 burley tobacco. The critical period for tobacco classified as grades 2 and 3 was between 4 and 6 weeks. A maximum yield of grade 2 tobacco of 1314 kg/ha occurred following 8 weeks of weed-free conditions. Fall panicum control beyond 8 weeks should not be necessary to obtain maximum yields of all grades of burley tobacco. Weed-free conditions for 6 weeks were found to be sufficient to prevent significant reductions in yield and Federal grade. Federal grade is an indicator of quality. Annual grasses following a weed-free period of only 4 weeks reduced cured leaf yields by almost 1000 kg/ha. A crop index was calculated to reflect the interaction of Federal grade and yield. Interference from regrowth of annual grasses occurring after a weed-free period of only 4 weeks significantly reduced the crop index. Interference of annual grasses from transplanting or 2 weeks after transplanting to harvest reduced the crop index by more than 90 percent.

In 1983, a better estimate of leaf response to different periods of interference was attempted by taking leaf length and width measurements. Leaf length was decreased significantly by interference of annual grasses that extended from transplanting to harvest only (Table 3). Width was more responsive requiring at least a 4 week weed-free period to prevent a significant reduction. Interference from annual grass regrowth following a 2 week weed-free period reduced width by 4.7 cm. Relative leaf area was calculated as length times width. Although length times width is not a true measurement of leaf area, leaf area can

Table 3. Response of Burley Tobacco to Different Annual Grass-free Periods Following Transplanting in 1983.[a]

Weed-free Period	Leaf Length[b]	leaf Width[b]	Relative Leaf Area[c]	Leaf Ratio[d]	Individual Grade Yields Grade 1	Grade 2	Grade 3	Grade 4	Total Cured Leaf Yield	Federal Grade[e]	Crop Index[f]
(weeks)	------(cm)-----		(cm^2)		---------------------(kg/ha)-------------------						
0	55.7x	26.4x	1478x	2.12xy	392	917xy	501x	319x	2129	.404	860
2	57.8xy	26.6x	1544x	2.19x	442	1239x	524xy	379xy	2594	.508	1318
4	57.6xy	28.2xy	1639xy	2.07xy	424	781y	559xy	418xy	2182	.441	962
6	62.4y	29.8xy	1870y	2.13xy	398	1028xy	455x	312x	2193	.456	1000
8	61.5y	30.3y	1874y	2.05xy	417	1130xy	568y	368xy	2483	.511	1269
10	62.3y	30.3y	1901y	2.06xy	438	720y	660yz	507y	2325	.443	1030
14	61.1y	31.3y	1941y	1.98y	442	824xy	775z	452y	2493	.469	1169

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Measurements were taken 12 weeks after transplanting.

[c]Relative leaf area equals leaf length times leaf width.

[d]Leaf ratio equals leaf length/leaf width.

[e]Values are based on a value of 1.000 for the Federal grade C1L.

[f]Crop index equals total cured tobacco leaf yield times the Federal grade.

be calculated by multiplying length times width times a constant for the type and variety of tobacco used (116). Actual leaf area calculations were not attempted, but the relative area should serve to evaluate leaf size responses.

Relative tobacco leaf area was decreased significantly if annual grasses were controlled for only 2 weeks or were allowed to grow undisturbed throughout the entire season. Leaf length/width ratios of tobacco leaves were reported by Suggs, et al., (116) to vary with variety and plant age. Variation of the ratio of leaf length/width in a particular variety taken at a specific plant age could be a valuable indicator of tobacco leaf response to a variable such as the length of interference of annual grasses. Leaf length/width ratios were erratic. The leaf length/width ratio of tobacco subjected to interference of annual grasses from transplanting to harvest was not significantly different from the weed-free check. The weedy check had a measurably higher ratio of 2.12 compared to 1.98 for the weed-free check indicating a trend toward slightly longer, narrower leaves as interference of annual grasses increased.

Dryer weather conditions in 1983 (Table B-1, Appendix) resulted in an irregular crop and a reduction in the annual grass population. The irregular nature of the burley tobacco crop in 1983 introduced considerable variation into the studies which tends to obscure the effects of treatments in a statistical analysis. A low annual grass population reduced the interference pressure preventing evaluations that would reflect the interference conditions in a normal crop year.

No significant differences due to treatments were found in grade 1 yields. Grade 1 contained the lower plant leaves that had matured early. Grade 2 tobacco yields subjected to different durations of interference of annual grasses were not significantly different when compared to yields from tobacco grown under weed-free conditions for the duration of the growing season. Erratic differences occurred among other treatments, but were unexplainable except by the effects of dry weather conditions. Tobacco yields in grade 3 which contained the next best grade of burley tobacco were the most responsive to treatment effect. A weed-free period of 10 weeks was required to prevent significant reductions in yield of more than 200 kg/ha. Tobacco yields in grade 4 were not significantly affected by interference of annual grasses compared to the full-season weed-free treatment. However, interference of annual grasses occurring after a 6 week weed-free period resulted in a significant decrease in burley tobacco yield compared to interference after a 10 week weed-free period. Evaluation of yields of individual grades is difficult due to a quality factor. As quality is affected, a shift of tobacco into a lower grade occurs. This reduces the ability to detect responses to treatment effects on yield. A response in an individual grade would be due to an effect on both quality and yield. No significant differences were detectable for Federal grade, yield, or crop index. Measureable trends were erratic and difficult to evaluate.

