JOURNAL OF THE NACAA

ISSN 2158-9429

VOLUME 15, ISSUE 2 – DECEMBER, 2022

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Planting Date and Cultivar Effects on Alfalfa Forage Production in Mississippi

Abstract

Alfalfa is one of the most widely grown forage crops in the USA and it is gaining popularity in the southeastern region due to its versatility as hay, baleage, or grass/legume mixed grazing. Traditional planting of alfalfa in the southeastern USA is recommended from mid-September to early November, but there are producers interested in the feasibility of spring planting that could allow alfalfa to establish a good root system before the onset of hot weather. The objective was to evaluate the impact of planting dates on forage production during the establishment year of three alfalfa cultivars in Mississippi. The experimental design was a randomized complete block in a split-plot arrangement replicated four times. The main plots were three planting dates. The planting dates (PD) were September 15 (PD1) and December 15 (PD2), 2020, and March 15 (PD3), 2021. The subplots were three alfalfa cultivars, 'Bulldog 505 (BD505),' 'Bulldog 805 (BD805),' and 'LA6010.' Plot size was 6 x 11 feet planted at 20 lb PLS ac^{-1}. Cultivars were harvested three times in 2021 to determine yield potential and nutritive value. The total yield for the plantings ranged from 4991 lbs ac^{-1} in September and 3087 lbs ac^{-1} in the March planting. The PD2 had a 5% decline in yield potential compared to

PD1 while PD3 had significantly lower yields with a 38% decline when compared to PD1. There was a significant PD x harvest interaction ($P < 0.0001$) for all nutritive value parameters (crude protein, acid detergent fiber, neutral detergent fiber, starch, in vitro dry matter digestibility, and water-soluble carbohydrates). This preliminary study indicates that late alfalfa planting could have limitations in alfalfa production in north Mississippi.

Abbreviations: PLS = pure live seed; PD = planting date; PD1 = September 15 planting; PD2 = December 15 planting; PD3 = March 15 planting; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ST = starch; IVTDMD = *in vitro* dry matter digestibility; WSC = water-soluble carbohydrates; LSD = least significant difference.

Keywords: alfalfa, biomass yield, nutritive value, planting date.

Introduction

The increase in fertilizer prices has forage producers looking for forage species that could reduce fertilization, increase forage production, and maintain high-quality forage. Alfalfa (*Medicago sativa*) can provide an opportunity to improve yield and nutritive value when well-established to form the basis for profitable and sustainable forage production. Alfalfa is a herbaceous perennial forage legume with high yield and nutritional value (Biazzi et al., 2017). It has an efficient biological nitrogen-fixation ability (Huyghe et al. 2014) and its deep root system can help improve soil structure. Alfalfa can result in higher dry matter yield when mixed with grasses such as bermudagrass (*Cynodon dactylon* L.; Tucker et al., 2021; White and Lemus, 2015). A sustainable stand will depend on selecting well-drained soils, adding lime and needed nutrients (phosphorus and potassium), selecting an adapted variety, and implementing the best establishment practices (land preparation, planting date, and seeding rate) to ensure germination (Undersander et al., 2011).

Mild winters in the southeastern USA could allow for a longer planting window for alfalfa (September to late October). However, a planting window is more conducive to the formation of a good root system that can carry the plant through the hot and humid summer conditions while storing carbohydrates for survival. Woodward and Kugler (2006) indicated that planting date can negatively affect alfalfa seedling development, stand density, and forage yield while reducing production potential and profitability when planting from August to September across two locations in the state of Washington. A similar effect was observed with Roundup Ready® alfalfa varieties under irrigation when planted from June to September in New Mexico (Lauriault, 2014). Rocateli et al. (2019) indicated that spring planting of alfalfa may be riskier due to insects, weeds, and wet conditions that can increase fungal and bacterial diseases. Alfalfa is not tolerant of a high-water table during establishment since these conditions could limit oxygen concentrations and alfalfa can be more susceptible to root rot.

