Management of Sorghum Aphids in Early and Late-Planted Grain Sorghum With an In-Furrow Insecticide Application

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Sorghum aphid, also known as sugarcane aphid, is an economically important pest of sorghum across the southern United States.

The sorghum aphid (*Melanaphis sorghi*), also known as the sugarcane aphid, has become a significant pest in the southern United States since its detection in Texas and Louisiana in 2013, now affecting 25 states and impacting sorghum yields. Management strategies, such as resistant cultivars and insecticide applications, are employed, but further research is needed to optimize these methods and evaluate the combined effects of insecticide application and planting dates on aphid control and sorghum yield. The objective of this study was to evaluate the impact of insecticide applications and planting dates on *M. sorghi* infestations and grain sorghum yield over three growing seasons in Tifton, GA. Earn **1.0 CEU in Integrated Pest Management** by taking the quiz for the article at Learning Center Courses.

Sorghum aphid (*Melanaphis sorghi*), also known as the sugarcane aphid, is an economically important pest of sorghum across the southern United States. Following detection of *M. sorghi* in Texas and Louisiana in 2013, this gray or pale yellow-colored insect emerged as a pest of sorghum and has since spread to 25 states in the southern United States, where it negatively impacts sorghum yield (Bowling et al., 2016;

Knutson et al., 2016; Brewer et al., 2017). The widespread geographic expansion of *M. sorghi* may be partly due to its dispersal ability, parthenogenetic nature, and ability to occupy a wide range of climatic conditions and ecosystems (Singh et al., 2004; Bowling et al., 2016), including disturbed ecosystems and agroecosystems where the preferred and alternate host plants are abundant (Bowling et al., 2016; Harris-Shultz & Ni, 2021).

Figure 1. Early and late-planted grain sorghum plants in Tifton, GA. Early planted grain sorghum reached maturity three weeks earlier than late planting.

M. sorghi is a major pest of all types of sorghum and persists on select non-crop hosts. Grain sorghum, sweet sorghum, and feed sorghum are all colonized by the aphid. Additionally, the invasive pest is also known to utilize sugarcane, Johnsongrass, sudangrass, energy cane, Columbus grass (a hybrid between sorghum and Johnsongrass), and giant miscanthus (Armstrong et al., 2015; Paudyal et al., 2019; Harris-Shultz & Ni, 2021). These preferred host plants support the aphid's survival, growth, and reproduction during offseasons when sorghum is not under cultivation.

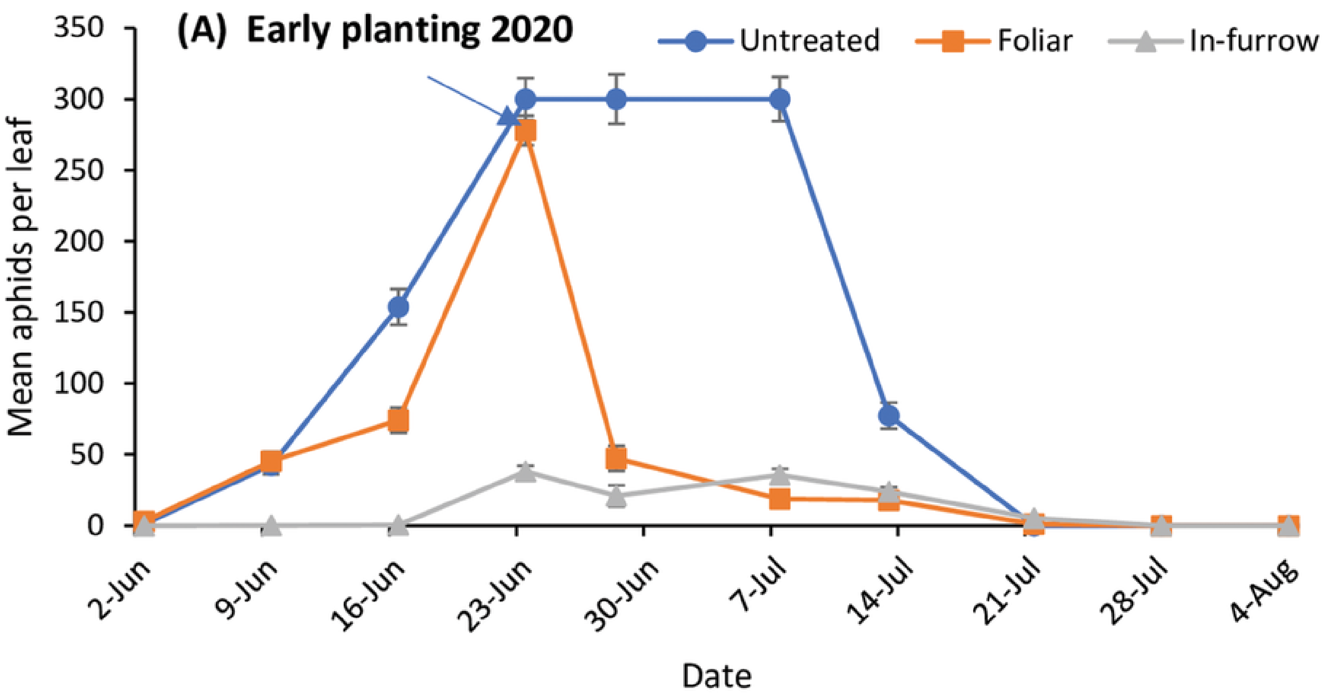
Damage from *M. sorghi* can be direct or indirect. Like other aphids, *M. sorghi* feeds by inserting the stylets into plant tissue and feeding on sap in the host plants. The sap obtained from the host plant is partially digested and then excreted as copious sugar-rich honeydew, which promotes the growth of sooty mold on sorghum leaves (Singh et al., 2004; Bowling et al., 2016). Damage caused by *M. sorghi* decreases or stops grain sorghum growth, reducing crop yield by more than 50% in susceptible grain sorghum plants (Bowling et al., 2016; Lahiri et al., 2021; Uyi et al., 2022a).

