Seed Production and Cost of Mourning Dove Field Plantings in Alabama

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Abstract: Cost-effectiveness of various planting options is an important consideration in selecting planting strategies for mourning dove (*Zenaida macroura*, hereafter 'dove') fields. We documented costs and seed yields of three cultivated and three wild dove foods, and tested effects of fertilization rate, row-spacing, and seeding rate on seed yield of highly-preferred dove foods. Browntop millet generally had the greatest seed yield and lowest cost/kg of seed produced. Broadleaf signalgrass *(Brachiaria platyphylla)* generally was the second highest-yielding species, but high seed cost limited cost/kg of seed produced for wild species. White proso millet, dove proso millet, and switchgrass *(Panicum virgatum)* produced little seed and had low cost-efficiency. Fertilization rate did not affect seed yield of the species we tested. Effects of row spacing and seeding rate on yield of browntop millet and dove proso millet varied between study sites. Browntop millet was by far the most cost-effective crop for dove field plantings. Seed production per unit cost may be increased by using narrower row spacings and lower seeding rates than currently recommended. Fertilization of dove field crops is not an effective option to increase seed yield and may be unnecessary.

Key words: dove field, mourning dove, planting, seed yield, *Zenaida macroura*

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Mourning doves are among the most popular and financially important game birds in the United States (Baskett and Sayre 1993), particularly in southern states (George 1993). Establishment and management of food plantings to enhance mourning dove habitat or to attract doves for hunting is a major component of mourning dove management in Alabama and many other states (Mahan 1978, Waters 1983, Baskett 1993). A recent survey of state wildlife agencies revealed that most mourning dove hunting in the eastern and central management units involves food and/or water sources (Baskett 1993). To date, however, there have been few published sources of information regarding establishment and management of food plantings for mourning doves (Tomlinson et al. 1994).

Recommended foods for planting in dove fields in Alabama and elsewhere include browntop millet, proso millet, sunflower, corn, and grain sorghum (Madson

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1978, Mahan 1978, Waters 1983). Of these, proso and browntop millets appear to be most preferred by doves (Hayslette and Mirarchi 2001), and browntop millet appears to be the most commonly planted crop to attract doves in Alabama (Waters 1986). Although most wildlife planting guides recommend planting millets in 76- to 107-cm rows at 9–22.5 kg/ha (Waters 1983, Alabama Cooperative Extension Service 1988), little is known about cost-effectiveness of this planting strategy compared to other row spacing/seeding rate combinations or to broadcast plantings. Broadcast plantings probably are more often used by small landowners in dove fields because row planting requires more specialized, costly equipment. Recent research also has indicated that encouragement and/or addition of high-quality wild dove foods such as switchgrass, broadleaf signalgrass, and yellow bristlegrass *(Setaria lutescens)* in food plantings may increase value and attractiveness of these plantings for mourning doves (Dillon 1961; Madson 1978; Hayslette and Mirarchi 2001, 2002, 2003), but little information currently is available regarding establishment of stands of these wild species.

Effective and cost-efficient establishment and management of food plantings for mourning doves and other wildlife requires information regarding relative costs and benefits of possible planting strategies (Waer et al. 1992, 1997; Bowers et al. 1996). The overall goal of this study was to measure and compare costs and benefits of various dove field management strategies. Specific objectives were to measure and compare seed yields and costs of preferred dove foods and to determine effects of fertilization rate, row spacing, and seeding rate on seed production of highly preferred dove foods (i.e., proso and browntop millets).

Study Area

We conducted experiments at three sites in eastcentral Alabama during May 1998–October 1999. Two sites, E.V. Smith Research Center and Piedmont Substation, are part of the Alabama Agricultural Experiment Station (AAES) system and are used primarily for agriculture and horticultural research and demonstration projects. E.V. Smith Center is located in southeastern Elmore and northwestern Macon counties and is characterized by sandy loam and fine sandy loam soils (Alabama Agricultural Experiment Station 2004). Piedmont Substation is located near Camp Hill in southeastern Tallapoosa County and is characterized by clay loam and sandy clay loam soils (Bowers et al. 1996). The third site, Barbour County Wildlife Management Area (WMA), is located in northwestern Barbour County and is characterized by loamy sand and sandy loam soils (Trayvick 2004). Barbour County WMA is owned and managed for white-tailed deer *(Odocoileus virginianus),* wild turkey *(Meleagris gallopavo),* mourning doves, northern bobwhite *(Colinus virginianus),* and other small game by the Alabama Department of Conservation and Natural Resources, Division of Wildlife and Freshwater Fisheries. Each experiment used different plots at each site; no plots were used in more than one experiment.