Once well-established, alfalfa production spans several years. Planting dates are of paramount importance to the successful production of alfalfa. They can impact seedling establishment and partial yield loss. Insufficient information on optimum planting dates for alfalfa development is available in Mississippi. The objective was to evaluate the impact of planting dates on forage production during the establishment year of three alfalfa varieties in Mississippi. It was hypothesized that a later seeding date, coupled with excessive water holding capacity soils, would negatively impact stand establishment and production during the seeding year.

Methods

A preliminary field study was conducted at the Henry H. Leveck Animal Research Farm at Mississippi State University in a Marietta fine sandy loam (Fine-loamy, siliceous, active, thermic Fluvaquenti Eutrudepts) during the fall of 2020 and spring of 2021. Plots were arranged in a randomized complete block in a split-plot arrangement replicated four times. The main plots were three planting dates. The planting dates (PD) were September 15 (PD1), December 15 (PD2), 2020, and March 15 (PD3), 2021. The subplots were three alfalfa cultivars, ‘Bulldog 505 (BD505),’ ‘Bulldog 805 (BD805),’ and ‘LA6010.’ The study area was planted in annual ryegrass in the fall of 2019 and remained fallow during the summer of 2020. A seedbed was prepared 4 weeks ahead of planting and treated with glyphosate at 2 pt ac^{-1} 10 d prior to planting to reduce weed competition. Plot size was 6 x 11 feet planted at 20 lb PLS ac^{-1}.

Plots were harvested to a 3-inch stubble with a self-propelled mower equipped with a bagging system. There were three harvest dates for PD1 and PD2 (May 7, June 15, and July 9) and three harvests for PD3 (May 28, June 29, and July 28). Harvest dates for each PD occurred when alfalfa reached 30% bloom. Forage subsamples were collected and dried at 140 °C for 72 h or until a constant weight was achieved for dry matter determination. Samples were ground to pass through a 1-mm screen using a Wiley mill (Thomas Scientific, Swedesboro, NJ) and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), *in vitro* true dry matter digestibility at 48 h (IVTDMD), water-soluble carbohydrates (WSC), and starch (ST) using a Foss DS2500 Near Infra-red Reflectance Spectroscopy (NIRS) instrument (Foss North America, Eden Prairie, MN) and applying the 2021 legume hay equation developed by the NIRS Forage and Feed Testing Consortium (Berea, KY).

Data were analyzed using harvest frequency as a repeated measure for each of the dependent variables. Data were tested and normality and homogeneity of variance were subjected to ANOVA using SAS PROC GLIMMIX procedure of SAS and the least significant difference was used to determine treatment differences at $\alpha = 0.05$.

Results

Climatic conditions

Total precipitation from September 2020 to August 2020 was 14.3 inches above the normal levels (Table 1). However, there were major precipitation deficits during June and August of 2021. The average temperature for the growing season was very similar to the long-term average. There were temperature fluctuations with October and

November of 2020 and March of 2021 being much cooler than average. There was little difference in growing degree days (GDD) for the growing season. Larger fluctuations in GDD were observed with less GDD for September and November of 2020 and March of 2021. This is usually related to cloud cover.

Table 1. Precipitation, temperature, and growing degree days (GDD) along with 30-yr average and deviation (Dev.) during the preliminary evaluation of alfalfa planting date at Starkville, MS from September 2020 to August 2021 (NOAA, 2022).

	Precipitation (in)			**Temperature (°F)**			***GGD₅₀****		
Month	2020-21	30-yr	Dev.	2020-21	30-yr	Dev.	2020-21	30-yr	Dev.
Sep	4.4	3.4	1.0	77.6	76.8	0.8	834	780	54
Oct	4.1	3.7	0.3	67.6	66.3	1.3	550	620	-70
Nov	2.4	4.3	-1.9	59.5	55.3	4.2	306	132	174
Dec	4.5	5.1	-0.6	49.1	49.5	-0.4	81	364	-283
Jan	4.0	5.4	-1.4	48.0	47.0	1.0	73	92	-19
Feb	3.3	5.0	-1.7	45.4	50.7	-5.3	115	131	-16
Mar	4.9	5.7	-0.8	61.1	58.0	3.1	359	288	71
Apr	5.4	5.9	-0.5	63.6	64.8	-1.2	414	454	-40
May	4.8	4.4	0.4	71.5	72.9	-1.4	675	717	-42
Jun	11.6	4.4	7.2	80.2	79.6	0.6	910	896	14
Jul	6.4	5.2	1.3	82.0	82.1	-0.1	998	1002	-4
Aug	11.6	4.7	6.9	82.1	81.8	0.3	1004	993	11
Total/ Mean	67.2	57.2	--	65.6	65.4	--	6319	6469	--