Beyond impeding photosynthesis due to blocking sunlight, sooty mold accumulation can clog grain sorghum harvest equipment, thereby reducing harvest efficiency (Singh et al., 2004; Bowling et al., 2016). During severe infestation or at high densities, feeding activities by nymphs and adults of *M. sorghi* cause physiological stresses leading to chlorosis, leaf wilt, and necrosis, or even stand losses in susceptible sorghum varieties (Singh et al., 2004; Bowling et al., 2016).

In many sorghum production areas in the United States, *M. sorghi* has emerged as a major pest, impacting crop growth and causing significant yield loss in grain and feed sorghum production (Brewer et al., 2017; Szczepaniec, 2018; Uyi et al., 2022b). For example, the Louisiana sorghum industry reported yield losses of approximately $7.7 million in 2013 due to *M. sorghi* infestation (Kerns et al., 2015), while severe infestations between 2015 and 2017 caused a significant decrease (>50%) in the total land area planted to sorghum in Georgia (Bostick et al., 2020). In Texas, a total of $169.83 million was reported to be the annual economy-wide loss (Zapata et al., 2018).

To suppress *M. sorghi* infestation and improve sorghum yield, researchers have developed several control and management strategies, such as planting resistant sorghum cultivars and relying on well-timed insecticide applications (Seiter et al., 2019;

Lahiri et al., 2021; Lytle and Huseth, 2021). While foliar application of registered insecticides such as flupyradifurone (*Sivanto Prime*, Bayer CropScience) and sulfloxaflor (*Transform*, Corteva Agriscience) suppress aphid infestation and preserve sorghum yield, studies on the efficacy of in-furrow application of flupyradifurone in grain and forage sorghum remain scarce (but see Uyi et al., 2023).