This study indicated that the critical weed-free period for iterference of fall panicum in burley tobacco was between 4 and 6 weeks under a population density pressure of approximately 100 plants/m^2.

Interference from regrowth of fall panicum after a 4 week weed-free period was sufficient to cause significant loss of burley tobacco quality and yield. Vigor reduction and leaf length were early indicators of the response that was reflected later in quality and yield of cured tobacco. An ideal preemergence or preplant incorporated herbicide should control annual grasses for up to 6 weeks with little need for residual control after that point. Under dry growing conditions and reduced annual grass population in 1983, Federal grade and cured leaf yield did not reflect the response detected earlier in the growing season by leaf length and width measurements.

Critical Duration of Interference of Annual Grasses

The critical duration of interference of annual grasses in burley tobacco was considered to occur between the first significantly responsive weedy period, measured in 2 week periods, compared to the weed-free check. In 1982, tobacco vigor was reduced by 32 percent in plots where fall panicum was allowed to grow for 6 weeks from transplanting before removal and maintanence of weed-free conditions for the remainder of the growing season (Table 4). Interference of fall panicum for 4 weeks after transplanting did not significantly reduce tobacco vigor. Interference in excess of 8 weeks severely reduced burley tobacco vigor by approximately 50 percent.

Interference of fall panicum for 2 weeks did not reduce leaf length. The longer fall panicum was allowed to interfere with burley tobacco beyond 2 weeks and up to 10 weeks after transplanting, the

Table 4. Response of Burley Tobacco to the Presence of Fall Panicum for Different Periods Following Transplanting in 1982.[a]

Weedy Period	Vigor Reduction[b]	Leaf Length[c]	Individual Grade Yields Grade 1	Grade 2	Grade 3	Total Cured Leaf Yield	Federal Grade[d]	Crop Index[e]
(weeks)	(%)	(cm)	----------	(kg/ha)	----------	----------		
0	7x	68.6v	608x	1180x	542vwx	2330w	.474x	1104x
2	6x	66.8v	480x	1250x	620vw	2350w	.459x	1078x
4	7x	60.2w	415x	1155x	656v	2226w	.495x	1102x
6	32y	54.4x	243yz	594y	392xy	1229xy	.282y	356y
8	37y	51.1y	157z	236z	313y	706yz	.249y	176y
10	48z	47.3z	92z	123z	161z	376z	.238y	89y
15	51z	46.6z	98z	15yz	111z	363z	.246y	89y

[a]Means followed by the same letter in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Ratings were taken 8 weeks after transplanting.

[c]Measurements were taken 12 weeks after transplanting.

[d]Values are based on a value of 1.000 for the Federal grade C1L.

[e]Crop index equals total cured tobacco leaf yield times the Federal grade.

greater the decrease in leaf length. Season long interference did not decrease leaf length below that for 10 weeks of interference.

Yield response was similar for tobacco classified as grade 1 or 2. The critical duration of interference of fall panicum was between 4 and 6 weeks. Interference of fall panicum for 6 weeks or more severely reduced grade 1 and 2 yields. Yields of grade 3 tobacco were not significantly reduced by 6 weeks of interference of fall panicum. Eight and ten weeks of interference of fall panicum significantly reduced yields of grade 3 tobacco by 42 and 70 percent, respectively. A dramatic division of the Federal grade occurred between 4 and 6 weeks of interference of fall panicum. The range of the Federal grades was from .495 to .474 for 4 or fewer weeks of interference of fall panicum and from .282 to .246 for 6 or more weeks of interference. The critical period for yield was also between 4 and 6 weeks. If fall panicum was allowed to grow for 6 weeks before removal and maintenance, yields were 1229 kg/ha compared to 2330 kg/ha for the weed-free checks. Severe yield reductions of more than 70 percent occurred, if fall panicum was allowed to interfere for 8 or more weeks before removal. The response of the Federal grade and yield was magnified by calculation of a crop index. Crop indexes were similar for 0, 2, and 4 weeks of interference of fall panicum. Six weeks of interference of fall panicum reduced the crop index to approximately 30 percent of the three shorter weedy periods. Crop index is an indicator of marketable return. As quality declines, the price per kilogram is reduced. Therefore, a reduction in both quality and yield can drastically reduce net income.

As was stated earlier, dry weather conditions in 1983 influenced tobacco growth (Table B-1, Appendix). The nonuniformity of the burley tobacco crop was thought to obscure the effects of interference of annual grasses. The critical weedy period for leaf length was between 6 and 8 weeks (Table 5). Interference by annual grasses for more than 8 weeks before removal reduced leaf length by 5.1 cm. Leaf width was more sensitive to interference of annual grasses than leaf length. Only 4 weeks of interference of annual grasses could be tolerated without a significant reduction in tobacco leaf width. Interference of annual grasses for 6 weeks reduced leaf width by 4.5 cm. The critical period for relative tobacco leaf area was between 4 and 6 weeks. Interference for 6 weeks reduced relative leaf area by more than 350 cm^2 and significantly increased the length/width ratio when compared to the weed-free check. No other period of interference from transplanting significantly affected the leaf/width ratio compared to the weed-free check.

