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Comparison of Herbicide Systems for Dark Fire-Cured Tobacco

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Abstract

Field experiments were conducted at Murray, KY in 2005, 2006, and 2007 to compare dark tobacco tolerance and weed control from various herbicide systems applied prior to transplanting. Herbicide treatments included sulfentrazone at 0.38 lb ai/A (12 oz/A Spartan 4F) applied pretransplant (PT), clomazone at 1 lb ai/A PT (2.67 pt/A Command 3ME), sulfentrazone at 0.38 lb ai/A plus clomazone at 1 lb ai/A PT, pendimethalin at 1.48 lb ai/A (3.6 pt/A Prowl 3.3EC) applied pretransplant incorporated (PTI), pendimethalin at 1.48 lb ai/A PTI followed by sulfentrazone at 0.38 lb ai/A PT, pebulate at 4 lb ai/A PTI (2.67 qt/A Tillam 6-E), napropamide at 2 lb ai/A PTI (4 lb/A Devrinol 50DF), pebulate at 4 lb ai/A plus napropamide at 2 lb ai/A PTI, and a nontreated control. Visual injury to dark tobacco from any herbicide system was considered minor and did not exceed 11% at 3 weeks after application, and was not apparent by 6 weeks after application in any year. Weed species evaluated included annual grasses (primarily large crabgrass and goosegrass), yellow nutsedge, common ragweed, and entireleaf morningglory. Herbicide systems that included pendimethalin or clomazone were most effective against annual grasses evaluated, while herbicide systems that included sulfentrazone were most effective against yellow nutsedge and those that contained clomazone were most effective against common ragweed. Sulfentrazone was most effective against entireleaf morningglory, but control was improved with the addition of clomazone or pendimethalin. Total dark-fired tobacco yield

where herbicides were applied ranged from 2,464 to 2,725 lb/A, although lowest total yield, quality grade index, and gross revenue was from tobacco that received pendimethalin only, most likely due to poor control of yellow nutsedge and common ragweed.

Introduction

Dark fire-cured tobacco is grown on approximately 16,500 acres in the United States in the areas of western Kentucky, northwestern Tennessee, and central Virginia, and is used primarily for the production of moist snuff products. The majority of the crop is grown in western Kentucky and northwestern Tennessee, where the average yield is 3,300 lb/A and the average market price is $2.68/lb. Total annual revenues for dark fire-cured tobacco are in excess of $138 million (USDA NASS 2012).

Weeds compete with tobacco for moisture, light, and nutrients, and this competition can adversely affect tobacco growth and yield (Chaundry et al. 1978). Weeds also contribute to disease and insect transmittal to tobacco, interfere with tobacco harvesting and curing operations, and increase foreign matter contamination in harvested tobacco (Hawks and Collins 1993). Hauser and Miles (1975) observed that uncontrolled weeds reduced flue-cured tobacco yields by 26%, reduced price index, and caused substantial changes in grade distribution and chemical composition of flue-cured tobacco. In Kentucky, monetary losses in burley and dark tobacco due to weeds were estimated at $22.2 million in 2001 (Webster 2001). Losses included reduction in yield and quality, extra land preparation and cultivation, and increased cost of harvesting.

Although dark tobacco is a very high value crop, it is grown on a relatively small area compared to major agronomic crops and, as a result, there are a limited number of pesticides that are registered for use. Dark tobacco is also grown at relatively low plant populations compared to other tobacco types, which limits its ability to compete with weeds (Bailey 2004).

Herbicides currently registered for use in dark tobacco include sulfentrazone, clomazone, carfentrazone, pendimethalin, napropamide, and sethoxydim. Sulfentrazone controls or suppresses several annual broadleaf weeds, nutsedges, and grasses (Fisher et al. 2004; Ritter et al. 2005). However, it does not control common ragweed and giant ragweed, which are presently two of the most common and troublesome weeds in dark tobacco. Clomazone controls common ragweed and several annual broadleaf weeds and grasses but does not control pigweed species (Bailey 2007). Carfentrazone is registered for use in dark tobacco as a non-selective herbicide for pre transplant burndown applications in conservation tillage tobacco, and as a directed spray application after transplanting. However, carfentrazone has no soil activity and its effectiveness is very limited depending on weed species and size. Carfentrazone has also shown potential to cause significant injury in dark tobacco from directed spray applications (Bailey and Pearce 2007). Due to limited weed control activity and potential for crop injury, carfentrazone is generally not recommended for use in dark tobacco. Pendimethalin and napropamide are primarily grass herbicides that provide limited control of broadleaf weeds. Sulfentrazone and pendimethalin are registered for use prior to tobacco transplanting, while clomazone and napropamide can be applied prior to or just after transplanting. Sethoxydim is the only true postemergence herbicide currently registered for use in dark tobacco. Weed control from sethoxydim is limited to grasses only. Pebulate was registered for use in dark tobacco until it was discontinued in 2006. Pebulate was the only herbicide other than sulfentrazone that provided control of yellow nutsedge, but control of other weed species was limited.