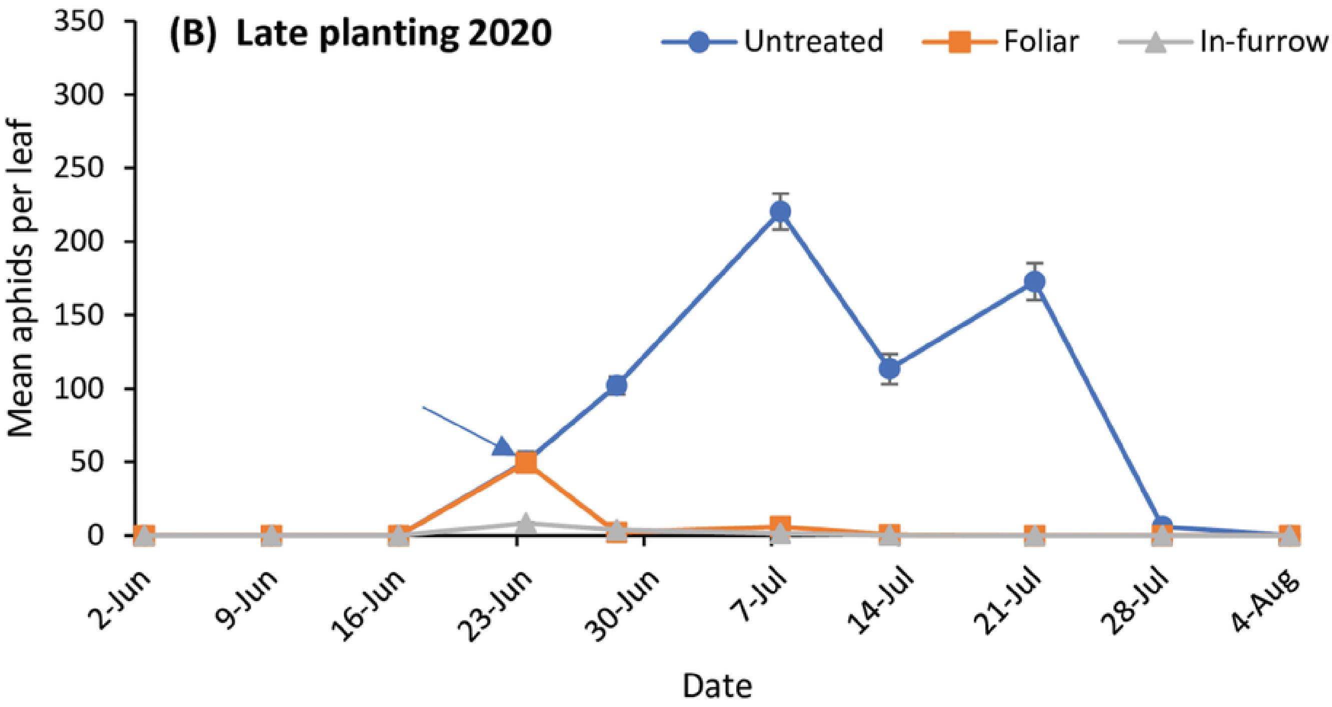


Figure 2. Mean number (±SE) of Melanaphis sorghi on bottom leaves for early (A) and late (B) planting in 2020 on grain sorghum in Tifton, GA. The arrow indicates the timing of foliar insecticide application.

Timing of sorghum planting can substantially affect aphid infestation and sorghum yield. For example, Seiter et al. (2019) reported that early planting generally limited aphid damage and improved yields in grain sorghum compared with later planting dates in Arkansas. Anecdotal observations in Georgia corroborate these findings, but no empirical data currently support this hypothesis. Studies that combine insecticide application methods—such as in-furrow insecticide application—and planting date as a strategy to manage *M. sorghi* are scarce (but see Uyi et al., 2023), highlighting the need for further research.

The objective of this study was to evaluate the impact of insecticide applications (in-furrow insecticide application and foliar insecticide application) and planting dates (early planting and late planting) on *M. sorghi* infestations and grain sorghum yield. Studies were conducted over three growing seasons (2020–2022) in Tifton, GA.

Materials and Methods

The impact of planting date (early planting and late planting) (Figure 1) and different methods of insecticide application on *M. sorghi* densities and grain sorghum yield were evaluated over three growing seasons (2020, 2021, and 2022) at Tifton, GA. In the spring of 2020, 2021, and 2022, plots of susceptible grain sorghum (*DKS-5353*, Dekalb, Bayer CropScience) were established at Tifton. A split-plot design was used for each experiment with planting date as the main plot factor and insecticide application as the subplot factor. Individual replicated plots measured 4 rows by 40-feet long (36-inch row spacing). The early planting dates were April 17, April 22, and May 2 for the 2020, 2021, and 2022 trials, respectively, while the late planting dates were May 28, June 11, and June 6 for the 2020, 2021, and 2022 study, respectively. The three insecticide treatments were untreated, 8 oz/ac flupyradifurone (Sivanto Prime) in-furrow, and 5 oz/ac flupyradifurone (Sivanto Prime) plus an adjuvant as a foliar application, applied at a set threshold. The in-furrow insecticide was applied at planting using microjet applicators to apply a total 5.1 gal/ac diluted insecticide; liquid insecticide was applied directly in the open furrow in front of the disk closer and press wheel. *M. sorghi* infestations were estimated by enumerating aphids on six lower and six upper leaves of six randomly selected sorghum plants per plot each week. The mean number of *M. sorghi* was averaged across the six subsamples per plot. Assessments started four weeks after planting and continued until the grain reached the hard dough stage.

When aphid population reached the economic threshold of 50 aphids per lower leaf, plots designated to receive foliar flupyradifurone applications received a one-time application of flupyradifurone using a self-propelled sprayer equipped with hollow cone nozzles (model TXVS-8, TeeJet Technologies, Spraying Systems Co.). Applications were delivered in a spray volume of 10 gal/ac. When the grain dried in the field to a moisture content of 15% or less, the center two rows from each plot were harvested using a self-propelled plot combine. For comparison purposes, all plots were adjusted to a common 14% moisture content and extrapolated to kilograms of grain per hectare. Costs for insecticide and application costs vary widely. For example, insecticide pricing varies by region of the country, formulation, and volume purchased by the grower.