No significant differences were found among the treatment yields of tobacco classified as grades 1 or 2. Tobacco not subjected to interference of annual grasses produced significantly higher yields of grade 3 tobacco than all other treatments with the exception of 6 weeks of interference of annual grasses. The weed-free check plots yielded significantly more grade 4 tobacco than did the treatments with a 4 week weedy period. Measureable decreases of .065, 354 kg/ha, and 309 points were recorded for Federal grade, yield, and crop index, respectively, when annual grasses interfered with burley tobacco for the entire season compared to no interference. These differences were not significant.

Table 5. Response of Burley Tobacco to the Presence of Annual Grasses for Different Periods Following Transplanting in 1983.[a]

Weedy Period	Leaf Length[b]	leaf Width[b]	Relative Leaf Area[c]	Leaf Ratio[d]	Individual Grade Yields Grade 1	Grade 2	Grade 3	Grade 4	Total Cured Leaf Yield	Federal Grade[e]	Crop Index[f]
(weeks)	-----(cm)-----		(cm^2)		----------(kg/ha)----------						
0	61.1x	31.3x	1941x	1.98xy	442	824	775x	452x	2493	.469	1169
2	60.7xy	28.6xy	1739xy	2.14yz	367	987	518y	344xy	2216	.458	1015
4	61.7x	31.7x	1959x	1.95x	415	1077	471y	303y	2266	.528	1196
6	58.4xy	26.8y	1580y	2.20z	487	893	661xy	448x	2489	.482	1200
8	56.0y	26.7y	1521y	2.11xyz	440	1077	498y	366xy	2381	.451	1074
10	55.8y	26.8y	1500y	2.08xyz	438	816	571y	438xy	2260	.427	965
14	55.7y	26.4y	1478y	2.12xyz	392	917	501y	319xy	2129	.404	860

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Measurements were taken 12 weeks after transplanting.

[c]Relative leaf area equals leaf length times leaf width.

[d]Leaf ratio equals leaf length/leaf width.

[e]Values are based on a value of 1.000 for the Federal grade C1L.

[f]Crop index equals total cured tobacco leaf yield times the Federal grade.

The response detected in tobacco leaf length and width measurements was not expressed in yield or quality measurements.

This study indicates that the critical duration of interference of fall panicum in burley tobacco is between 4 and 6 weeks for quality and cured leaf yield under a population density pressure of approximately 100 plants/m^2. Vigor reduction was a good early indicator of plant response to interference of fall panicum. Leaf length was a more sensitive indicator of interference of fall panicum than was tobacco vigor. An ideal postemergence herbicide should be applied about the fourth week and should halt the effects of interference of fall panicum shortly after application. Under dry conditions and reduced annual grass population, Federal grade and cured leaf yield did not reflect the response to interference indicated earlier in the season by leaf length and width measurements.

INTERFERENCE OF ANNUAL GRASSES IN DARK FIRE-CURED TOBACCO

Critical Annual Grass-free Period

The critical annual grass-free period for vigor reduction and leaf length in dark fire-cured tobacco was between 2 and 4 weeks in 1982 (Table 6). Annual grass regrowth after 4 weeks of weed-free conditions did not significantly affect tobacco vigor or leaf length. Interference of annual grasses from transplanting or 2 weeks after transplanting to harvest reduced tobacco vigor by 24 percent or more and leaf length by

Table 6. Response of Dark Fire-cured Tobacco to Different Annual Grass-free Periods Following Transplanting in 1982.[a]

Weed-free Period	Vigor Reduction[b]	Leaf Length[c]	Individual Grade Yields Grade 1	Grade 2	Grade 3	Grade 4	Total Cured Leaf Yield	Total Cured Plant Weight
(weeks)	(%)	(cm)	----------	----------	----------	(kg/ha)	----------	----------
0	26x	59.2y	216x	256x	157x	362x	991x	1428x
2	24x	52.1x	212x	265x	145x	390x	1012x	1457x
4	8y	73.7z	262x	476y	527y	1401y	2666y	3738y
6	5y	76.7z	378y	440y	660y	1706yz	3184yz	4258yz
8	4y	79.2z	426yz	504yz	684y	1754z	3368z	4568yz
10	6y	76.9z	409yz	436y	745y	1529yz	3119yz	4356yz
14	4y	77.4z	499z	650z	664y	1817z	3630z	4934z

[a]Means followed by the same letter in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Ratings were made 8 weeks after transplanting.

[c]Measurement were taken 12 weeks after transplanting.

more than 25 cm compared to no interference. The predominant annual grass species that occurred as regrowth was large crabgrass.