Dark tobacco growers commonly ask which herbicide system has the least potential for crop injury and/or yield reduction and provides the most effective control of the weed spectrum typically encountered in western Kentucky and northwestern Tennessee tobacco fields. Due to the high value of dark tobacco, many growers use reduced rates of herbicides due to crop injury concerns, and often observe reduced weed control as a result. The objective of these experiments was to evaluate dark tobacco response and weed control where full rates of all available residual herbicide systems were used.

Materials and Methods

Field experiments were conducted in 2005, 2006, and 2007 at the West Farm of Murray State University near Murray, KY. Soil type was a Grenada silt loam (fine-silty, mixed, thermic Glossic Fragiudalfs) with 1.8% organic matter. Soil pH was 6.1 in 2005, 6.4 in 2006, and 6.5 in 2007. These soils are representative of the western district dark-fired tobacco production region of western Kentucky.

Test sites were moldboard plowed and disked one month before tobacco transplanting. Fertilizer was broadcast applied and incorporated prior to transplanting according to University of Kentucky soil test recommendations. Mefenoxam (Ridomil Gold EC[1] at 1 pt/A) and chlorpyrifos (Lorsban-4E[2] at 1 qt/A) were broadcast applied and incorporated at 0.5 and 1 lb ai/A, respectively, prior to transplanting to control soil-borne diseases and insects. Final field preparation was done with a field cultivator. The same field cultivator was also used to shallowly incorporate (≤2 in.) all herbicide treatments that were applied pretransplant incorporated (PTI).

Plants of dark tobacco cultivar ‘Narrowleaf Madole’ were produced in a greenhouse float system using standard practices in each of the three years of the experiment. Experiments were transplanted into the field on June 9, 2005, June 1, 2006, and June 6, 2007. Tobacco was transplanted on 40-in. row spacing with 32-in. plant spacing within rows. Plots were four rows wide and 40-ft. in length.

The experimental design was a randomized complete block with treatments replicated four times. Herbicides were applied at the highest rates allowed on product labels. Treatments included sulfentrazone at 0.38 lb ai/A (12 oz/A Spartan 4F[3]) applied pretransplant (PT), clomazone at 1 lb ai/A (2.67 pt/A Command 3ME[4]) PT, sulfentrazone at 0.38 lb ai/A plus clomazone at 1 lb ai/A PT, pendimethalin at 1.48 lb ai/A (3.6 pt/A Prowl 3.3EC[5]) applied PTI, pendimethalin at 1.48 lb ai/A PTI followed by sulfentrazone at 0.38 lb ai/A PT, pebulate at 4 lb ai/A (2.67 qt/A Tillam 6-E[6]) PTI, napropamide at 2 lb ai/A (4 lb/A Devrinol 50DF[7]) PTI, and pebulate at 4 lb ai/A plus napropamide at 2 lb ai/a PTI. A nontreated control was included that did not receive any herbicide treatment. All other production practices were standard according to University Extension Services guidelines (Seebold and Pearce 2013).

All herbicide applications were made using CO_2-pressurized sprayers calibrated to deliver 15 gal/A at 22 psi with standard flat-fan spray tips[8]. All treatments were applied on June 8, 2005, May 31, 2006, and June 5, 2007.

Crop injury and weed control were visually evaluated using a 0 to 100% scale where 0 = no plant injury and 100 = plant death (Frans et al. 1986). The nontreated control was used to identify the weed densities in the field and set the zero (0) rating for weed control. Crop injury was evaluated at one and three weeks after herbicide applications. Weed control was evaluated early season at four to five weeks following herbicide applications and late season at four to five weeks prior to tobacco harvest. Tobacco was cultivated once with a standard 2-row sweep and harrow cultivator following the early season weed control evaluation. Thirty tobacco plants per plot were manually stalk harvested at six weeks after flower removal, impaled on sticks and hung in a conventional fire-curing barn. Standard fire-curing practices were used with the crop being exposed to four firings with hardwood slabs and sawdust to achieve an acceptable leaf color and texture for current marketing conditions. Following curing, tobacco leaves were removed from the stalks, separated into three stalk positions [lower stalk (lug), mid stalk (second), and upper stalk (leaf)], and weighed. Tobacco was then graded according to United States Department of Agriculture standards for Type 22 dark fire-cured tobacco (USDA 1986) and grades were assigned an index value of 1 to 100 as described by Miller and Legg (1990). Grade index data are a weighted average of grades across stalk positions. Gross revenue was determined using loan values based on grades for Type 22 dark fire-cured tobacco (Anonymous 2004). Gross revenue values are the sum of loan values for the grade of each stalk position multiplied by the yield of each stalk position.

