Use of Alfalfa in Crop Rotation to Control Herbicide Resistant Pigweed

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Abstract: (Limit 200-300 words)
Use of herbicide resistant grain crops has increased continuous cropping with a move away from historical crop rotation recommendations that included the use of a hay crop. Infestation of soybean fields by herbicide resistant weeds such as Palmer pigweed (*Amaranthus palmeri*) is estimated at over 3.5 million acres in Arkansas. Research showed that over 90% of the pigweed seedbank will be depleted in 4 years if no additional seed are added. Competition from an alfalfa hay crop could reduce weed emergence and seed maturity due to good soil cover and the monthly hay cutting schedule. The objective of this study was to determine if alfalfa or a summer-annual grass grown in rotation with soybean could reduce weed populations. Research was conducted at the LSU Red River Research Station and two farm demonstrations were conducted in Arkansas. Excessively wet weather prevented fall planting on the research site and one field demonstration site. Wet conditions delayed fall planting and stand development on the second farm demonstration site. The spring-establishing alfalfa stands did not develop quickly enough to provide a canopy over the pigweed. Plants counts showed approximately 14 alfalfa plants and 3 pigweed plants ft^{-2} by mid-summer at the LSU site. Clipping the pigweed promoted branching regrowth which strongly competed with the seedling alfalfa causing severe stand thinning. Thus, alfalfa was replanted in fall 2019. Good stands of alfalfa eventually developed in the farm demonstrations, but pigweed competition, insect pests, and deer damage reduced the number of hay harvests and total yield. August stand counts showed an average alfalfa occupancy in Randolph County of 89% with 23% for pigweed and 94% alfalfa occupancy with 59% for pigweed in Cross county. Viable alfalfa stands were present in fall and should be on track to provide competition and monthly harvest benefits in 2020.

Introduction:

Use of herbicide resistant grain crops has caused a move toward continuous cropping and a move away from historical crop rotation recommendations that included the use of a hay crop. Crop production in Arkansas and the Southeast is complicated by the infestation of herbicide resistant weeds which require expensive strategies for control. In soybeans, for example, a glyphosate herbicide program is no longer successful in controlling pigweed (*Amaranthus palmeri*, also referred to as Palmer amaranth or Palmer pigweed) that has become glyphosate resistant. In Arkansas, over 3.5 million acres are cropped to soybeans and cotton annually (2012 USDA) Ag Census) and nearly all fields are infested with herbicide resistant weeds. Research has shown yield losses of 17% at a pigweed population of one weed per 10 feet of row and the population in many fields is much higher (Klingaman and Oliver, 1994). Costs of controlling resistant weeds have risen by $30-$40 per acre with a potential added cost of over $100 million (Bob Scott, personal communication). Research showed that over 90% of the pigweed seedbank will be depleted in 4 years if no additional seed are added (Barber et al., 2015).

Growing alfalfa in rotation with soybeans could be beneficial to reduce weed populations and to rebuild soil structure contributing to improved soil health. Fall-planted alfalfa would develop a canopy in spring the first year before pigweed emergence and the regrowth cycle should remain ahead of the pigweed throughout the growing season. The dense canopy provided by alfalfa could reduce pigweed emergence and the frequent hay cutting schedule (every 30 days) could prevent pigweed from producing mature seed. It has been noted that pigweed is seldom a problem in wheat grown for grain in that region, but is a significant problem in soybeans (Dr. Bob Scott, personal communication). Grain yields are reported in many studies to be 10-25% higher following alfalfa in a rotation.