Different periods of interference from large crabgrass regrowth following weed-free periods affected tobacco yields in individual grades. The yield of dark fire-cured tobacco in grade 1 was significantly reduced by large crabgrass interference occurring after a 6 week weed-free period. Interference following a weed-free period of 4 or less weeks caused tobacco to yield significantly less than when interference occurred after the 4-week weed-free period. Tobacco subjected to no interference yielded significantly more grade 2 dark fire-cured tobacco than when subjected to annual grass interference following 6 weeks or less of weed-free conditions. A weed-free period of 4 weeks was required to prevent significant reductions of grade 3 tobacco yields. A 6 week weed-free period was required to prevent reductions in grade 4 tobacco yields. A weed-free period of at least 6 weeks was required to reduce interference to an acceptable level for total cured tobacco plant weight and cured leaf yields. Interference from regrowth of annual grasses following a 4 week weed-free period reduced total cured plant weight and cured leaf yield. Interference of annual grass from transplanting to harvest produced the lowest total cured tobacco plant weight and cured yield. Dark fire-cured tobacco vigor reduction and leaf length response were not good indicators of yield response.

Dry weather conditions in 1983 were thought to be responsible for a reduced population of annual grasses. A higher population density would have increased the interference of annual grasses (Table B-2, Appendix).

Although trends were evident, no significant responses were found in dark fire-cured tobacco leaf length, width, relative leaf area, and length/width ratio (Table 7). Interference of annual grasses occurring after different weed-free periods did not affect tobacco yields in grades 1, 2, 4, and 5. A 4 week weed-free period was required to prevent significant reduction of grade 3 yields. A weed-free period of only 2 weeks reduced interference of annual grasses with tobacco sufficiently so that total cured tobacco plant weight and leaf yield were not affected. As the weed-free period increased from 4 weeks to 14 weeks, interference from annual grasses was slightly reduced. A measurable but nonsignificant increase in total cured leaf yield of 323 kg/ha was recorded.

In 1982, results obtained in the dark fire-cured tobacco critical weed-free requirement study were comparable to those found in the burley tobacco study even though the annual grass population was of a different composition and density. A combination of large crabgrass and giant foxtail at a density of 70 plants/m^2 produced similar interference pressures. Comparable results were also found in the two types of tobaccos in 1983 due in part to similar weather conditions that occurred in both test areas. Although densities of 100 plants/m^2 are thought to be more appropriate for interference studies, the relatively low densities of annual grasses that occurred in 1983 still exerted interference pressure on tobacco (21). Preemergence or preplant incorporated herbicide application rates would have to be sufficient to control potentially heavy annual grass populations for a minimum of 6 weeks after transplanting to prevent reductions in yield and quality of

Table 7. Response of Dark Fire-cured Tobacco to Different Annual Grass-free Periods Following Transplanting in 1983.[a]

Weed-free Period	Leaf Length[b]	leaf Width[b]	Relative Leaf Area[c]	Leaf Ratio[d]	Individual Grade Yields					Total Cured Leaf Yield	Total Cured Plant Weight
					Grade 1	Grade 2	Grade 3	Grade 4	Grade 5		
(weeks)	-----(cm)----		(cm^2)		--------(kg/ha)--------						
0	60.8	28.4	1748	2.24	524	437	140x	582	671	2153x	3007x
2	62.6	29.9	1885	2.11	590	569	152x	438	725	2474xy	3470xy
4	65.9	32.2	2124	2.06	560	622	371xy	475	657	2685xy	3641xy
6	67.0	31.8	2142	2.12	526	556	358xy	733	733	2960y	4087y
8	65.2	31.2	2046	2.10	648	606	309xy	843	696	3102y	4257y
10	67.0	32.5	2171	2.09	539	658	517y	624	687	3025y	4188y
14	66.5	32.3	2176	2.07	544	469	515y	716	764	3008y	4201y

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Measurements were taken 12 weeks after transplanting.

[c]Relative leaf area equals leaf length times leaf width.

[d]Leaf ratio equals leaf length/leaf width.

dark fire-cured tobacco. Interference occurring from regrowth of annual grasses from 6 weeks to harvest does not significantly affect dark fire-cured tobacco. At 6 weeks after transplanting tobacco may successfully interfere with annual grasses.

Critical Duration of Interference of Annual Grasses

The critical duration of interference of annual grasses in dark fire-cured tobacco for vigor reduction and leaf length was between 6 and 8 weeks in 1982 (Table 8). Significant reductions occurred only if annual grasses interfered with the tobacco for 8 or more weeks. The critical period of interference of individual tobacco yields in grades 3 and 4 were similar to that recorded for vigor and leaf length. However, yields of grades 1 and 2 were more sensitive, tolerating only 4 weeks of interference from transplanting without significant reductions. As the period of interference was extended, reductions in yield were more severe. Six weeks of interference of annual grasses following transplanting reduced total cured tobacco plant weight by approximately 1100 kg/ha. Six weeks of interference reduced total cured tobacco leaf yield to 2884 kg/ha compared to 3630 kg/ha recorded for the weed-free check. The critical duration of interference of annual grasses was between 4 and 6 weeks.

In 1983, data obtained for tobacco leaf length, width, relative leaf area, and length/width ratio were erratic. The erratic nature of these measurements was attributed in part to dry weather conditions.