Methods

1998 Seed Yield/Cost Study

We conducted an experiment to document and compare seed yields and establishment costs of plantings of white proso millet, dove proso millet, browntop millet, broadleaf signalgrass, and yellow bristlegrass at all three study sites during May-August 1998. At each site, we established 60, 3- × 5-m study plots, arranged in four blocks of 15 each (three by five arrangement with 1-m buffers between adjacent plots) in an open field during May 1998. We planted each crop on three randomly-selected plots in each block (12 total plots/crop/site, 36 plots/crop across all sites) during 2–18 June. Prior to planting, we limed and fertilized plots according to soil test recommendations. Seeds were broadcast at 23 kg/ha and culti-packed (Piedmont Substation and E.V. Smith Center) or covered ≤2.5 cm by hand-raking (Barbour County WMA).

We removed all seed heads in one randomly-located 1-m^2 sample from each plot during 1–27 August. Samples were taken ≥0.5 m from plot edges to avoid edge effects on seed yield. Effort was made to time sampling to peak seed maturation and availability. Samples were air-dried 96 hours, and seed from each sample was threshed and cleaned mechanically or by hand. We measured mass of seed in each sample to the nearest 0.01 g. We converted seed yield/m^2 to yield/ha, and compared yield among crops and sites using two-way analysis of variance (ANOVA) and Tukey's procedure. An alpha level of 0.05 was used for these and all subsequent analyses, unless noted. We also calculated seed cost/ha and seed cost/kg of seed produced for each crop at each site. We did not consider lime and fertilizer, equipment, or labor costs, because these costs were equal for all crops tested, and so did not affect relative cost-efficiency of crops.

1999 Fertilization Study

We conducted an experiment to determine the effect(s) of fertilization rate on seed yield of six dove field crops (white proso millet, dove proso millet, browntop millet, broadleaf signalgrass, yellow bristlegrass, and switchgrass) during June–October 1998 at E.V. Smith Center, Piedmont Substation, and Barbour County WMA. We used the following four fertilization rates: no fertilization; N, P, and K as recommended by soil test; twice recommended N (P and K as recommended); and three times recommended N (P and K as recommended). At each study site, we established 72, 1.5- × 6.1-m study plots, arranged in three blocks of 24 each (four by six arrangement with 3-m buffers between adjacent plots) in an open field during May 1998. We assigned each combination of crop and fertilization rate randomly to one plot in each block (three total plots/site in each crop/fertilizer combination). We limed plots according to soil test recommendations in mid-June, and applied experimental fertilizer using a drop spreader and incorporated it by tilling and/or light disking during 23 June–7 July. We planted plots in 18-cm rows at a seeding rate of 22.5 kg/ha and planting depth of 1.3 cm using a seed drill during 14–21 July. We used narrow rows to approximate a broadcast planting. Rainfall during much of June and early July forced a relatively late planting schedule.

We monitored plot growth at 20-day intervals, and sampled all plots of a particular crop at a given site when ≥75% of seed heads of that crop had reached maturity. Most sampling was conducted during 13 September–8 October, although we sampled switchgrass plots during 11–22 October. Sampling consisted of removing all seed heads in one randomly-located 1-m^2 plot area. Samples were taken ≥0.2 m from plot edges to avoid edge and fertilizer runoff effects on seed yield. Samples were dried 48 h at 65 C, and seed from each sample was threshed and cleaned mechanically. We measured mass of seed in each sample to the nearest 0.01 g. We converted seed yield/m^2 to yield/ha, and compared yield among sites, crops, and fertilization rates using three-way ANOVA and Tukey's procedure. We also calculated seed cost/ha and seed cost/kg of seed produced for each crop at each site, as in the 1998 warm-season seed yield study.

