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PRIOR CROPPING WITH GRAIN SORGHUM INHIBITS WEEDS

FRANK A. EINHELLIG[1] and JAMES A. RASMUSSEN[2]

[1]*Department of Biology*
University of South Dakota
Vermillion, South Dakota 57069

[2]*Department of Biology*
Mount Marty College
Yankton, South Dakota 57078

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Abstract—Three years of field data in northeastern Nebraska demonstrate that a grain sorghum crop reduces weediness in the following crop year. Weed growth was consistently lower in sorghum areas the year after strip-cropping fields with sequences of four-row bands of grain sorghum, soybeans, and corn. Percentage weed cover was significantly lower early in the year, and midsummer weed biomass was well below that found after corn and soybeans. Weed biomass in June and July following corn was two to four times that of grain sorghum strips. Inhibitory effects of grain sorghum were primarily on broadleaf weeds, often showing no action on grass weeds. No obvious differences were noted in the weed species present after the three crops. Allelopathy provides a logical explanation for the sorghum-mediated weed inhibition found in this study. The data have implications for weed management strategies in agriculture.

Key Words—Allelopathy, grain sorghum, *Sorghum bicolor*, weed inhibition, weed management.

INTRODUCTION

Cultivated *Sorghum* species have a history of use in weed management. Overland (1966) noted that they were among those crops used as "smother crops," with the implication that they competitively suppressed weed populations growing during the same time period. Recently, Putnam et al. (1983) showed that grain sorghum [*Sorghum bicolor* (L.) Moench] and sudangrass [*Sorghum sudanense* (Piper) Stapf.] were useful cover crops for controlling weeds in orchards.

Residues from frost-killed sorghum planted in the intertree space in apple and cherry orchards inhibited weed growth. A sorghum × sudangrass hybrid used in these studies reduced the weed biomass to less than 40% of that found without a cover crop. In annual cropping systems, planting without tillage into a desiccated cover crop of sorghum or sudangrass almost totally eliminated certain weed problems (Putnam and DeFrank, 1983). At least part of these effects were attributed to allelopathy.

Sorghum species contain a variety of water-soluble substances that can inhibit seed germination and seedling growth. Guenzi and McCalla (1966a) isolated substantial quantities of ferulic, *p*-coumaric, vanillic, syringic, and *p*-hydroxybenzoic acids from decomposing *S. bicolor* residues. Subsequent work indicated phytotoxicity from these compounds could persist in field conditions for at least 28 weeks (Guenzi and McCalla, 1966b; Guenzi et al., 1967). Lehle and Putnam (1983) found inhibitory activity from several chemical fractions separated after aqueous extraction of herbage from *S. bicolor* cv. Bird-a-boo, and these fractions included more than phenolic acids. Phytoxicity from germinating seeds, root exudates, and aqueous extracts of foilage has also been reported from other *S. bicolor* cultivars (Hussain and Gadoon, 1981; Panasiuk et al., 1986). Extracts from various organs of *S. vulgare* Pers., a forage crop, and Johnson grass, [*S. halepense* (L.) Pers.], a troublesome weed, contain allelopathic chemicals (Alsaadawi et al., 1986; Abdul-Wahab and Rice, 1967). The latter produces dhurrin and taxiphyllin, two cyanogenic compounds which yield HCN and *p*-hydroxybenzaldehyde upon hydrolysis (Nicollier et al., 1983). Apparently a variety of compounds may contribute to any suspected cases of *Sorghum* allelopathy.

Agricultural weed control alternatives to the present commercial herbicide-dominated programs are now being given wide consideration (Einhellig and Leather, 1988). As noted, there is compelling evidence that planting into a sorghum cover crop residue may provide weed control. Weed suppression has also been obtained when fall-seeded alfalfa immediately follows a summer *Sorghum* forage (Forney et al., 1985). What is less well established is the year-to-year carryover weed-control capability of a sorghum crop. Hence, these investigations were undertaken to determine the impact of *S. bicolor* on the weed population in a subsequent year. Their initiation was stimulated from observations in a working farm situation.

METHODS AND MATERIALS

Field Site. The study sites were located on a farm in northeastern Nebraska, known locally as the Gary Young farm (South Half of 3129, One West, Cedar County, Nebraska). Soils of this area are Peoria loess and are deep, well-drained, and eroded (Milliron, 1985). The history of the fields was well documented, and there was no record of herbicide or commercial fertilizer application. In the study years, crops were planted using a no-till approach, and no herbicide, pesticide, or fertilizer were employed. Data from the first year (1985) were from a field with Nora silty clay loam with 6–11% slope. The other two years' data were collected from two fields with Moody silty clay loam soil, 2–6% slope. Both soil types are closely related and are described as being suited for dry land corn, soybeans, oats, and alfalfa. Our soil analysis showed 29% clay with a pH of 7.1 for the first year field, and 27% clay, pH 6.9, for the latter years. These analyses are in agreement with the county soil survey (Milliron, 1985).