Table 8. Response of Dark Fire-cured Tobacco to the Presence of Annual Grasses for Different Periods Following Transplanting in 1982.[a]

Weedy Period	Vigor Reduction[b]	Leaf Length[c]	Individual Grade Yields Grade 1	Grade 2	Grade 3	Grade 4	Total Cured Leaf Yield	Total Cured Plant Weight
(weeks)	(%)	(cm)	(kg/ha)					
0	4w	77.4x	499w	650w	664xy	1817x	3630w	4934w
2	0w	75.6xy	407wx	473wx	787x	1731x	3398wx	4618wx
4	5w	74.4xy	488w	480wx	675xy	1720x	3363wx	4484wx
6	13wx	74.0xy	387xy	398xy	537xy	1542xy	2884xy	3850xy
8	19xy	69.4y	306yz	370xyz	435y	1162y	2273y	3028y
10	41z	54.2z	273z	174z	165z	417z	1029z	1390z
14	26y	59.2z	216z	256yz	157z	362z	991z	1428z

[a]Means followed by the same letter in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Ratings were taken 8 weeks after transplanting.

[c]Measurements were taken 12 weeks after transplanting.

The weed-free check was not significant different from any period of interference (Table 9).

Season long interference of annual grasses reduced individual yields only of grade 3 dark fire-cured tobacco. Different periods of interference had no significant effect on other grades. Season long interference of annual grasses significantly reduced total cured tobacco plant weight and cured leaf yield.

Under a population density pressure of 70 annual grass plants/m^2 the critical duration of interference of annual grasses was between 4 and 6 weeks. Although plant density and species were different, these results compare with those obtained in the 1982 burley tobacco interference study. The critical interference requirements for the two types of tobaccos may be similar.

POSTEMERGENCE ANNUAL GRASS CONTROL IN BURLEY TOBACCO

In 1982, annual grass control treatments did not significantly influence burley tobacco vigor (Table 10). Fluazifop-butyl plus a crop oil concentrate gave significantly more control of annual grasses than did cultivation or pendimethalin applied preplant incorporated. Annual grass control treatments did not significantly affect burley tobacco percent bloom or yields of in grade 1 and 2 tobacco. Tobacco treated with fluazifop-butyl plus a crop oil concentrate produced significantly less grade 3 tobacco than did tobacco that was cultivated. None of the

Table 9. Response of Dark Fire-cured Tobacco to the Presence of Annual Grasses for Different Periods Following Transplanting in 1983.[a]

Weedy Period	Leaf Length[b]	leaf Width[b]	Relative Leaf Area[c]	Leaf Ratio[d]	Individual Grade Yields Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Total Cured Leaf Yield	Total Cured Plant Weight
(weeks)	-----(cm)-----		(cm^2)		--(kg/ha)--						
0	66.5xyz	32.3xyz	2171xyz	2.07	544	469	515x	716	764	3008x	4201x
2	66.0xy	32.8xyz	2174xyz	2.02	517	558	594x	844	485	2998x	4164x
4	69.3xy	34.1x	2371xy	2.04	594	607	344xy	894	630	3069x	4280x
6	71.8x	33.7xy	2420x	2.15	542	669	419xy	936	784	3349x	4670x
8	64.4xyz	29.1yz	1883xyz	2.23	636	536	480x	738	843	3233x	4545x
10	62.8yz	29.7xyz	1869yz	2.12	458	561	496x	812	392	2720xy	3788xy
14	60.8z	28.4z	1748z	2.24	524	437	140y	382	671	2154y	3007y

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Measurements were taken 12 weeks after transplanting.

[c]Relative leaf area equals leaf length times leaf width.

[d]Leaf ratio equals leaf length/leaf width.

Table 10. Response of Burley Tobacco to Cultivation and Herbicide Treatments in 1982.[a]

Treatment	Vigor Reduction[b]	Annual Grass Control[b]	Bloom[c]	Individual Grade Yields Grade 1	Individual Grade Yields Grade 2	Individual Grade Yields Grade 3	Total Cured Leaf Yield	Federal Grade[d]	Crop Index[e]
	-------------(%)-------------			---------------(kg/ha)---------------					
Cultivation	15	92x	38	445	771	729x	1945	.258	508
Pendimethalin	12	91x	40	420	593	622xy	1635	.285	472
Sethoxydim + COC	15	97xy	27	396	602	610xy	1608	.243	391
Sethoxydim	16	97xy	41	440	729	613xy	1852	.294	593
Fluazifop-butyl + COC	20	99y	24	391	601	551y	1543	.315	410

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Ratings were taken 8 weeks after transplanting.

[c]Ratings were taken 12 weeks after transplanting.

[d]Values are based on a value of 1.000 for the Federal grade C1L.

[e]Crop index equals cured tobacco leaf yield times the Federal grade.

COC = Agridex crop oil concentrate.

treatments caused significant differences in total cured leaf yields, Federal grades, or crop indexes.