1999 Row Spacing/Seeding Rate Study

We conducted an experiment to determine effect(s) of row spacing and seeding rate on seed yield of white proso millet, dove proso millet, and browntop millet during June–October 1999 at E.V. Smith Center and Piedmont Substation. We used four seeding rates (5.6, 11.2, 16.8, and 22.5 kg/ha) and three row spacings (18, 36, and 72 cm). We established study plots at each site as in the previous experiment, except that three blocks of 36 plots (four by nine arrangement) each were used at each site. Each combination of crop, row spacing, and seeding rate was assigned randomly to one plot in each block (three total plots in each crop/spacing/rate combination). We limed and fertilized plots according to soil test recommendations on 23 June at E.V. Smith Center and 6 July at Piedmont Substation, and materials were incorporated by tilling and/or light disking. Plots were planted at a depth of 1.3 cm using a seed drill during 14–21 July and were monitored and sampled as in the fertilization study. Samples also were dried and processed as in this previous study. We compared seed yield/ha among sites, crops, and row spacing/seeding rate combinations using three-way ANOVA and Tukey's procedure. An alpha-level of 0.10 was used in Tukey's procedure because of small sample sizes ($N = 3$) within row spacing/seeding rate combinations for each crop at each site.

Results

1998 Seed Yield/Cost Study

Differences in seed yield among crops varied among sites (crop × study site interaction: $F_{8, 156} = 11.8$, $P < 0.001$, Table 1). Seed yield of browntop millet was greater than yield of any other crop at Barbour County WMA and E.V. Smith Center, but yield did not vary among crops at Piedmont Substation. Browntop millet seed yield was more than two times greater at E.V. Smith Center than at any other site. Seed costs were much lower for cultivated crops than for wild species. Cost/ha was lowest for browntop millet, and cost/kg of browntop millet seed produced was <20% of that of any other crop at all three sites. Broadleaf signalgrass was the most expensive seed at >40 times the cost/ha of seeds of cultivated crops. Seed cost/kg of seed produced was highest for broadleaf signalgrass at two of the three sites.

Table 1. Seed yield ($N = 12$) and cost (US$) of 5 warm-season mourning dove foods at three sites, east-central Alabama, June–August 1998.

Site	Crop	Seed yield (kg/ha) $\bar{x}$ [a]	Seed yield (kg/ha) SE	Seed cost/ha	Seed cost/kg seed produced
Barbour Co. WMA	Browntop millet	350.1A	53.8	20.00	0.06
	White proso millet	74.8B	20.4	25.00	0.34
	Broadleaf signalgrass	16.0B	9.0	1246.50	77.91
	Yellow bristlegrass	10.2B	5.5	763.65	74.87
	Dove proso millet	2.2B	1.5	30.00	13.64
E.V. Smith Center	Browntop millet	775.7A	157.2	20.00	0.03
	Broadleaf signalgrass	20.4B	4.3	1246.50	61.10
	Yellow bristlegrass	18.7B	10.8	763.65	40.84
	White proso millet	1.9B	1.1	25.00	13.16
	Dove proso millet	0.0B	0.0	30.00	
Piedmont Substation	Browntop millet	191.7A	28.9	20.00	0.10
	Broadleaf signalgrass	97.3A	17.4	1246.50	12.81
	Yellow bristlegrass	17.9A	5.3	763.65	42.66
	White proso millet	15.4A	3.9	25.00	1.62
	Dove proso millet	8.1A	3.2	30.00	3.70

a. Within sites, column means with the same letter do not differ ($P > 0.05$) using Tukey's procedure.

1999 Fertilization Study

Fertilization rate did not affect seed yield of any crop at any site (fertilization rate main effect: $F_{3,129} = 0.1$, $P = 0.963$; fertilization rate X crop interaction: $F_{15,129} = 0.6$, $P = 0.858$; fertilization rate X study site interaction: $F_{6,129} = 0.7$, $P = 0.683$; fertilization rate X crop X study site interaction: $F_{30,129} = 0.8$, $P = 0.822$). Differences in seed yield among crops varied among sites (crop × study site interaction: $F_{10,129} = 25.9$, $P < 0.001$, Table 2). Seed yield of browntop millet was greater than yield of any other crop at Barbour County WMA and E.V. Smith Center, and broadleaf signalgrass yield was greater than yield of the remaining four crops at E.V. Smith Center. Seed yields of browntop millet and broadleaf signalgrass did not differ at Piedmont Substation but were greater than yields of all other crops at that site. Seed cost/ha was equal (US$30/ha) among cultivated crops in 1999. Cost/ha of wild seeds was at least 25 times greater than that of cultivated seeds and was greatest for switchgrass. As in 1998, seed cost/kg of seed produced was much less for browntop millet than for any other crop at all three sites. Because switchgrass produced little or no seed at all sites, seed cost/kg of switchgrass seed produced generally was much higher than seed cost/kg of any other crop.