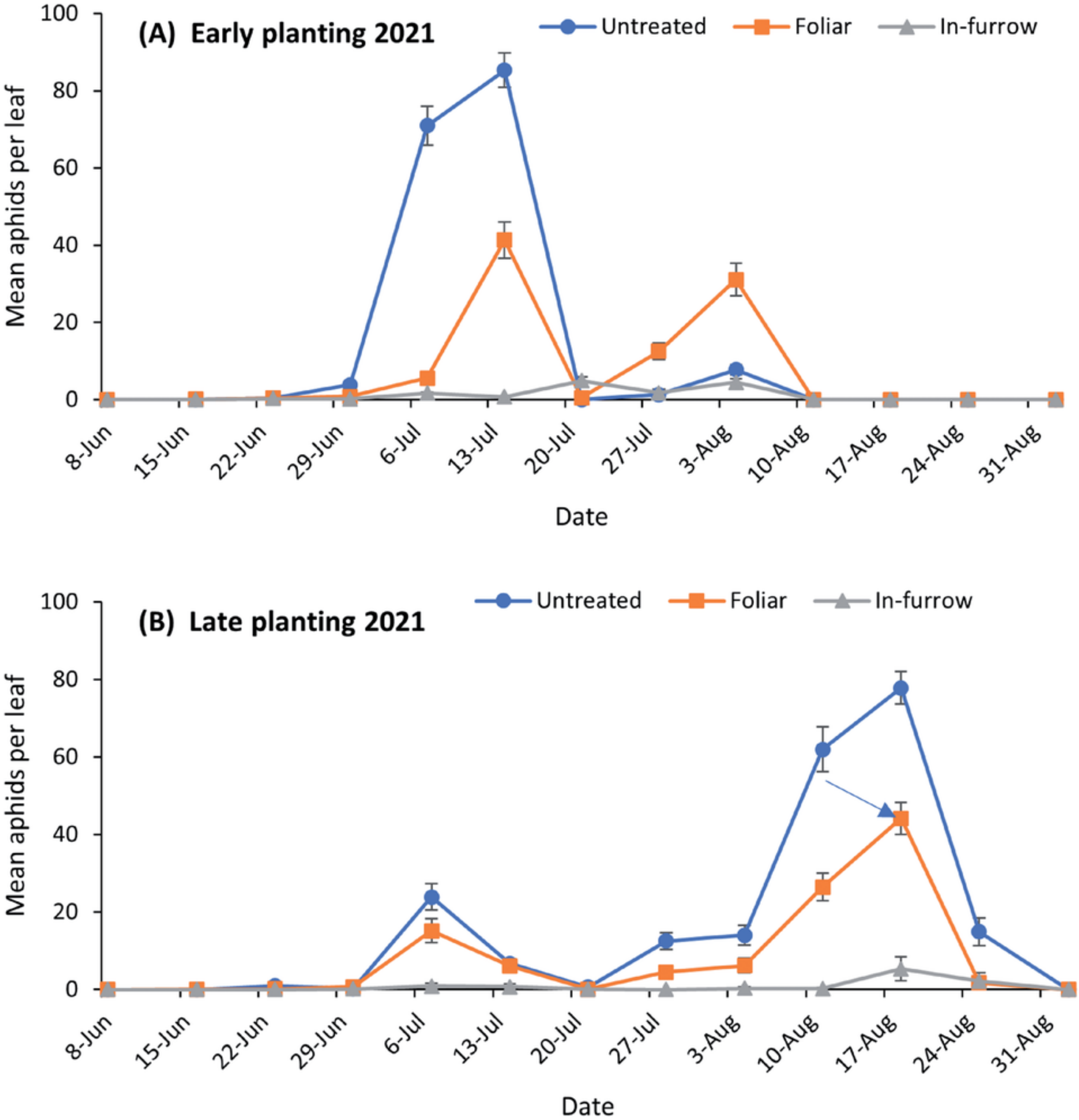


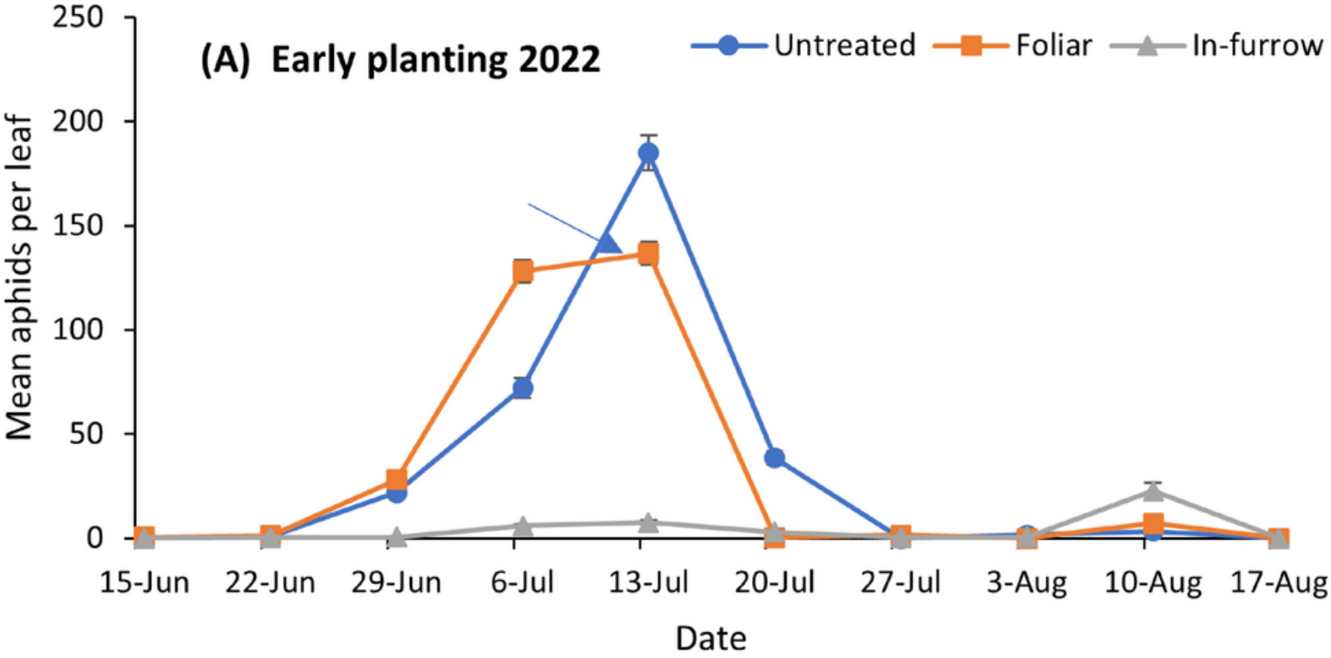
Figure 3. Mean number (±SE) of Melanaphis sorghi on bottom leaves for early (A) and late (B) planting in 2021 on grain sorghum in Tifton, GA. The arrow indicates the timing of foliar insecti- cide application. Grain sorghum in the early planted sorghum did not receive a foliar insecticide application because aphid populations never reached the threshold.

For purposes of economic analyses, the authors observed that Sivanto Prime insecticide costs $376/gal in the local market; therefore, the insecticide-only cost for the foliar application is $14.69/ac and insect-only cost for the in-furrow application is $23.60/ac. There is no additional application cost in an in-furrow application as the tractor and planter must go over the field for planting. However, there is an additional cost of making a foliar application as this trip across the field would not be necessary if not making a well-timed insecticide application. Costs for a trip over the field using a field sprayer vary with equipment type, age, fuel consumption, and operating speed. For purposes of comparison, the authors assumed an operating cost of $8/ac; therefore, the actual cost of the foliar application is $22.69/ac when accounting for insecticide and application cost.

Grain Value and Statistical Analysis

Grain value is also highly variable based on local conditions. For example, growers must consider their basis, grain quality, distance to market, demand at a particular time of year, and premiums for delivering to a terminal elevator as opposed to a country elevator. Further, the distance that the grain must be trucked to reach the buying point is a factor. Considering the time frame that grain from this study could have been marketed (September 2020 through December 2022), grain sorghum spot prices in Georgia ranged from $10 to $19/bu. For purposes of discussion, the authors based all economic analyses on an average spot price over that period, which was approximately $14/bu.

The effect of planting date and insecticide applications on grain sorghum yield was evaluated using univariate General Linear Model analysis of variance (GLM ANOVA). When an F-statistic was significant, the differences in means were compared using the Tukey's Honest Significant Difference (HSD) test. All analyses were performed using IBM SPSS Statistical software version 20.0 (SPSS). Melanaphis sorghi counts varied widely across treatments and years of study. In 2020, M. sorghi was first detected by early June in the early planted grain sorghum plots and late June in the late-planted plots (Figure 2a, b).