In 1983, no treatment significantly influenced burley tobacco vigor or percent bloom when compared to other treatments. Seven weeks after transplanting fluazifop-butyl plus a crop oil concentrate controlled less annual grasses than did cultivation or pendimethalin applied preplant incorporated (Table 11). Nine and twelve weeks after tobacco transplanting all treatments gave excellent annual grass control. Treatments did not significantly affect total cured leaf yields, Federal grades, or crop indexes.

Tobacco leaves from the bottom position of plants treated with sethoxydim contained significantly less reducing sugars than tobacco leaves from the same position of plants that were cultivated (Table 12). Percent reducing sugars in tobacco leaves from all three positions of the tobacco plants subjected to all annual grass control treatments fell within the normal range for burley tobacco (1, 113).

In 1982, tank-mixing acephate with fluazifop-butyl plus a crop oil concentrate reduced the control of annual grasses to 94 percent compared to 99 percent achieved by fluazifop-butyl plus a crop oil concentrate without acephate. No other significant tobacco response could be directly attributed to acephate use in either year.

Table 11. Response of Burley Tobacco to Cultivation and Herbicide Treatments in 1983.[a]

Treatment	Annual Grass Control[b] 7 Weeks	9 Weeks	12 Weeks	Total Cured Leaf Yield	Federal Grade[c]	Crop Index[d]
	(%)			(kg/ha)		
Cultivation	100x	97	98	3173	.472	1498
Pendimethalin	93x	98	99	2484	.435	1081
Sethoxydim + COC	89xy	96	97	2909	.482	1402
Sethoxydim	90xy	96	98	3045	.482	1468
Fluazifop-butyl + COC	80y	95	98	3102	.519	1610

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Control was estimated at three periods of time after transplanting.

[c]Values are based on a value of 1.000 for the Federal grade C1L.

[d]Crop index equals total cured tobacco leaf yield times the Federal grade.

COC = Agridex crop oil concentrate.

Table 12. Levels of Reducing Sugar Content in Burley Tobacco at Three Leaf Positions as Influenced by Cultivation and Herbicide Treatments.[a]

Treatment	Reducing Sugar Content		
	Bottom	Middle	Top
	(%)		
Cultivation	0.60a	0.52	0.73
Pendimethalin	0.61ab	0.63	0.75
Sethoxydim + COC	0.48ab	0.75	1.25
Sethoxydim	0.39b	0.57	0.81
Fluazifop-butyl + COC	0.53ab	0.55	1.53

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

COC = Agridex crop oil concentrate.

POSTEMERGENCE ANNUAL GRASS CONTROL IN DARK FIRE-CURED TOBACCO

In 1982, fluazifop-butyl plus a crop oil concentrate significantly reduced vigor of dark fire-cured tobacco when compared to tobacco that was cultivated (Table 13). Pendimethalin applied preplant incorporated and fluazifop-butyl plus a crop oil concentrate provided similar control of annual grasses. All other treatments controlled significantly more annual grass than did pendimethalin applied preplant incorporated. No treatment significantly affected grade 1 or 2 tobacco yields. Dark fire-cured tobacco treated with sethoxydim produced lower yields of grade 3 tobacco than did tobacco that was cultivated or treated with pendimethalin. Tobacco that was cultivated yielded more grade 4 tobacco than did that treated with the postemergence herbicides. Cultivated tobacco produced significantly higher total cured leaf yields and total cured plant weight than did any postemergence herbicide treated tobacco.

In 1983, dark fire-cured tobacco vigor reductions recorded 7, 9, and 12 weeks after transplanting averaged 5 percent or less across all treatments. Treatments did not significantly reduce tobacco vigor. Seven weeks after transplanting the postemergence herbicides controlled fewer annual grasses than did cultivation or pendimethalin applied preplant incorporated (Table 14). Nine weeks after transplanting sethoxydim plus a crop oil concentrate controlled more annual grasses than did sethoxydim alone. Control by sethoxydim plus a crop oil concentrate was equal to control by cultivation. By 12 weeks after

Table 13. Response of Dark Fire-cured Tobacco to Cultivation and Herbicide Treatments in 1982.[a]

Treatment	Vigor Reduction[b]	Annual Grass Control[b]	Individual Grade Yields				Total Cured Leaf Yield	Total Cured Plant Weight
			Grade 1	Grade 2	Grade 3	Grade 4		
	(%)		(kg/ha)					
Cultivation	1x	94x	510	529	617x	1547x	3203x	4117x
Pendimethalin	5xy	79y	468	427	580x	1160xy	2635xy	3435xy
Sethoxydim + COC	8xy	94x	419	395	393xy	1091y	2298y	2947y
Sethoxydim	8xy	95x	436	460	376y	778y	2050y	2664y
Fluazifop-butyl + COC	11y	88xy	394	440	416xy	942y	2192y	2886y

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Ratings were taken 8 weeks after transplanting.

COC = Agridex crop oil concentrate.