1999 Row Spacing/Seeding Rate Study

Results of the 1999 row spacing/seeding rate study varied by crop (row spacing/seeding rate combination X study site X crop interaction: $F_{22,139} = 2.1$, $P = 0.004$), so data were re-analyzed separately by crop.

Browntop Millet.—Results of the browntop millet row spacing/seeding rate

Table 2. Seed yield and cost (US$) of 6 warm-season mourning dove foods during warm season fertilization[a] study at three sites, east-central Alabama, 1999.

Site	Crop	Seed yield (kg/ha) *N*	$\bar{x}$ [a]	SE	Seed cost/ha	Seed cost/kg seed produced
Barbour Co. WMA	Browntop millet	12	1024.3A	129.4	30.00	0.03
	Broadleaf signalgrass	11	231.4B	46.2	953.33	4.12
	Yellow bristlegrass	11	59.9B	22.9	740.03	12.35
	White proso millet	12	4.0B	1.7	30.00	7.50
	Dove proso millet	12	1.4B	0.9	30.00	21.43
	Switchgrass	11	0.0B	0.0	956.03	
E.V. Smith Center	Browntop millet	11	2063.5A	174.7	30.00	0.01
	Broadleaf signalgrass	10	416.2B	64.1	953.33	2.29
	Yellow bristlegrass	11	10.6C	4.7	740.03	69.81
	Switchgrass	12	0.1C	0.1	956.03	9560.30
	White proso millet	11	0.0C	0.0	30.00	
	Dove proso millet	12	0.0C	0.0	30.00	
Piedmont Substation	Browntop millet	12	663.5A	68.7	30.00	0.05
	Broadleaf signalgrass	11	608.4A	49.3	953.33	1.57
	Yellow bristlegrass	12	260.4B	48.4	740.03	2.84
	White proso millet	12	30.9B	14.1	30.00	0.97
	Dove proso millet	12	0.7B	0.7	30.00	42.86
	Switchgrass	12	0.4B	0.2	956.03	2390.08

a. There was no effect of fertilization rate on seed yield; therefore, means presented are combined across fertilization levels.

b Within sites, column means with the same letter do not differ ($P > 0.05$) using Tukey's procedure.

Table 3. Seed yield ($N = 3$) of browntop and dove proso millets at 12 row spacing/seeding rate combinations, each at one site, east-central Alabama, 1999.

Crop - site[a]	Seed yield (kg/ha) 18 cm row spacing		36 cm row spacing		72 cm row spacing	
Seeding rate (kg/ha)	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Browntop millet - E.V. Smith Center						
5.6	1765.5AB	674.2	1725.8AB	415.2	1298.7A	444.0
11.2	1293.1A	418.8	2012.0AB	150.2	2201.6AB	16.4
16.8	2856.7B	270.6	2130.0AB	311.6	1773.5AB	286.4
22.5	2595.5AB	235.8	1810.0AB	287.2	1453.5AB	34.8
Dove proso millet - Piedmont Substation						
5.6	26.3BC	13.3	15.1C	14.5	15.9C	10.9
11.2	70.5ABC	14.9	24.5BC	8.8	12.8C	6.4
16.8	68.4ABC	3.1	140.5A	11.7	11.4C	5.7
22.5	91.6AB	46.0	84.7ABC	3.0	67.9ABC	4.7

a. Within crop-site combinations, means with the same letter did not differ ($P > 0.10$) using Tukey's procedure.

study varied between study sites (planting combination × study site interaction: $F_{11,44} = 2.4$, $P = 0.022$). At E.V. Smith Center, yield was greatest when planted in 18-cm rows at a rate of 16.8 kg/ha (Table 3). At three of four seeding rates, greatest yield of browntop millet resulted from the narrowest row spacing. At no row spacing, however, did the highest seeding rate result in the greatest seed yield. Browntop millet yield generally was much lower at Piedmont Substation (≤392 kg/ha) than at E.V. Smith Center, and yield did not vary among row spacing/seeding rate combinations at Piedmont Substation.