Several hay and livestock producers in Arkansas are developing agreements with crop producers to lease resistant weed infested fields for growing hay. Which hay crop will serve them best is a question to be answered, but in northeast Arkansas, some livestock growers are interested in alfalfa due to it's value for their own livestock and also market opportunities. Alfalfa could provide quality feed for livestock producers that lease these infested fields. There is also the long-term possibility of cash sales of alfalfa hay across the state and the southeast and to an operating pelletizing mill in northeast Louisiana that specializes in alfalfa based feeds. Arkansas has over 954,000 beef cattle, 22,100 dairy cattle, 61,000 horses, and 60,000 sheep and goats (2012 USDA Ag Census) all of which could benefit from improved quality hay. Typical hay grown in the area is tall fescue, annual ryegrass or bermudagrass which are often harvested at a late stage of maturity which has low forage quality. Small square baled alfalfa typically sells for $8-10 for the horse market and large bales (800 lbs) are valued over $75 for moderate quality alfalfa hay. The estimated gross value of an annual alfalfa crop would be $900 to $1,600 per acre depending on bale type and marketing. The major row crop region of eastern Arkansas is also ideally located for potentially shipping quality hay throughout the southeast.

Materials and Methods:

Research Site - LSU:

The experiment was conducted at LSU AgCenter's Red River Research Station near Bossier City, LA in a Caplis very fine sandy loam soil (coarse-silty over clayey, mixed over smectitic, superactive, calcareous, thermic Oxyaquic Udifluvents) with an average slope of < 1%. The selected field had been under continuous corn-soybean rotation for at least the previous 5 years and had a severe glyphosate resistant pigweed infestation. Selected physical and chemical properties of soil (0 – 15 cm) at the study site are presented in Table 1. Soil texture was determined by Bouyoucos hydrometer method, pH was determined with a 1:1 soil to water ratio, and extractable nutrients with Mehlich III extraction followed

by analysis with induced coupled plasma atomic emission spectroscopy (ICP-AES) (Spectro CIROS^{CCD}, Mahwah, NJ).

Table 1. Soil properties of experiment site – LSU Red River Station

Soil Property	
Sand, g kg^{-1}	640
Silt, g kg^{-1}	255
Clay, g kg^{-1}	106
pH (1:1 soil to water)	6.64
Total C, g kg^{-1}	5.5
Mehlich-III extractable nutrients	
P, mg kg^{-1}	31.2
K, mg kg^{-1}	95.1
Ca, mg kg^{-1}	577
Mg, mg kg^{-1}	145
Cu, mg kg^{-1}	0.89
Zn, mg kg^{-1}	0.36

The experiment consisted of 5 treatments:

- control (continuous soybean)
- 1-year annual grass followed by soybean
- 2 years alfalfa followed by soybean
- 3 years alfalfa followed by soybean
- 4 years alfalfa followed by soybeans

Frequent heavy rain throughout fall of 2018 prevented fall planting as intended. Round-up ready alfalfa (W-L 372HQRR) was planted at 25 pounds acre^{-1} in the appropriate plots using a seed drill (8-inch row spacing) on March 18, 2019. The experiment was a randomized complete block in 4 replications. Plot size was 26.7 ft. wide by 100 ft. long. Soybean in the control plots was planted on hipped rows on May 22, 2019 using hybrid CZ4540LL (Bayer Corp.) at 120,000 seeds acre^{-1} and hybrid pearl millet (ExCeed BMR) was planted at 25 pounds acre^{-1} on July 9, 2019 in the annual grass plots. Alfalfa and pigweed plant stand density was collected on July 16, 2019 from 3 randomly selected 1 ft^2 areas per plot. Biomass production from each alfalfa treatment was determined by harvesting 70 ft^2 of each plot at a stubble height of 2 inches. Alfalfa was harvested on July 25 and September 4, 2019 and pearl millet was harvested on September 4. The remainder of each plot was mowed and baled as hay following each biomass harvest. Furrow irrigation was utilized as relative to soybean production needs but all plots were irrigated. Alfalfa and pearl millet was planted on beds leaving a furrow to facilitate irrigation. No fertilization was provided for any of the treatments.

Project objective:

1. Determine if inclusion of alfalfa or summer annual grass grown for hay in a crop rotation could reduce populations of herbicide resistant weeds in grain crop fields

Project results:

1. Pearl millet competed well with the pigweed and provided weed reduction and a hay crop in year one.
2. Spring-seeded alfalfa does not exhibit enough competition to reduce pigweed populations in the establishment year.