Table 14. Response of Dark Fire-cured Tobacco to Cultivation and Herbicide Treatments in 1983.[a]

Treatment	Annual Grass Control[b]			Individual Grade Yields					Total Cured	Total Cured
	7 Weeks	9 Weeks	12 Weeks	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Leaf Yield	Plant Weight
	----------(%)----------			--------------------------(kg/ha)--------------------------						
Cultivation	100x	100x	99	538	552	524	877	574	3065	4150
Pendimethalin	99x	99xy	99	428	610	433	479	853	2961	4024
Sethoxydim + COC	93y	100x	99	455	471	421	810	516	2673	3721
Sethoxydim	92y	98y	98	425	445	314	580	625	2389	3275
Fluazifop-butyl + COC	95y	99xy	99	513	515	363	652	687	2730	3822

[a]Means followed by the same letter or no letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

[b]Control was estimated at three periods of time after transplanting.

COC = Agridex crop oil concentrate.

transplanting no treatment significantly affected individual grade yields, total cured leaf yields, or total cured plant weights.

In 1982, acephate added to a tank-mix with sethoxydim or sethoxydim plus a crop oil concentrate reduced the vigor of dark fire-cured tobacco. No other responses could be attributed to this early-season application of acephate when compared to cultivated tobacco where no acephate was applied.

POSTEMERGENCE HERBICIDES AS AN ALTERNATIVE ANNUAL GRASS CONTROL OPTION

Postemergence annual grass herbicides can provide an alternative control option when annual grasses become a problem after transplanting. Whether cultivation is required to achieve maximum yields remains controversial. Although relatively small benefits have been demonstrated on soils with high clay content, experiments on light soils more often fail to show significant increases in tobacco yields (1). Another potential problem at this time is the lack of a postemergence broadleaf herbicide for use in tobacco. Although sethoxydim and fluazifop-butyl control annual grasses, reduced interference by annual grasses can cause proliferation of broadleaf weeds (56). In areas with heavy broadleaf weed pressure, postemergence grass herbicides as the only means of weed control would not be advisable. No-till tobacco has shown potential although yields have been low (82). Postemergence grass herbicides could become an important part of a no-till tobacco program; however, postemergence broadleaf weed control would still be a problem.

Annual grass root residue left by postemergence control of established grasses could be of importance. Root residue of annual grasses have been shown to exhibit allelopathic activity (19, 20, 109). Continued evaluation of postemergence grass herbicides should help to determine their importance and role as a weed control alternative in tobacco.

V. SUMMARY AND CONCLUSIONS

Studies were conducted to determine the critical annual grass-free requirement and critical duration of annual grass interference in burley and dark fire-cured tobaccos. The critical point in growth and yield reduction was considered to be that period at which a significant decrease was first noted compared to the weed-free check.

Treatments for determination of the annual grass-free requirement consisted of 2, 4, 6, 8, and 10 week annual grass-free periods. To study the critical duration of annual grass interference, treatments consisting of naturally occurring infestations of annual grasses were allowed to develop for 2, 4, 6, 8, and 10 weeks before removal and subsequent maintenance of weed-free conditions. A season long annual grass infestation and a season long weed-free treatment served as controls. Annual grass-free periods were established and maintained by hand-hoeing.

The critical annual grass-free period for burley and dark fire-cured tobacco quality and yield in 1982 was between 4 and 6 weeks. Therefore, any preemergence or preplant incorporated herbicide used to control annual grasses in tobacco should persist for at least 6 weeks. The annual grass populations were 100 plants/m^2 and 70 plants/m^2 for burley and dark fire-cured tobaccos, respectively. The critical duration of annual grass control was between 4 and 6 weeks for burley and dark fire-cured tobacco quality and yield. A postemergence herbicide could be applied up to the fourth week provided competition of annual grasses ceased shortly after application. In 1983, inadequate rainfall and low population density reduced or obscured interference by annual grasses. Burley and dark fire-cured tobacco responded similarly under population densities of 70 to 100 plants/m^2, although the composition of annual grass species was different.

Separate studies were conducted to determine the efficacy of the postemergence herbicides, fluazifop-butyl and sethoxydim, compared to conventional cultivation and preplant incorporated treatments of pendimethalin. The postemergence herbicides were applied with a crop oil concentrate. Treatments of sethoxydim without crop oil were included to evaluate any effect the crop oil concentrate might have on tobacco. Each of the above treatments was also applied in combination with acephate to evaluate any possible change in herbicide activity or crop response.

In 1982, burley tobacco plant vigor was not significantly reduced by any treatment. Control of annual grasses with postemergence herbicides was excellent and as well or better than that achieved with a preplant incorporated application of pendimethalin. The postemergence herbicides controlled annual grasses as well or better than cultivation. All herbicide treatments were evaluated without the added benefit of cultivation. Burley tobacco in plots treated with pendimethalin yielded more than tobacco in plots treated with postemergence herbicides. Cultivated dark fire-cured tobacco yielded more than tobacco treated with any of the herbicides. The marketable return of tobacco reflected by crop index was not affected by any treatment.