All data were subjected to analysis of variance and means were separated using Fisher's protected LSD Test at $P = 0.05$ using statistical analysis software[9]. Tobacco injury data and weed control data were arcsine square-root transformed prior to analysis, but only nontransformed data are presented as transformation did not affect results of data analysis.

Results and Discussion

Data for tobacco injury and weed control are presented by year as there were significant year by treatment interactions for injury and all weed species evaluated. Data for dark-fired tobacco yield by stalk position, total yield, quality grade index, and gross revenue were pooled across years as there were no significant year by treatment interactions.

Tobacco Injury. Herbicide treatments caused relatively minor stunting of tobacco each year (ranging from 1 to 11%) and stunting was most prevalent at three weeks after transplanting. Stunting was transient and was not apparent by six weeks following transplanting (data not shown). The combination of pendimethalin followed by sulfentrazone resulted in the greatest tobacco injury all three years, with 10, 11 and 2% injury for 2005, 2006 and 2007, respectively (Table 1). In 2007, pendimethalin alone resulted in similar injury (2%). Injury from other herbicide combinations ranged from 1 to 5% in 2005 and 0 to 5% in 2006. Less tobacco injury occurred in 2007 and did not exceed 2% from any herbicide treatment. Differences in tobacco injury between years may be explained by differences in rainfall received soon after herbicide application. Both 2005 and 2006 were considered above normal for rainfall, with 2.9 and 2.5 in. rainfall occurring in the first 2 weeks following herbicide application and transplanting. Conversely, 2007 was considered a dry season, with only 0.3 in. of rainfall occurring in the first 2 weeks following herbicide application and transplanting. The heavier rainfall in 2005 and 2006 likely contributed to greater herbicide uptake by tobacco which resulted in greater crop injury.

Weed Control. All weed control data are from late-season evaluations taken at four to five weeks prior to tobacco harvest.

Annual grasses were evaluated in 2005 and 2007 and species composition was primarily large crabgrass and goosegrass. Annual grass control in both years was generally greatest in treatments containing pendimethalin (Table 2). In 2007, treatments that included clomazone provided annual grass control equivalent to pendimethalin. Annual grass control from pendimethalin or clomazone ranged from 89 to 97% while annual grass control from other herbicides ranged from 45 to 88%. Addition of sulfentrazone to pendimethalin or clomazone did not improve control of annual grasses.

Yellow nutsedge was evaluated in 2006 and 2007 and was controlled the greatest by treatments containing sulfentrazone (91 to 97%). Treatments containing pebulate also provided good yellow nutsedge control, but results were not as consistent between the two years (77 to 78% control in 2006 and 90 to 91% control in 2007). The addition of clomazone or pendimethalin to sulfentrazone, or the addition of napropamide to pebulate, did not improve yellow nutsedge control compared to sulfentrazone or pebulate alone.

Common ragweed is one of the more troublesome weeds encountered in dark tobacco production and is also an alternate host to bacterial wilt and tobacco ringspot virus (Daub et al. 1991; Lucas 1975). Common ragweed was evaluated in 2005 and 2006 and treatments that contained clomazone generally provided the highest level of control in both years. Napropamide-containing treatments provided some control of common ragweed, but were not as effective or as consistent between the two years as clomazone-containing treatments.

Entireleaf morningglory was evaluated in 2005 and 2007. Treatments containing sulfentrazone were most effective in controlling entireleaf morningglory in both years. Sulfentrazone alone controlled entireleaf morningglory 90% in 2005 and 89% in 2007. The addition of clomazone to sulfentrazone improved entireleaf morningglory control to 97% in both years. The addition of pendimethalin PTI prior to sulfentrazone PT also improved entireleaf morningglory control to 94% in 2005 and 96% in 2007.