The data collection plan for the first year was to analyze weed conditions the year after fields had been strip cropped with alternating, four-row bands of grain sorghum [*Sorghum bicolor* (L.) Moench] and soybeans [*Glycine max* (L.) Merr.]. In the next two years, corn (*Zea mays* L.) was added as a third crop in the strip-cropping sequences. Crops were planted on a 38-in.-row spacing, and the cultivars of the crops planted were different each year. Early weed cover the following year was obtained from sampling the entire field. Biomass sampling of weeds later in the season was obtained from within adjacent 12-m lengths of the former strip crops, which were left unplanted during the sampling year.

Data Collection. The point-contact method was used to quantify weed cover in May of the year after the crops (Crockett, 1964). Sampling was conducted using a point frame with 10 contact points spaced 10 cm apart. Each previous crop area was systematically sampled with 50 point frames, making a total of 500 points. Care was taken to avoid sampling the edges of the strip plots. Points hitting aerial cover of grass and broadleaf weeds were recorded. The data were analyzed by considering each point frame as a sample. Differences between the treatments in grass weeds, broadleaf weeds, and total weed cover were ascertained using analysis of variance (ANOVA) with Duncan's multiple-range test.

Later in the growing season (June and July), systematic sampling of aboveground weed biomass involved clear-clipping five 0.5-m^2 quadrats in each of the undisturbed prior-year crop areas. Weeds were separated into grass weeds and broadleaf weeds, and dry weights were obtained after 48 hr at 105°C. Statistical comparisons of the grass, broadleaf, and total weed biomass components between crop areas were made using ANOVA as previously described.

RESULTS

Data from all three years of this study demonstrated that the nature of the crop species in one year influenced weed growth in the subsequent year. Weed reduction in areas where grain sorghum had been the previous year was often apparent from visual inspection. During the first year of data collection, 1985, the weed population was monitored in a field which had been cropped in 1984 with alternating bands of grain sorghum and soybeans. When the field was viewed in early May 1985, strips where the soybeans had been the previous year were quite green, compared to a more barren appearance in the grain sorghum strips.

Point-frame sampling data obtained on May 7 established that grain sorghum strips had about one fourth the weed cover found in the soybean rows (Figure 1). Both grass and broadleaf weeds were significantly less where sorghum had grown the year before. By May 28, the aerial weed cover in the sorghum strips was 80% of that found after soybeans, a differential that was not statistically different. However, ANOVA showed that the broadleaf component of this weed cover was still significantly lower in grain sorghum. Visual observations at this time also suggested that the weed biomass was much less in sorghum strips.

Weed biomass in quadrats sampled on June 18 averaged 27 g for prior sorghum areas, compared to 48 g in soybeans (Figure 1). The biomass of broadleaf weeds in soybean areas was two and one-half times that of sorghum,

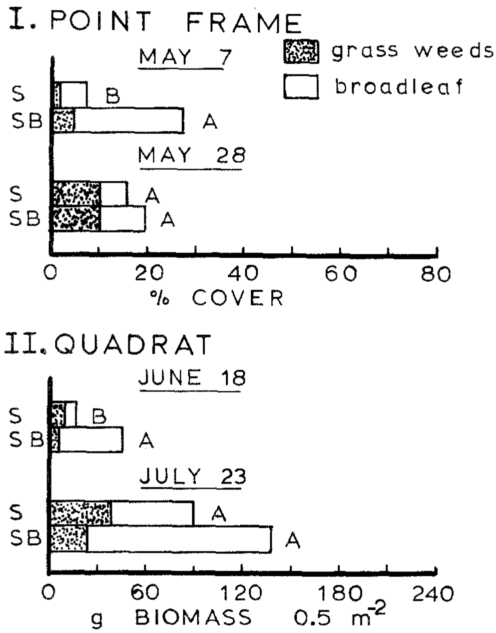

FIG. 1. Effects of the prior year (1984) crop on weed abundance in 1985. S = grain sorghum; SB = soybeans. Bars within each sampling date having different letters are significantly different, $P < 0.05$, ANOVA with Duncan's multiple-range test.

whereas grass weeds were significantly higher in the sorghum. Sampling in July still showed grain sorghum strips had less weed biomass, but there was much more variability among quadrats, and the difference in total biomass between the treatments was not significant. *Setaria* spp. appeared to make up a greater component of the weeds found in sorghum strips. Other species noted in both areas included *Polygonum pensylvanicum* L., *Kochia scoparia* (L.) Schrad., *Lactuca serriola* L., *Solanum rostratum* Dun., *Ambrosia trifida* L., *Amaranthus retroflexus* L., *Convolvulus arvensis* L. and *Physalis subglabrata* Mackenz. & Bush.