Dove Proso Millet.—Results of the dove proso millet row spacing/seeding rate study varied between study sites (planting combination × study site interaction: $F_{11,43} = 2.4$, $P = 0.019$). At Piedmont Substation, dove proso millet yield was greatest when planted in 36-cm rows at 16.8 kg/ha and generally was greater at narrow row spacing/high seeding rate combinations than at wide row spacing/low seeding rate combinations (Table 3). The highest seeding rate produced the greatest seed yield at two of three row spacings, and the most narrow row spacing produced the greatest yield at three of four seeding rates. At E.V. Smith Center, only 4 of 12 row spacing/seeding rate combinations produced yield ≥1 kg/ha, and seed yield did not vary among row spacing/seeding rate combinations.

White Proso Millet.—Seed yield of white proso millet did not vary among row spacing/seeding rate combinations ($F_{11,44} = 1.7$, $P = 0.106$) or between sites ($F_{1,44} = 3.9$, $P = 0.054$) with no row spacing/seeding rate X site interaction ($F_{11,44} = 0.8$, $P = 0.661$). Mean white proso millet yield was 15.0 kg/ha (± 2.6; $N = 72$).

Discussion

Results of 1998 and 1999 warm-season plantings indicate that browntop millet is by far the most cost-efficient option for dove field plantings among the warm-season species that we tested. Browntop millet was the least expensive and greatest-yielding species in both years and at all sites, although browntop millet yield varied among sites and between years. Variation in browntop millet yield among sites in this study may have reflected differences in soil characteristics and/or recent prior use among sites. Consistent differences among sites in both years seem to support this explanation; ratio of seed yield among sites (Piedmont Substation:Barbour County WMA:E.V. Smith Center) was 1:1.5:3.1 in 1998 and 1:1.8:4.0 in 1999. In particular, recent chemical weed control in corn and oat plantings on our study site at E.V. Smith Center likely resulted in a depleted weed seed bank and reduced weed competition for our plantings. In contrast, our Piedmont Substation and Barbour County sites had no recent prior history of weed control, although our fields at Barbour County WMA had been cultivated for wildlife food plantings in the years immediately preceding our study. Personal observation indicated greater weed competition at these latter two sites than at E.V. Smith Center.

Differences in seed yield of browntop millet and broadleaf signalgrass between years may reflect differences in planting methods. Greater yield in 1999 than in 1998 suggests that row planting using a shallow-running grain drill may be more appropriate for these species than broadcast planting and covering by dragging or disking. Browntop millet should be covered with ≤2.5 cm of soil (Waters 1983, 1986; Alabama Cooperative Extension Service 1988). Drilling likely provides a more uniform, precisely controlled planting depth and plant spacing than does broadcasting and covering with disk or drag, which may lead to greater germination rate, light interception, and efficiency of water and nutrient uptake. If so, our narrowest (18 cm) row spacing used in the row spacing/seeding rate experiment likely did not approximate a broadcast planting as we intended.

On the basis of seed yield and cost-efficiency, white and dove proso millets generally appear to be poor choices for planting in Alabama dove fields. These were among the least-yielding crops planted each year, with the exception of white proso millet at Barbour County WMA in 1998 and dove proso millet in the row spacing/seeding rate study at Piedmont Substation in 1999. Factors limiting growth of white and dove proso millets in most cases are unclear, but soil characteristics and/or lack of moisture do not appear to explain the variability in proso millet yields we documented. White proso millet yield at Barbour County WMA was dramatically greater in 1998 than in 1999 although fields used in 1998 adjoined and had the same soil type as those used in 1999 and total rainfall during June–August was greater in 1999 (Alabama Agricultural Statistics Service 1998, 2000). Likewise, dove proso millet seed production at Piedmont Substation was greater in the 1999 row spacing/seeding rate study than in the 1999 fertilization study, although these experiments were conducted in the same year in fields with similar soils <0.5 km apart. Proso millet is known to use water very efficiently (Briggs and Shantz 1913, Shantz and Piemeisel 1927); its low water requirement makes it well adapted to production in semiarid conditions (Shanahan et al. 1988). The fact that E.V. Smith Center had the least weed competition of the three sites we used also suggests that such competition did not limit proso millet growth. These results all suggest that other site- or field-specific factors limited growth of proso millets at our study sites.