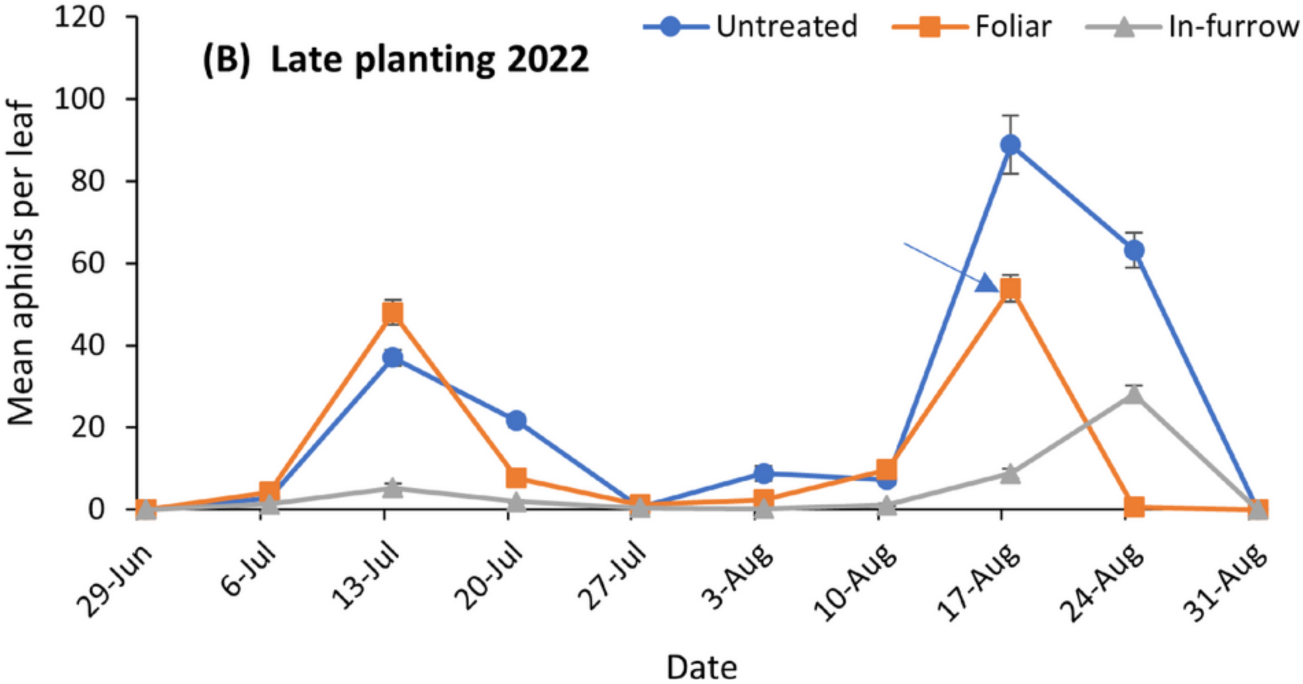


Figure 4. Mean number (±SE) of Melanaphis sorghi on bottom leaves for early (A) and late (B) planting in 2022 on grain sorghum in Tifton, GA. The arrow indicates the timing of foliar

insecticide application.

Melanaphis sorghi counts were generally lower in 2021 compared to 2020. Melanaphis sorghi first appeared in mid-May in the early planted plots and late June in the late-planted plots in 2021 (Figure 3a, b). In the 2022 study, M. sorghi first appeared on June 23 in the early planted study and June 29 in the late-planted trial (Figure 4a, b). Across year of study, aphid populations were noticeably higher in early planted plots compared to later-planted plots. When M. sorghi numbers exceeded the economic threshold, foliar insecticide application to designated early or late-planted plots immediately suppressed M. sorghi infestation below the threshold level. Across all three study years, M. sorghi populations in plots receiving in-furrow application treatment were exceptionally low and never reached the threshold used to trigger foliar applications (Figures 2–4). In contrast, M. sorghi populations were always higher on grain sorghum in the untreated plots compared to those that received in-furrow or foliar insecticide treatments.

Generally speaking, grain sorghum yield was greater early planted plots and plots receiving in-furrow treatments. In 2020, early planting preserved grain yield by 60% compared to late planting, while in-furrow and foliar treatments preserved grain yield by nearly 90% compared to the untreated control (Figure 5a). In-furrow insecticide application alone improved yield by nearly 30% and 70% compared with foliar insecticide application and the untreated control, respectively.

In 2021, grain yield was more than sevenfold greater in early planted plots relative to late-planted plots; additionally, grain yield was significantly greater in plots receiving the in-furrow insecticide treatment compared to foliar applied or untreated (Figure 5b). In 2022, early planting relative to late planting preserved grain yield by 45% compared with late-planted plots, and the in-furrow insecticidal application improved grain yield by 35% when compared with untreated control and foliar insecticide application (Figure 5c). Simple economic analyses of the costs and returns of using the insecticide were calculated. As detailed earlier in the methods, the authors estimated application plus insecticide costs at $22.69/ac for a foliar application and $23.60/ac for an in-furrow application. Using the average spot grain sorghum price of $14/bu, a grower would only need to preserve an additional 1.62 bu/ac to cover the costs of a foliar insecticide application or an additional 1.69 bu/ac to cover the costs of an in-furrow application. Any yield preservation above these values indicates increased profit to the grower. Considering early planting date only, the foliar insecticide treated plots (relative to untreated control) yielded an additional 62.9 (2020) and 0.8 (2022) bu/ac; no foliar insecticide applications were triggered on early planted grain sorghum made in 2021. Considering late-planted plots, the foliar treatment preserved an additional 10.5 (2020), 0.5 (2021), and −6.4 (2022) bu/ac. Conversely, the early planted in-furrow treated plots yielded an additional 109.1 (2020), 3.8 (2021), and 70.3 (2022) bu/ac, respectively. Late-planted in-furrow treated plots yielded an additional 17.3 (2020), 2.1 (2021), and 27.8 (2022) bu/ac.

Discussion

The results of this study clearly showed that in-furrow insecticide application of flupyradifurone significantly suppressed *M. sorghi* infestations and preserved grain sorghum yield.