Results:

Research Study - LSU

A good stand of alfalfa was emerged following the March planting. However, a dense stand of pigweed emerged later in the spring after alfalfa and the vigorous pigweed quickly outgrew the alfalfa plants (Figure 1). Pigweed plants were clipped above the alfalfa twice between mid-June and mid-July in an attempt to keep them at the height of alfalfa and reduce seed development. Mean alfalfa counts in July were 14 plants ft^{-2} with 3.2 pigweed ft^{-2}. By late July, at the time of the first harvest, shading from pigweed resulted in alfalfa being spindly with weak stems (Figure 2). Mowing of alfalfa plots did not greatly suppress pigweed since there tended to be multi-branched regrowth from the remaining pigweed stubble which caused severe stand thinning of the seedling alfalfa. The alfalfa population declined below a viable threshold by October so alfalfa treatments were replanted on November5 for 2020. Alfalfa was treated for infestations of three-cornered alfalfa hopper (*Spissitilus festinus*) and potato leaf hopper (*Empoasca fabae*) on three occasions during the season using Lambda-cyhalothrin (Karate, by Syngenta, US) at 1.6 oz/A. Damage from these insects did contribute to the weakened condition of alfalfa plants.

Both soybean with herbicide application and pearl millet provided good pigweed suppression. The later planting of soybean with mechanical disturbance immediately prior to planting and use of soybean herbicides, Fierce (Flumioxazin + Pyroxasulfone) at 3.75 oz/A (Valent, USA), Prowl (Pendimethalin) at 2.4 pt/A (BASF, USA), and Liberty (Glufocinate) at 29 oz/A, combined to reduce pigweed infestation in soybeans (Figure 3). Planting of pearl millet was delayed to allow for control of pigweed by disking prior to establishment. Pigweed plants counts after harvest were not significantly different between the pearl millet and soybean treatments with 0.009 pigweed ft^{-2} for soybean and 0.019 pigweed ft^{-2} following pearl millet (Figure 4).

Approximately 1 ton $acre^{-1}$ dry biomass was harvested from each of the alfalfa treatments but alfalfa contributed less than 5% of the yield. Pearl millet did reduce pigweed infestation but the late planting allowed for only one harvest of approximately 1 ton $acre^{-1}$ dry biomass. During part of the growing season water was not available for irrigation but soybeans yielded 42.9 bushels $acre^{-1}$ with the limited irrigation.

Results suggest that a spring seeding of alfalfa does not provide the competitive benefits for controlling pigweed that would be anticipated for a fall seeding. Good weed suppression by pearl millet suggests that a hay crop can be a viable management tool for pigweed control. With fall re-established alfalfa treatments, the coming season may provide a better opportunity to evaluate the efficacy of alfalfa management in suppressing pigweed infestation.

Figure 1. Growth of spring-seeded alfalfa and glyphosate resistant pigweed by June 7, 2019 at the Red River Research Station near Bossier City, LA.

Figure 2. Harvest strip from spring-seeded alfalfa stand with glyphosate resistant pigweed on July 25, 2019 at the Red River Research Station near Bossier City, LA.

Figure 3. Soybeans with glyphosate resistant pigweed at the Red River Research Station near Bossier City, LA.

Figure 4. Pearl millet stubble in early November 2019 following September hay harvest at LSU Red River Research Station. Note the absence of pigweed regrowth.

Farm Demonstration Methods

Alfalfa was planted following soybeans in two Arkansas fields infested with herbicide resistant pigweed. One third of each field will be rotated back to soybean after 2, 3, and 4 years of alfalfa hay production.

Randolph County Farm Demonstration Site

A 25 acre field previously used for soybean production was planted with W-L 372HQRR alfalfa at a rate of 22 lbs/acre on October 30, 2018. The field had a history of severe pigweed infestation. The soil was a Bosket sandy loam. The soil pH was 6.7 and P and K were 116 and 302 lbs/acre respectively. Frequent rainfall delayed soybean harvest in fall of 2018 causing a delay in alfalfa planting. Alfalfa was planted about three weeks later than planned. Temperatures turned cold the week following planting and heavy rains continued through the winter which delayed development of the alfalfa. Although a good plant population emerged, seedlings remained at approximately 1 inch in height until spring. The stand developed slowly through the spring on a similar schedule as for the spring seeding in Cross County. Approximately 4 acres were re-seeded in spring due to washing and excessive sand cover from the high rainfall. Fertilizer was applied at a rate of 0-0-87 +1.5B on June 15 and at 0-0-90 on October 15.