Our findings suggest that, in areas where they will grow well, dove proso and browntop millets generally produce greater yield at narrower row spacings at a given seeding rate. These results agree with those of earlier proso millet research conducted in the Great Plains region (Nelson 1977) and confirm that competition for light, moisture, and nutrients limits plant populations of these species within rows in a density-dependent manner. Thus, at a given seeding cost/ha, dove proso and browntop millet survival and seed yield may be increased by decreasing row spacing. Decreasing row spacing to increase seed production/ha of these millets may be not be practical in dove fields, however, because narrower rows and denser stands make finding downed doves more difficult (Madson 1978, Waters 1983) and planting in narrow rows may be impossible with standard planting equipment (Nelson 1977). Although broadcast plantings do not require specialized equipment, seed yield benefits, particularly of browntop millet, may be less from broadcast plantings than from plantings drilled in narrow rows.

We offer that at sites suited to growing dove proso millet, seed yield may increase with increased seeding rate. Specifically, managers of sites suitable for growing dove proso millet may increase yield/ha by increasing seeding rate up to 22.5 kg/ha. The positive relationship between seed yield and seeding rate does not appear to hold for browntop millet, however. At E.V. Smith Center, maximum browntop millet yield was realized at a seeding rate of only 11.2 kg/ha at the widest row spacing and at 16.8 kg/ha at other spacings. These results suggest that planting browntop millet at rates >16.8 kg/ha may be inefficient, resulting in plant densities too high for maximal plant survival. A lower seeding rate needed to produce maximum seed yield further suggests greater cost-efficiency for browntop millet than for dove proso millet, even on sites where dove proso millet grows well.

The cost-efficiency of plantings of wild species seems limited primarily by high seed cost. Wild seeds we used were purchased from collectors offering small quantities for research purposes. If a more affordable source of these seeds were available, plantings of broadleaf signalgrass and yellow bristlegrass may be a viable option for dove field managers. Broadleaf signalgrass may be particularly well-suited to dove field plantings; it was the second greatest-yielding species at all three sites in 1999 and at two of three sites in 1998. Additionally, if wild species reseed and regenerate in subsequent years, cost-efficiency of planting wild species may be greater than documented here because benefits in the form of seed yield in subsequent years would be realized without additional planting costs. Our study only documented benefits in year of planting. A complete evaluation of the cost-efficiency of high-yielding wild species such as broadleaf signalgrass would require documentation of seed production of stands in multiple years following planting, and adjustment of cost/benefit ratios based on these marginal benefits.

Lack of effects of fertilization rate on seed yield of the species we tested seemed surprising, considering that increasing rate of fertilization is known to increase forage production of cool-season wildlife plantings (Bowers et al. 1996). Our results suggest that soil fertility did not limit growth of the crops we tested on our study areas, and indicate that increasing fertilization levels to increase seed production/ha in dove fields in these areas and others like them is not necessary. However, the ability of unfertilized plots to produce seed may vary with site-specific factors such as soil type and past cultivation/fertilization history, and large differences in seed yield among crops and study sites may have obscured subtle effects of fertilization levels in our study. Thus, until factors affecting seed yield of the species we tested are better understood, caution may be advisable in forgoing fertilization of dove fields, particularly in areas differing greatly from our study areas in soil type, cultivation history, or other factors.

Management Implications

Our study indicates that browntop millet generally is the most cost-efficient warm-season crop for planting in Alabama dove fields. Browntop millet should be planted in rows, if possible, at 11.2–16.8 kg/ha. Rows narrower than the recommended 76- to 107-cm spacing may be used to increase seed production/ha if denser stands will not cause difficulty retrieving harvested doves. Dove and white proso millets are not recommended for planting in Alabama dove fields unless previous experience or small, experimental plantings suggest that a particular field is suitable for these crops. Establishing stands of broadleaf signalgrass may be a cost-effective management option for Alabama dove fields, but cost-efficient seeding of broadleaf signalgrass will require more affordable seed than is currently available. Fertilization of the crops we tested appears ineffective for increasing seed yield, and may be unnecessary in many southern dove fields.

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