*Growing degree days (GDD) base 50.

Biomass production

There were no significant differences among cultivars as influenced by planting date, therefore biomass data were averaged among cultivars. Planting date was significant ($P < 0.0001$) revealing seasonal yield decline among planting dates (Fig. 1). The December planting had a 5% decline in yield potential compared to the September PD, but this relationship was non-significant (Fig 1.). The March PD had significantly lower yields with a 38% decline when compared to the September planting. The total yield for the plantings ranged from 4991 lbs ac^{-1} in September and 3087 lbs ac^{-1} in the March planting. There were no significant differences among cultivars as influenced by planting date. Bulldog 505 had 20 and 17% lower biomass production when compared to Bulldog 805 and LA6010.

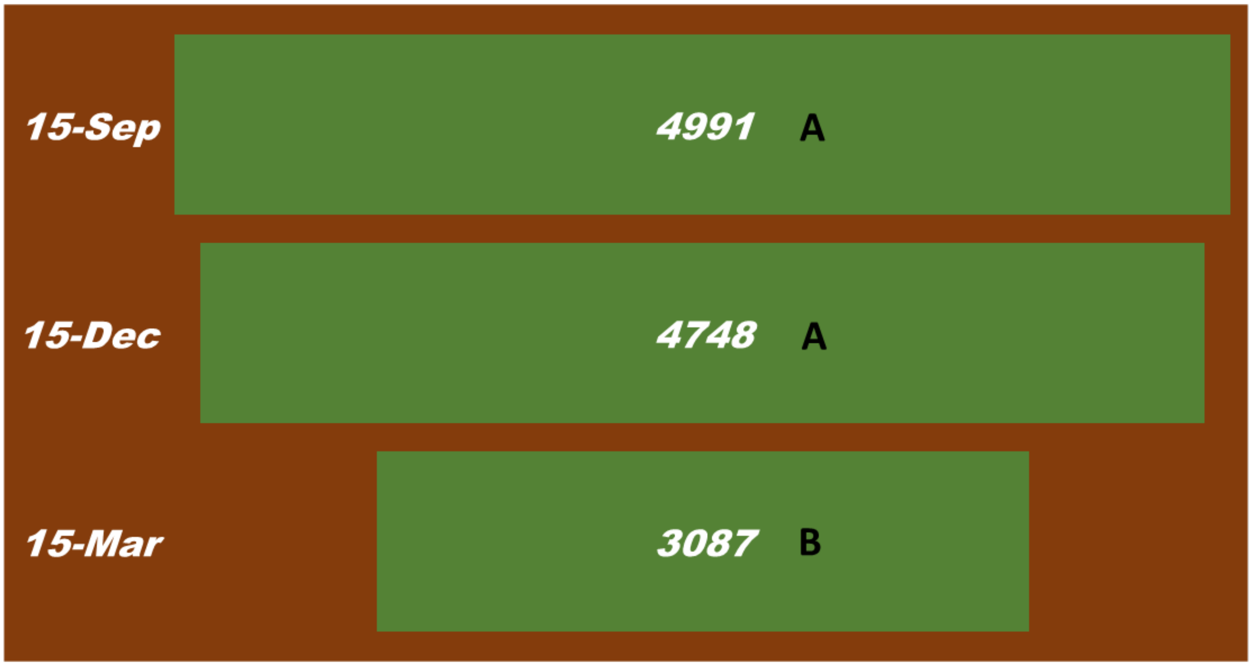

Figure 1. Impact of planting date on alfalfa dry matter biomass yield in 2021 at Starkville, MS. Biomass averaged across cultivars. Planting dates with similar letters indicate no significant differences at α = 0.05.