Pigweed was clipped on June 7. Hay was harvested on July 27 and September 20 for a total yield of 1.1 tons/acre (Table 4). Glyphosate was applied for winter weeds in February and for weedy grasses in August. Three-cornered alfalfa hoppers and potato leafhoppers were the main insect pests and were

treated on June 15 and August 8 with lambda cyhalothrin. An application of 46-0-0 per acre was applied on August 8 to boost the alfalfa due to excessive insect damage. That application stimulated the alfalfa but also increased growth and competition from the pigweed.

Cross County Farm Demonstration Site

A 22-acre field previously used for soybean production was no-till planted with W-L 372HQRR alfalfa at a rate of 23 lbs/acre on April 11, 2019. The field had a history of severe pigweed infestation. Frequent rain prevented planting in fall. The soil test showed a pH of 6.1, and P and K of 84 and 325 lbs/acre, respectively. Fertilizer at 0-60-40+1B and 1 ton/acre lime were applied the first week of April and an application of 0-0-110 was made in October. The field was sprayed with 1 quart/acre glyphosate on April 10 to control existing vegetation before planting. Armyworms were treated in mid-May and three-cornered alfalfa hopper and potato leafhopper were treated three times over the season. Half the field was treated with 2 pints/acre Butyrac to suppress pigweed on July 1. Glyphosate was applied twice for grassy weed control. Pigweed was clipped in May. Hay was harvested on June 13 (Table 4). Deer feeding pressure was heavy and suppressed alfalfa growth in late summer, reducing hay production.

The Cross County producer planted 30 acres of sorghum-sudangrass for hay adjacent to the alfalfa field. A buffer strip was unplanted between the alfalfa and sorghum-sudangrass in which a dense stand of pigweed developed (Figure 4). The sorghum-sudangrass was harvested twice for hay and no pigweeds were observed following the second cutting.

Alfalfa stand evaluation

Stand counts of the farm demonstrations were made on May 13, July 9, July 23, and August 6 at 40 sites across the field using a 5x5 wire frame with squares of 5”x5”. A square was counted if all or part of an alfalfa or pigweed plant was observed in the square, giving a stand occupancy rate (Table 3). On May 13, the percent row coverage was also determined by counting the number of one-inch sections that contained alfalfa within a three-foot section of row adjacent to where occupancy counts were made.

Results – Farm Demonstrations

Good alfalfa stands emerged for both farm demonstrations, but both developed too slowly in spring to provide adequate competition to suppress pigweed. Insect pest problems developed early which compounded competition from the pigweed.

Table 3. Percent row coverage and stand occupancy of spring-seeded alfalfa and pigweed in Randolph and Cross County farm demonstrations

Date	% alfalfa row coverage	% alfalfa occupancy	% pigweed occupancy
Randolph County			
May 13	**82**	**83**	**0**
July 9		**97**	**33**
July 23		**91**	**38**
August 6		**89**	**23**
Cross County			
May 13	**80**	**97**	**13**
July 9		**99**	**61**
July 23		**96**	**39**
August 6		**94**	**59**

Figure 4. Competitive effect of sorghum-sudangrass (left) with Palmer pigweed (right) growing in the buffer strip between sorghum-sudangrass and the alfalfa. Photo taken in July, 2019 in Cross County.

Alfalfa hay yield and quality were low for both farm demonstrations (Table 4), likely due to insect pests, weed competition, and deer damage (Cross County). Pigweed content was approximately 40% and 30% for first and second cutting in Randolph County and 30% for Cross County. Sorghum-sudan hay in Cross County produced good yield and competition for the pigweed, although hay quality was low due to plant maturity. Pigweed content of the soghum-sudan hay was less than 15% for each harvest. Nitrate-N concentration was not high in alfalfa or sorghum-sudan hay.