Fields in the second and third year had corn added to the strip cropping so that comparisons might be made with a crop where there would be no question about effects from residual nitrogen fertility. At each of the sampling dates in both 1986 and 1987, the weed growth was significantly lower in strips of the prior year sorghum than either soybeans or corn (Figures 2 and 3).

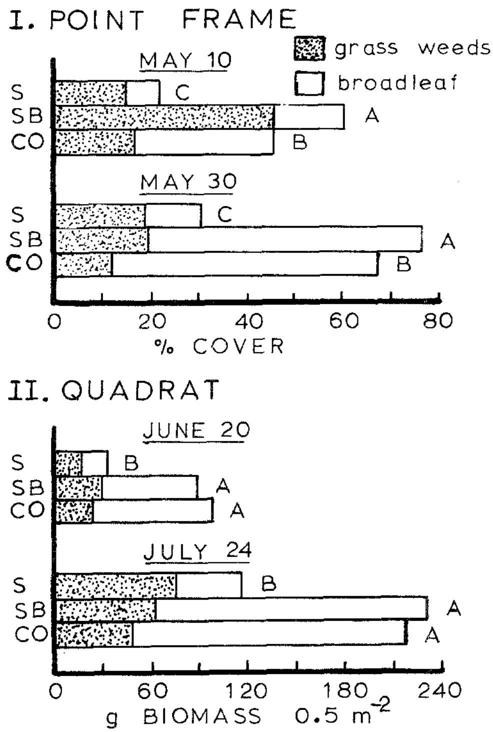

FIG. 2. Effects of the prior year (1985) crop on weed abundance in 1986. S = grain sorghum; SB = soybeans; CO = corn. Bars within each sampling date having different letters are significantly different, $P < 0.05$, ANOVA with Duncan's multiple-range test.

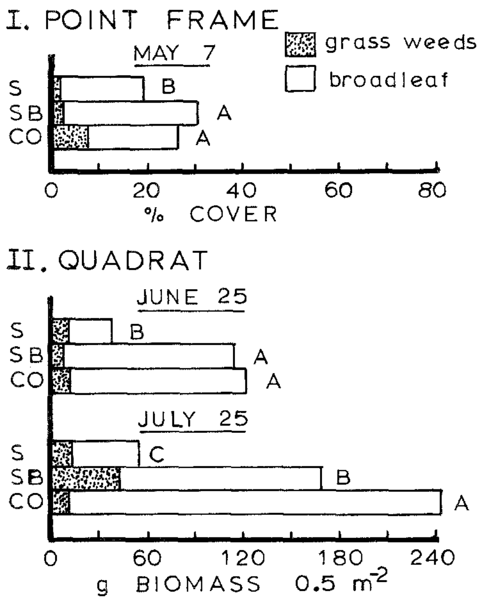

FIG. 3. Effects of the prior year (1986) crop on weed abundance in 1987. S = grain sorghum; SB = soybeans; CO = corn. Bars within each sampling date having different letters are significantly different, $P < 0.05$, ANOVA with Duncan's multiple-range test.

Weed cover from all weeds in grain sorghum areas early in the 1986 season was approximately one third of that found after soybeans, and one half that following corn (Figure 2). This was also the pattern seen for the differences in broadleaf weeds among the three treatments, whereas grasses were not significantly different between sorghum and corn. At the second sample, weed cover in grain sorghum was 40 and 45%, respectively, of that in the prior year soybean and corn. These differences reflected the significant reduction in broadleaf weed cover following grain sorghum. In contrast, grass weed cover in corn was slightly less than in the other two prior crops. Data from both June and July showed a significant reduction in weed biomass after grain sorghum (Figure 2). The total biomass in grain sorghum plots on June 20 was approximately one third of that found after corn, and on July 24 these same areas were 54% of corn plots. Essentially all of these differences were in the broadleaf component of the biomass. No marked differences in the species composition among the three treatments were observed.