There was a significant trend of 5 and 36% lower yields for the December and March PD when compared to the September planting. Harvest yields were significantly influenced by cultivars, where BD805 sand LA6010 had 18 and 13% greater mean harvest yield, respectively, than BD505. There was a harvest date effect for alfalfa yield where the third harvest had 34 and 51% lower yield when compared to the first and second harvests, respectively. This might be related to warmer temperatures and higher humidity toward the mid-year. A planting date x cultivar interaction was observed across harvests. There was a decline in biomass production with a delay in planting date and BD505 had lower yields across all planting dates when compared to the two other varieties. A planting date x harvest date interaction was significant (P = 0.0004) for mean harvest biomass. Yields were lower for the third harvest in PD3 by 14 and 66%

when compared to PD1 and PD2, respectively. The decrease in mean harvest yield across harvest dates and PD is more related to high temperatures and humidity in July and August causing alfalfa to slow growth due to stress.

Table 2*.* Effect of three planting dates (PD1 = September 15, PD2 = December 15, and PD3 = March 15) on mean harvest biomass of three alfalfa varieties and three harvests during 2021 in Starkville, MS.

		Planting Dates			
Cultivar	**PD1**	**PD2**	**PD3**	**Mean**	**$LSD_{0.05}$**
	--------------- *Harvest Biomass (lb DM ac^{-1})* ---------------				
BD505	1292	1455	1080	1276	NS
BD805	1960	1557	1107	1541	402
LA6010	1740	1737	1016	1498	425
Mean	1664	1583	1068		
$LSD_{0.05}$	493	189	NS	--	--
Harvest					
1	2019	1621	1247	1629	384
2	1976	1790	1082	1616	293
3	997	1337	875	1070	288
Mean	1664	1583	1068		
$LSD_{0.05}$	423	176	189	--	--

Nutritive value

There was a planting date x harvest interaction ($P < 0.0001$). There was lower CP for PD3 during the first and second harvest of the season (Table 3). The second harvest also provided lower CP across all PD. No differences in crude protein (CP) were observed among cultivars across planting or harvest dates. There was a PD effect with PD2 having greater CP levels. Harvest also influenced CP with harvest 2 having lower CP concentrations. Higher CP concentration in PD3 could be related to slower growth due to plant stress and greater accumulation of nutrients.

Acid detergent fiber (ADF) was affected by the alfalfa planting date ($P = 0.0086$) with PD2 having a lower ADF concentration. A difference in ADF was also observed among cultivars ($P = 0.0076$) with BD505 having a lower concentration. Differences among harvests ($P < 0.0001$) indicated that the third harvest had a 12% lower ADF concentration than the second harvest. There was a planting date x harvest interaction ($P < 0.0001$). Lower ADF was observed during the third harvest for PD1 and PD2 (Table 3). On the other hand, the first harvest exhibited lower ADF in PD3. A decline in ADF was observed for harvests 1 and 2 across PD, where the exception of the third harvest where ADF showed an opposite trend.

Neutral detergent fiber (NDF) was affected by cultivar ($P = 0.0136$) and harvest (P < 0.0001). Bulldog 805 alfalfa had a 5% lower NDF concentration compared to the other two varieties The NDF concentration was 17% lower for the third harvest when compared to the two previous harvests. There was a planting date x harvest interaction ($P < 0.0001$). The ADF concertation was lower for the third harvest across PD1 and PD2, but PD3 had slightly higher ADF compared to the other harvests (Table 3). The NDF concentration declined across PD for the first and second harvests while the opposite trend was observed for the third harvest.