Irrespective of planting dates, the application of flupyradifurone in-furrow suppressed aphid populations to near zero and improved grain sorghum yield by more than 35% across years (2020, 2021, and 2022) compared to untreated control and foliar insecticide application. The high efficacy of in-furrow insecticide treatment in suppressing *M. sorghi* population and preserving grain yield has only been previously reported in our early study conducted at Tifton, GA, and Florence, SC (see Uyi et al., 2023).

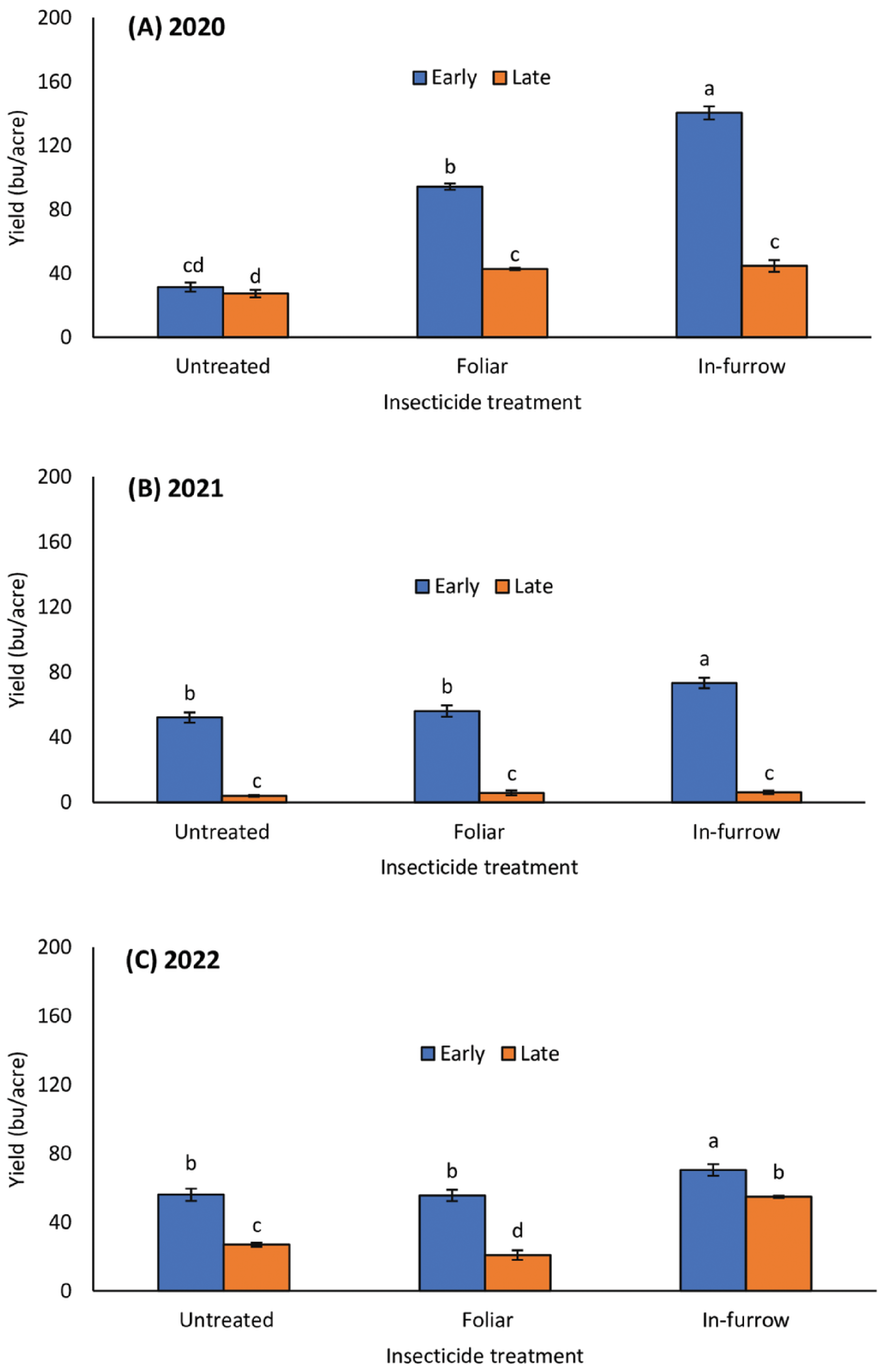
In support of other studies (e.g., Lytle & Huseth, 2021; Uyi et al., 2023), we observed that a single foliar application of flupyradifurone significantly reduced *M. sorghi* population below the economic threshold level. However, some aphids were still present after application, suggesting that the use of foliar application alone may not always be effective in suppressing *M. sorghi* in grain sorghum.

The finding that a well-timed foliar insecticide application preserved grain sorghum yield supports an earlier report by Lahiri et al. (2021), who found that one-time application of flupyradifurone significantly improved grain sorghum yield in both resistant and susceptible sorghum cultivars across locations in Georgia, South Carolina, and Alabama.