Table 4. First year hay yield and forage tests for Randolph and Cross county farm demonstrations

	Hay Yield	**% Crude Protein**	**% TDN**	**Nitrate-N**
Randolph County				
Alfalfa – 1st cutting	**0.33 t/acre**	**13.1**	**53.2**	**405**
Alfalfa – 2nd cutting	**0.76 t/acre**	**13.4**	**58.9**	**780**
Cross County				
Alfalfa – 1st cutting	**0.4 t/acre**	**14.2**	**58**	
Sorghum-sudan	**1.26 t/acre 1st cut**	**5.9**	**53.1**	**427**
Sorghum-sudan	**3.2 t/acre 2nd cut**	**6.3**	**52.2**	**620**

Discussion:

Farm Demonstration Discussion:

WL Alfalfa donated enough seed for the farm demonstrations to increase the total acreage by over 50% from 30 acres up to 47 acres (Randolph County - 25 acres; Cross County - 22 acres). Field days were held for both demonstrations with approximately 25 in attendance (see flyer attached). Local producers were very interested in the potential for a high quality hay crop for their livestock.

Spring-seeded alfalfa did not develop quickly enough to become competitive with the vigorous pigweed. The seedling alfalfa developed at the same time as the pigweed and negated the anticipated benefits of both competition and monthly cutting schedule of the alfalfa on reducing the pigweed growth. The Randolph county field was fall-planted, but onset of cold weather and continued heavy rain prevented it from becoming well-established until spring. Normally a well-established fall-planted stand would be expected to develop a dense canopy and be ready for first hay harvest by early May. The competition plus the monthly cutting schedule would keep the alfalfa growth cycle ahead of the pigweed. That did not happen in this case and the pigweed became well-developed in both demonstration fields. However, by managing insect pests, clipping weeds, and harvesting hay, the alfalfa stands did finally become well developed by late summer (Figures 5 and 6). It is anticipated that in year-two both fields will follow a normal growth and cutting schedule providing the expected benefits in 2020.

Figure 5. Alfalfa field in September 2019 after first growing season at Randolph County farm demonstration site.

Figure 6. Spring-seeded alfalfa field after first growing season in September 2019 at Cross County farm demonstration site.

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References:

Barber, L. T., K. L. Smith, R. C. Scott, J. K. Norsworthy, A. M. Vangilder. 2015. Zero Tolerance: A Community-Based Program for Glyphosate-Resistant Palmer Amaranth Management. https://www.uaex.edu/publications/pdf/FSA2177.pdf

Klingaman, T.E., and L.R. Oliver. 1994. Palmer amaranth (Amaranthus palmeri) interference in soybeans (Glycine max). Weed Sci. 42:523-527

Keywords:
Alfalfa, hay, crop rotation, soybean, herbicide resistant pigweed, competition, fall-seeding, spring-seeding

New Approach to Control Pigweed
- Field Tours -

Attend one or both locations!!

- *Monday, September 9 at 5:30 p.m. - James Farm, Pocahontas, AR*
- *Friday, September 20 at 5:30 p.m. - Washington Springs Ag, Cherry Valley, AR*

Come learn how alfalfa in rotation with soybeans can mow down herbicide resistant pigweed!

Pigweed biology and control

Alfalfa management

Planting guidelines

Economics

- ***To preregister for field day and dinner: for Pocahontas call 870-892-4504, for Cherry Valley call 870-238-5745 or call Linda McCargo at 501-671-2171***
- ***The tour will include both field and indoor presentations.***

Directions :

- *September 9: James Farm is located at* **4511 AR-304 , Pocahontas, AR**. *Take Hwy 67 to the south side of Pocahontas. Take Hwy 304 east about 3.4 miles and watch for field day signs.*
- *September 20 - To* Washington Springs Ag at **175A County Road 324, Cherry Valley AR**: Take HWY 1 to County Road 324 just north of Cherry Valley. Turn east on CR 324 over the RR to the field. Watch for field day signs.

Alfalfa U.S. Alfalfa Farmer Research Initiative

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