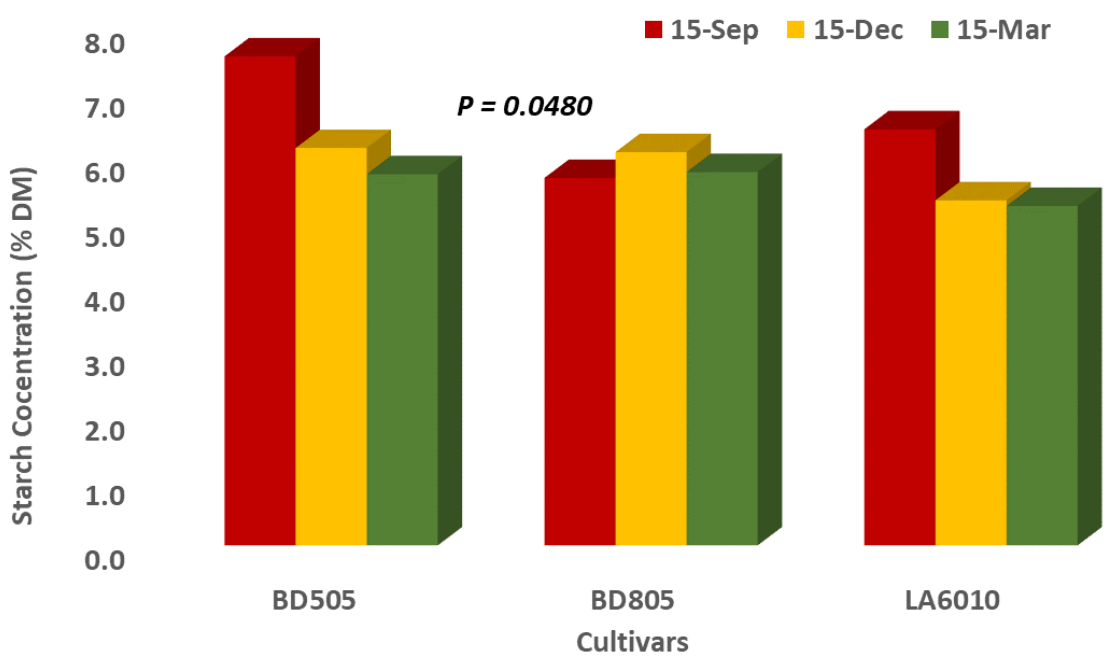

Figure 2. Influence of planting date and alfalfa cultivar on starch concentration during the 2021 growing season at Starkville, MS.

There was a planting date x cultivar interaction (P = 0.0480) for alfalfa starch concentration. Starch concentration was 16% greater for PD1 than the other two harvests combined (Fig. 2). Bulldog 805 also had a 16% greater starch concentration than the other two cultivars (Fig. 2). There was a planting date x harvest interaction ($P < 0.0001$). Starch concentration increased by 65% for the third harvest compared to previous harvests. This could be related to temperature and humidity stress which reduces stem growth more than leaf growth causing the plant to increase starch storage. The starch concertation was greater for the third harvest across PD1 and PD2 (Table 3). The first harvest during PD3 had a greater starch concentration than subsequent harvests within the same PD.

Table 3. Effect of planting (PD1 = September 15, PD2 = December 15, and PD3 = March 15) and harvest dates on nutritive value* of alfalfa during the 2021 growing season at Starkville, MS. Cultivars were averaged across planting date and harvest.