In 1983, vigor was not affected by any treatment. However, low rainfall and nonuniformity of the tobacco crop introduced variability that obscured the treatment effects. By 2 weeks after application of the postemergence herbicides, postemergence annual grass control was less than with conventional treatments. A slow rate of annual grass kill by postemergence herbicides was attributed in part to dry weather conditions. By 4 and 7 weeks, annual grass control was excellent in all treatments. Burley tobacco Federal grade, yield, and marketable returns reflected by crop index were not affected by treatments. Dark fire-cured tobacco yields in postemergence plots were similar to or slightly lower than those in conventionally treatmented plots.

Vigor reduction in dark fire-cured tobacco indicated a possible antagonism resulting from sethoxydim with or without a crop oil concentrate when tank-mixed with acephate. Tank-mixing with acephate did not affect annual grass control with postemergence herbicides. Incompatibility was noted in the form of crystallization of acephate. Crystals floated on the surface of the mix and required vigorous agitation to achieve suspension. Although acephate efficacy studies were not conducted, it is felt that reduced activity may occur if acephate is tank-mixed with either sethoxydim or fluazifop-butyl. Enhancement of tobacco growth by acephate could not be verified.

Postemergence treatments appear to have potential for annual grass control in tobacco. Applications should coincide well with the critical period for interference determined by the interference phase of this study. How postemergence herbicides could fit into the existing tobacco weed control program is difficult to evaluate. At the present time, a preplant incorporated treatment of pendimethalin in combination with cultivation provides good control of annual grasses, as well as, most broadleaf weeds.

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APPENDIX

Table A-1. Federal Grade Marks for U. S. Type 31 Tobacco - Burley.

Key to Grades

Group	Quality	Color	
X - Flyings	1 - Choice	L - Buff	V - Greenish
C - Lugs or Cutters	2 - Fine	F - Tan	VF - Greenish Tan
B - Leaf	3 - Good	FR - Tannish Red	VR - Geenish Red
T - Tips	4 - Fair	R - Red	G - Green
M - Mixed	5 - Low	D - Dark Red	GF - Green Tan
N - Nondescript		K - Variegated	GR - Green Red
S - Scrap		M - Mixed	

Federal Grade Values of Individual Grades

Grade	L	F	M	G
X1	.958	.951		
X2	.930	.909		
X3	.841	.804		
X4	.705	.643	.499	.378
X5	.523	.450	.377	.253

Grade	L	F	K	M	V	G
C1	1.000	.983				
C2	.963	.939				
C3	.911	.846	.787	.608	.702	.467
C4	.837	.716	.666	.513	.590	.361
C5	.614	.506	.546	.418	.439	.247

Grade	L	FR	R	D	K	M	VF	VR	GF	GR
B1	.983	.712	.585							
B2	.863	.618	.498							
B3	.695	.542	.433	.351	.647	.495	.591	.377	.398	.336
B4	.532	.428	.347	.262	.496	.386	.453	.302	.270	.228
B5	.375	.313	.261	.209	.290	.261	.221	.221	.189	.159

Grade	F	FR	R	D	K	VF	VR	GF	GR
T3	.517	.438	.358	.286	.480	.439	.312	.278	.234
T4	.376	.323	.270	.216	.350	.320	.235	.218	.184
T5	.261	.234	.206	.168	.240	.231	.175	.173	.145

Grade	F	FR
M4	.585	.469
M5	.410	.316

Grade	L	F	R	G
N1	.267	.203	.156	.136
N2	.182		.105	.097

Table B-1. Rainfall Data - Tobacco Experiment Station, Greeneville, TN.

date	June Rainfall 1982	June Rainfall 1983	July Rainfall 1982	July Rainfall 1983	August Rainfall 1982	August Rainfall 1983
	(cm)					
1		.25	.46		.18	5.38
2		1.12			.41	
3						
4	3.56		4.50	1.42		
5		1.12	3.56	.38		
6					.43	
7	.51					
8	tr*					
9				.58		1.78
10						1.22
11				.13		
12					2.82	.20
13		5.00				
14						
15						
16						
17		.64		.51		.13
18						.36
19	.23		2.03			
20						
21						
22		.25				
23		.25	.20	.08	.71	
24						1.17
25			1.30		2.08	.84
26			.51			
27		.51				
28	1.07	1.35		.64	.79	.84
29	.48			.38	tr	
30		.36		.48	.1	
31	-	-		7.19		.99

*tr=trace.

Table B-2. Rainfall Data - Highland Rim Experiment Station, Springfield, TN.

date	June Rainfall 1982	June Rainfall 1983	July Rainfall 1982	July Rainfall 1983	August Rainfall 1982	August Rainfall 1983
	--------	--------	-------- (cm)	--------	--------	--------
1		.03	.61			
2			.33			
3	.99					
4	3.45	.38	.05	.76		
5		.91	2.29			
6					tr*	
7					.38	.66
8						.03
9						.20
10		.89				1.32
11				.38		
12						
13						
14						
15	.99					
16	2.13	.15				
17		.86				3.56
18	.96				.18	
19	1.40			1.50	.13	
20		.58		.56		
21						.91
22		1.73		.08		
23	.23			.03		
24						.08
25			3.89		tr	1.57
26			.25			
27						.18
28	.39			.20		
29		.03			1.63	
30						
31	-	-		.56		.84

*tr=trace.

VITA

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