Tobacco Yield, Quality Grade Index, and Gross Revenue. Yields of lug, second, and leaf stalk positions were generally similar between herbicide treatments (Table 3). Total yield in herbicide-treated plots ranged from 2,464 to 2,725 lb/A, compared to 2,148 lb/A in nontreated control plots that received no herbicide treatment. Within herbicide-treated plots, highest total yield was from tobacco that received pendimethalin PTI followed by sulfentrazone PT (2,725 lb/A), and lowest total yield was from tobacco that received pendimethalin PTI only. Differences in these two treatments are most likely associated with differences seen in yellow nutsedge and entireleaf morningglory control.

Quality grade index ranged from 61.9 to 70.1, with highest quality grade index in tobacco that received clomazone PT only and lowest quality grade index in tobacco that received pendimethalin PTI only (Table 3). Gross revenue corresponded with quality grades, and was greatest in tobacco that received clomazone PT only ($5,225/A) and least in tobacco that received pendimethalin PTI only ($4,518/A). Gross revenue in untreated tobacco was $3,795/A, which was not significantly different than pendimethalin PTI only.

Conclusion

Sulfentrazone plus clomazone was the most effective of any of the herbicide treatments at controlling the four weed species evaluated in this study. These data suggest that herbicide systems that include sulfentrazone are critical in controlling the weed species typically seen in dark tobacco fields of Kentucky and Tennessee. Clomazone should also be included in fields where common ragweed is expected, and addition of clomazone or pendimethalin can improve annual grass and morningglory control compared to sulfentrazone alone. Although slightly higher early-season injury was observed with pendimethalin followed by sulfentrazone, particularly in years where substantial rainfall occurred in the first two weeks following herbicide application and transplanting, this injury was minor and did not translate to reductions in dark fire-cured tobacco yield, quality grade index, or gross revenue.

Sources of Materials

[1]Ridomil Gold EC. 4 lbs mefenoxam per gallon. Syngenta Crop Protection, 410 S. Swing Road, Greensboro, NC 27409.

[2]Lorsban-4E. 4 lbs chlorpyrifos per gallon. Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN 46268.

[3]Spartan 4F. 4 lbs sulfentrazone per gallon. FMC Corporation, 1735 Market Street, Philadelphia, PA 19103.

[4]Command 3ME. 3 lbs clomazone per gallon. FMC Corporation, 1735 Market Street, Philadelphia, PA 19103.

[5]Prowl 3.3EC. 3.3 lbs pendimethalin per gallon. BASF Corporation, 26 Davis Drive, Research Triangle Park, NC 27709.

[6]Tillam 6-E. 6 lbs pebulate per gallon. Syngenta Crop Protection, 410 S. Swing Road, Greensboro, NC 27409.

[7]Devrinol 50DF. 50% napropamide. United Phosphorus, Inc., 630 Freedom Business Center, Suite 402, King of Prussia, PA 19406.

[8]Teejet 8002VS flat fan spray tip. Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189.
[9]Statistical Analysis Software. SAS Institute, Inc. SAS Campus Drive, Cary, NC 27512.

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Table 1. Dark tobacco injury from herbicide treatments.

Herbicide Treatment	Application Timing	Application Rate	Tobacco Visual Injury 3 weeks after transplant[a] 2005	2006	2007
		lb ai/A (product/A)	------------ % -----------		
Sulfentrazone (Spartan 4F)	PT	0.38 (12 oz)	2 bc	3 bc	0 b
Clomazone (Command 3ME)	PT	1 (2.67 pt)	1 bc	0 c	0 b
Sulfentrazone + Clomazone	PT	0.38 + 1 (12 oz/A + 2.67 pt)	3 bc	4 b	0 b
Pendimethalin (Prowl 3.3EC)	PTI	1.48 (3.6 pt)	5 b	5 b	2 a
Pendimethalin fb[b] Sulfentrazone	PTI fb PT	1.48 + 0.38 (3.6 pt fb 12 oz)	10 a	11 a	2 a
Pebulate (Tillam 6-E)	PTI	4 (2.67 qt)	2 bc	3 bc	0 b
Napropamide (Devrinol 50DF)	PTI	2 (4 lb)	1 bc	2 bc	0 b
Pebulate + Napropamide	PTI	4 + 2 (2.67 qt + 4 lb)	2 bc	5 b	0 b
Untreated Control	-	-	0 bc	0 c	0 b

[a]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD as P=0.05
[b]Abbreviations: fb = followed by; PT = pretransplant; PTI = pretransplant incorporated.

Table 2. Weed control from herbicide treatments estimated 4 to 5 weeks before harvest.