Harvest	**PD1**	**PD2**	**PD3**	**Mean**	**$LSD_{0.05}$**	**PD1**	**PD2**	**PD3**	**Mean**	**$LSD_{0.05}$**
	---------------------------------- Concentration (% DM) ----------------------------------									
			CP					***ST***		
1	24.0	24.5	18.7	22.4	0.8	3.4	4.1	7.2	4.9	0.6
2	17.7	19.6	19.2	18.8	1.2	5.3	4.4	5.2	5.0	NS
3	20.1	21.1	20.6	20.6	NS	11.9	9.0	4.4	8.1	1.5
Mean	20.6	21.7	19.5	-	-	6.6	5.8	5.6	-	-
$LSD_{0.05}$	1.1	0.6	1.1	-	-	1.6	0.8	0.7	-	-
			ADF					***IVTDMD***		
1	33.1	30.1	28.0	30.4	1.8	79.4	80.8	82.8	81.0	1.6
2	36.1	33.1	31.4	33.5	2.2	75.0	77.6	79.6	77.4	1.9
3	26.8	27.7	34.3	29.6	2.0	83.3	82.8	76.5	80.8	1.3
Mean	32.0	30.3	31.2	-	-	79.2	80.4	79.6	-	-
$LSD_{0.05}$	1.6	1.5	1.7	-	-	2.1	1.1	1.2	-	-
			NDF					***WSC***		
1	39.7	38.3	35.5	37.8	2.6	5.7	6.6	8.1	6.8	1.6
2	43.1	41.4	41.6	42.0	NS	6.7	6.7	7.0	6.8	1.9
3	32.9	35.0	42.1	36.7	2.6	8.1	7.9	5.9	7.3	1.3
Mean	38.6	38.2	39.8	-	-	6.8	7.1	7.0	-	-
$LSD_{0.05}$	3.5	1.7	2.8	-	-	2.1	1.1	1.2	-	-

*CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; ST = starch; IVTDMD = *in vitro* true dry matter digestibility; WSC = water soluble carbohydrates.

In vitro true digestible dry matter (IVTDMD) was influenced by a planting date x harvest date interaction (*P* < 0.0001). The PD2 had a slightly greater IVTDMD concentration than the other PD. As for harvests, the second harvest exhibited lower IVTDMD concentration. The second harvest exhibited lower IVTDMD concentrations across all PD (Table 3). This could be related to a shift in lignin concentration and an increase in leaf:stem ratio caused by environmental conditions for plants under stress.

Water soluble carbohydrates (WSC) were significantly different among alfalfa cultivars (*P* = 0.0011) and harvest dates (*P* = 0.0012). Bulldog 505 had a 7% greater WSC concentration than BD805 and LA6010. The same pattern was observed where the third harvest had 7% greater WSC than the previous harvests. This is an indication of plant stress and slow growth during the summer slump which led to a greater accumulation of nutrients. There was a planting date x harvest interaction (*P* < 0.0001). The third harvest had greater WSC across PD1 and PD2, while PD3 exhibited greater accumulation during the first harvest (Table 3). It was expected that WSC concentration in alfalfa would decrease during the third harvest to balance photosynthesis and respiration due to warmer temperatures, but above-normal rainfall patterns in July and August could have compensated for this phenomenon.

Conclusion

The data in this preliminary study suggest that the best time to plant alfalfa in central Mississippi might be from mid-September to late October. Although a successful stand could be achieved with a December planting, yields may not be sufficient to economically justify a later planting. This could be a possibility for southern locations close to the coastal area with less cooler temperatures and a wider planting season. Planting in the fall can allow the plant to develop crowns that could withstand the harsher summer conditions of the southeastern USA while providing greater forage production and perhaps extending the longevity of the stand. Based on these findings, a mid-September to Mid-October planting is recommended for north Mississippi while a mid-October to mid-November establishment might be more ideal south Mississippi based on the initial yield reduction. Since this was a preliminary exploratory study, there is a need to develop a more in-depth study with a large array of cultivars and dormancies (FD5 to FD10). Data besides biomass production should include stand counts throughout the growing season and at least three to four years of data collection to determine cultivar persistence and stability, recovery time after harvest, weed pressure impact in stand establishment, and identification of detrimental fungal and bacterial diseases. Further research is warranted to determine the impacts of economic returns associated with seeding date, root development, and cost recovery.

Conflict of Interest

The authors declare that there is no conflict of interest.

Acknowledgement

This publication is a contribution of the Mississippi Agricultural and Forestry Experiment Station (MAFES), the Mississippi State University Extension Service (MSU-ES) upon work that is also supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Hatch project under accession number 1016223, Project Number MIS-164010. Thank you to Tristan Peavey (undergraduate student) for assisting with land preparation and planting.

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