Conclusion

This current study strongly suggests that early planting is required for maximum grain yield. This finding is consistent with a recent study in Arkansas (Seiter et al., 2019), Georgia, and South Carolina (Uyi et al., 2023) that also found that early planting improved grain yield. Contrary to the findings of others that reported reduced *M. sorghi* numbers in early planted grain sorghum (Szczepaniec, 2018; Seiter et al., 2019), early planting in our study supported higher aphid populations. However, these findings also showed that grain sorghum growers in Georgia can benefit from early planting by as much as 40% in yield. In addition to the advantages of early planting on *M. sorghi* management, early planting can help to avoid periods of high temperatures and drought during flowering and grain development that can lead to reduced yields.

In simple economic terms, these data show that investment in a well-timed foliar spray or an in-furrow insecticide treatment consistently returns increased profit to the grower. The foliar spray paid for itself in 2020 only, while the in-furrow spray paid for itself regardless of planting date across all three years. Caveats to this argument are that the study was conducted with an *M. sorghi*-susceptible grain sorghum variety and that *M. sorghi* populations were evident throughout the study. The value of using an in-furrow insecticide application with resistant germplasm or in locations or years with very low *M. sorghi* pressure is outside the scope of this study.



(A) 2020
Early
Late
Yield (bu/acre)
200
160
120
80
40
0
cd
d
b
c
a
c
Untreated
Foliar
In-furrow
Insecticide treatment
(B) 2021
Early
Late
Yield (bu/acre)
200
160
120
80
40
0
b
c
b
c
a
c
Untreated
Foliar
In-furrow
Insecticide treatment
(C) 2022
Early
Late
Yield (bu/acre)
200
160
120
80
40
0
b
c
b
d
a
b
Untreated
Foliar
In-furrow
Insecticide treatment

Figure 5. Mean (±SE) grain yield (bu/acre) in early and late-planted grain sorghum treated with flupyradifurone in-furrow (IF) or foliar in 2020 (A), 2021 (B), and 2022 (C) in Tifton, GA. Means with different letters are significantly different (Tukey's HSD test, P

To conclude, our study demonstrates the benefits of combining early planting and in-furrow insecticide application to preserve grain sorghum yield and further suggests that early planting of grain sorghum and using in-furrow insecticide are the most consistent ways to suppress aphid infestations and preserve grain yield in sorghum production. Therefore, these findings suggest that growers should endeavor to plant their grain sorghum early in the year (mid-April to early May) and utilize an in-furrow flupyradifurone insecticide application to preserve yield and maximize economic returns on grain sorghum production in the southeastern United States.

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1. **When was sorghum aphid first detected in the southern United States?**
   a. 2011.
   b. 2012.
   c. 2013.
   d. 2016.

2. **Melanaphis sorghi can indirectly damage host plants by promoting the growth of sooty mold on leaves.**

a. True.
b. False.

3. **How do sorghum aphids contribute to reduced harvest efficiency?**
   a. By inserting stylets into plant tissue.
   b. By clustering on sorghum leaves and clogging harvest equipment.
   c. By promoting sooty mold growth, which can accumulate and clog harvest equipment.
   d. By impeding photosynthesis.

4. **Between 2015 and 2017, severe *M. sorghi* infestations caused a ____ decrease in the total land area planted to sorghum in Georgia.**
   a. 50%.
   b. <50%.
   c. 7.7%.
   d. >50%.

5. **Which of the following was NOT an insecticide treatment used in the study?**
   a. 5 oz per acre flupyradifurone (Sivanto Prime) in-furrow.
   b. 5 oz per acre flupyradifurone (Sivanto Prime) plus an adjuvant as a foliar application.
   c. 8 oz per acre flupyradifurone (Sivanto Prime) in-furrow.
   d. Untreated.

6. **Under what conditions were sorghum aphid populations always higher?**

a. In all treated plots.
b. On plots receiving in-furrow treatments.
c. On plots receiving foliar treatments.
d. On untreated plots.

7. **In-furrow insecticide application alone improved yield by ____ and ____ compared with ____ and _____, respectively.**
   a. 30%, 90%; foliar application, untreated control.
   b. 30%, 70%; foliar application, untreated control.
   c. 20%, 70%; foliar application, untreated control.
   d. 30%, 70%; untreated control, foliar application.

8. **A grower would need to preserve an additional ______ bu/ac to cover the costs of in-furrow application.**
   a. 1.62
   b. 1.69
   c. 22.69
   d. 23.60

9. **Across planting dates, in-furrow application of flupyradifurone improved sorghum yield by more than ____ across years.**
   a. 5%
   b. 15%
   c. 25%
   d. 35%

10. **The study findings suggest that growers should plant grain sorghum mid-April to early May.**
    a. True.
    b. False.