Herbicide Treatment	Application Timing	Application Rate	Annual Grass[ab] 2005	Annual Grass[ab] 2007	Yellow Nutsedge 2006	Yellow Nutsedge 2007	Common Ragweed 2005	Common Ragweed 2006	Entireleaf Morningglory 2005	Entireleaf Morningglory 2007
		lb ai/A (product/A)	%							
Sulfentrazone (Spartan 4F)	PT	0.38 (12 oz)	51 d	77 c	91 a	97 a	30 d	31 e	90 b	89 b
Clomazone (Command 3ME)	PT	1 (2.67 pt)	74 bc	96 a	17 c	23 d	78 ab	87 a	62 d	51 d
Sulfentrazone + Clomazone	PT	0.38 + 1 (12 oz + 2.67 pt)	83 ab	97 a	96 a	97 a	83 a	86 a	97 a	97 a
Pendimethalin (Prowl 3.3EC)	PTI	1.48 (3.6 pt)	89 a	96 a	23 c	24 d	33 cd	50 d	73 c	44 e
Pendimethalin fb[b] Sulfentrazone	PTI fb PT	1.48 fb 0.38 (3.6 pt fb 12 oz)	94 a	96 a	93 a	97 a	44 c	63 bc	94 ab	96 a
Pebulate (Tillam 6-E)	PTI	4 (2.67 qt)	45 d	80 c	77 b	91 b	41 cd	64 bc	35 ef	48 d
Napropamide (Devrinol 50DF)	PTI	2 (4 lb)	68 c	76 c	22 c	36 c	74 ab	61 c	31 f	60 c
Pebulate + Napropamide	PTI	4 + 2 (2.67 qt + 4 lb)	69 c	88 b	78 b	90 b	69 b	72 b	39 e	62 c
Untreated Control	-	-	0 e	0 d	0 d	0 e	0 e	0 f	0 g	0 f

[a]Predominant annual grass species were large crabgrass and goosegrass
[b]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD as P=0.05.
[b]Abbreviations: fb = followed by; PT = pretransplant; PTI = pretransplant incorporated.

Table 3. Effect of herbicide treatment on dark-fired tobacco yield, quality grade index, and gross revenue[a].

Herbicide Treatment	Application Timing	Application Rate	Stalk Position[bc] Lug	Stalk Position[bc] Second	Stalk Position[bc] Leaf	Total	Quality Grade Index[d]	Gross Revenue[e]
		lb ai/A (product/A)	lb/A				0-100	$/A
Sulfentrazone (Spartan 4F)	PT	0.38 (12 oz)	362 a	518 ab	1779 a	2659 ab	64.9 ab	5,057 a
Clomazone (Command 3ME)	PT	1 (2.67 pt)	317 ab	517 ab	1795 a	2629 ab	70.1 a	5,225 a
Sulfentrazone + Clomazone	PT	0.38 + 1 (12 oz + 2.67 pt)	352 a	531 a	1811 a	2694 ab	64.4 ab	5,098 a
Pendimethalin (Prowl 3.3EC)	PTI	1.48 (3.6 pt)	313 ab	505 ab	1646 a	2464 b	61.9 b	4,518 ab
Pendimethalin fb[f] Sulfentrazone	PTI fb PT	1.48 + 0.38 (3.6 pt fb 12 oz)	335 ab	551 a	1839 a	2725 a	63.4 ab	4,809 a
Pebulate (Tillam 6-E)	PTI	4 (2.67 qt)	313 ab	508 ab	1749 a	2570 ab	63.6 ab	4,767 a
Napropamide (Devrinol 50DF)	PTI	2 (4 lb)	317 ab	530 a	1678 a	2525 ab	66.7 ab	4,883 a
Pebulate + Napropamide	PTI	4 + 2 (2.67 qt + 4 lb)	330 ab	538 a	1814 a	2683 ab	65.9 ab	5,030 a
Untreated Control	-	-	280 b	446 b	1422 a	2148 c	66.2 ab	3,795 b

[a]Data pooled across years, 2005-2007.
[b]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD as P=0.05.
[c]Tobacco leaves removed by stalk position following fire-curing. Lug corresponds to lower stalk leaves, second from midstalk, and leaf from upper stalk.
[d]Quality grade index is a numerical representation of Federal quality grade received for tobacco and is a weighted average of grade index for all stalk positions.
[e]Gross revenue is the total gross value of tobacco based on Federal grade and price support values.
[f]Abbreviations: fb = followed by; PT = pretransplant; PTI = pretransplant incorporated.

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