In the third year, treatment effects on weed abundance early in the season could not be as readily seen as they had been in the other two years. However, data obtained on May 7 showed aerial weed cover was significantly lower in the prior year grain sorghum areas than either of the other two crops (Figure

3). Favorable temperatures resulted in very rapid early weed growth in 1987, so a second assessment of cover was not obtained. In June, it was easy to see the contrast between grain sorghum and the other two treatments. Although grain sorghum plots had less weed growth, the distribution of species appeared similar across the three areas, and these were similar to previous years. Grain sorghum quadrats on June 25 averaged less than one third the weed biomass found in plots of the prior year corn or soybean (Figure 3). All of the biomass difference was from a suppression of broadleaf weeds. The July corn quadrats had more than four times the biomass of the grain sorghum quadrats, and at this sampling corn areas supported more weed biomass than the soybean areas.

DISCUSSION

The data show weed abundance in the year following grain sorghum was markedly suppressed in comparison to the weed conditions after either corn or soybeans. These results were obtained in the absence of tillage. The impact of grain sorghum was not an absence of weeds, but one of delayed emergence and growth inhibition. Total biomass accumulation late in the season was well below that which occurred in the nonsorghum areas. The reproducibility of these results is evidenced by the fact that they occurred in three different fields and with variations in moisture (Table 1) and other climatic conditions over the three year study.

Edaphic factors do not provide a logical explanation for the reduction in

TABLE 1. MONTHLY PRECIPITATION (cm) BETWEEN CROP PLANTINGS AND SUBSEQUENT YEAR SAMPLING PERIOD

Month	1984–1985	1985–1986	1986–1987
June	21.3	11.9	14.9
July	8.5	3.8	3.1
August	2.0	16.0	7.0
September	2.1	9.1	11.2
October	10.5	2.7	5.9
November	2.8	2.8	1.3
December	2.2	0.0	0.2
January	0.7	0.3	0.3
February	0.0	0.0	1.4
March	0.4	0.3	19.2
April	17.0	5.3	2.6
May	11.1	7.5	11.7
June	11.9	14.9	13.0
July	3.8	3.1	11.5
14-Month total	94.3	80.7	103.3

weeds the year after grain sorghum, since the test areas were side-by-side strips having the same soil type and receiving a comparable quantity of moisture. It is possible that weed germination in soybean areas could have been stimulated by nitrates that might be higher in these areas (Roberts and Smith, 1977; Vincent and Roberts, 1977). This might account for the greater weed cover in soybeans than corn plots in 1986. It cannot explain the fact that weed cover in the corn was still more than twice that found following grain sorghum. If there was any bias of the physical conditions between the corn and grain sorghum areas, it was that the former had a more extensive surface cover of crop residue than occurred with grain sorghum, and this might be expected to slightly delay soil warming in the corn plots. In spite of this, early emergence and subsequent growth of weeds was greater where corn had been.

Allelopathic conditions from grain sorghum as the donor plant must be considered as a major factor in the weed inhibition. We suspect that no one compound mediates this allelopathy, but that it is the result of the collective action of several compounds (Einhellig et al., 1982; Lehle and Putnam, 1983; Einhellig, 1987). The focus of this research was not on isolation and identification of the allelochemicals, but it is likely they included cyanogenic glycosides and a variety of phenolic acids and aldehydes that have been previously reported (Guenzi and McCalla, 1966a; Martin et al., 1938).

The extent of any sorghum-mediated allelopathy will be influenced by environmental conditions, both with regard to production of allelochemicals and seasonal carryover. The level of accumulation of many phenolic and coumarin allelochemicals in a plant is influenced by plant age, light intensity, and numerous stress conditions (Woodhead, 1981; Lehle and Putnam, 1982). Rainfall could be important to the persistence of allelochemicals into the next crop year. However, the data over the three years showed similar effects in all years even though the second year was drier than the others. It is possible that the heavy rainfall in March of the third year may have reduced the degree of difference in weed cover among the plots in May of 1987.

Recognition that under no-till conditions *S. bicolor* can suppress weeds in the year following the crop has potential applications in agriculture. Any such application strategies should be tested with intended tillage operations, crop cultivars, rotation sequences, and climatic and soil conditions of the region. It has also been shown that some allelochemical inhibitions can work in conjunction with commercial herbicides (Einhellig, 1987). Hence, grain sorghum might be used in a crop rotation sequence either with or in the absence of other weed control measures. In any case, the planned use of a grain sorghum crop as a provision for weed management could reduce reliance on herbicides.

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