az2005 October 2022

Sugarcane Aphid, Melanaphis sacchari (Zehntner), (Hemiptera: Aphididae) in Arizona Sorghum

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In 2016, the sugarcane aphid, *Melanaphis sacchari* (Zehntner) (Hemiptera: Aphididae), was first detected and confirmed as a new pest of sorghum species in Arizona. It Scientists first confirmed this invasive species on sorghum in the USA in 2013 and since in nineteen states as well as in all sorghum production regions of Mexico. Sugarcane aphid survives and multiplies primarily on graminaceous crops such as sugarcane, sorghum, and sudangrass as well as weedy johnsongrass. The main factors for sugarcane aphid's geographic spread appear to be its ability to overwinter on living hosts of those species, allowing for early build up of populations that synchronize with susceptible stage of sorghum, and secondly, the ability to disperse by wind, allowing for augmentation of populations every season. Its dark tarsi, cornicles, and antennae easily differentiate it from other aphids. In 2016 and 2017, sugarcane aphid infestations were very large, often with thousands of sugarcane aphid per leaf in most sorghum production areas in Arizona. We conducted field experiments from March to September 2017 at The University of Arizona's Maricopa Agricultural Center in Maricopa, AZ. Sugarcane aphid significantly damaged sorghum resulting in yield loss of 30% compared to sorghum that was not treated with insecticides. We are reporting first-hand information of the pest's occurrence, damage that it causes to sorghum, results of field trials investigating insecticides, and management guidelines.

Introduction

The sugarcane aphid *Melanaphis sacchari*, is a non-native pest introduced to the United States of America. It is a key pest on sorghum, *Sorghum bicolor* (L.) Moench, and sugarcane, *Saccharum officinarum* in many areas of Africa, Asia, Australia, and parts of Central and South America (Singh et al. 2004). In North America, it appeared on sugarcane in Hawaii in 1896 (Pemberton 1948, Zimmerman 1948), Florida in 1977 (Summers 1978, Mead 1978, Denmark 1988), and Louisiana in 1999 (White et al. 2001). In 2013, it was first detected and caused significant yield losses in sorghum along the Texas Gulf Coast (Villanueva et al. 2014), and then in Louisiana, Oklahoma, and Mississippi. In 2014, sugarcane aphid expanded its range to twelve states in the United States. At the end of 2015, this common pest of sugarcane demonstrated a shift to host plants in the genus *Sorghum* – grain sorghum, forage sorghums, sorghum x sudangrass crosses, sudangrass, and the weed johnsongrass. These reports spanned 17 states in the United States and in all sorghum-producing regions in Mexico (Bowling et al. 2015). In 2016, we reported its occurrence in Arizona and California on sorghum (Mostafa and Ellsworth 2016), commercial sudangrass fields near Stanfield, AZ, and also on sugarcane at a commercial nursery near Apache Junction, east of Phoenix, AZ. Sudangrass and related hybrids are annual warm-season forage grasses grown for green chop, silage, hay, and pastures in AZ (Knowles and Ottman 2015). Forage sudangrasses include common sudangrass (*Sorghum sudanense* Stapf.), sudangrass hybrids, and sorghum-sudangrass hybrids (*Sorghum bicolor* (L.) Moench x *Sorghum sudanense* Stapf.). A probable explanation for the rapid expansion of the range of sugarcane aphid is the wind-aided movement of alates emanating from maturing sorghum fields (Bowling et al. 2016). High populations are found during the summer and decline by winter. In Arizona, we had no economic thresholds for sugarcane aphid. In 2017, we conducted tests on the effect of forage sorghum planting dates and insecticides on sugarcane aphid populations. Most research elsewhere is largely for grain sorghum. In Arizona, 83% of the total acreage devoted to sorghum is forage sorghum. We provide here first-hand information about sugarcane aphid occurrence, the damage it causes to forage sorghum, pest management guidelines, and future needs for more integrated management approaches and strategies in Arizona.

Occurrence and Identification of Sugarcane Aphid on Sorghum in Arizona

In July 2016, the first sugarcane aphid infestation was found on sorghum and sudangrass in Arizona. It was also found on sugarcane at a nursery site near Apache Junction, AZ (Fig. 1). We collected and positively identified infestations of sugarcane aphid from commercial fields in Maricopa, Pinal, La Paz, Yuma and Cochise Counties in Arizona. The aphid has short, dark cornicles (tailpipe-like structures), dark tarsi (feet), and slender antennae that darken near the tip. Winged (alate) sugarcane aphids look similar to wingless ones, but with black markings that run crossways on their back; they also have conspicuous dark veins in their wings and black hardened structures at the base of their wings (Fig. 1). Sugarcane aphids are typically gray during cool periods and light yellow in warm summer conditions.

The sugarcane aphid can be confused with other aphids that are occasionally found on sorghum. One is the corn leaf aphid, *Rhopalosiphum maidis*, which is small with bluish green body color and darker abdomen strips (Fig. 1). The head, legs, cornicles, and antennae are black in color. The corn leaf aphid is usually found deep in the whorl of the middle leaf of preboot stage silage sorghum, but may also be on the underside of leaves, stems, or in panicles. Sorghum plants generally can tolerate many corn leaf aphids without being significantly damaged and control measures are seldom justified. Another similar aphid is the greenbug, *Schizaphis graminum* (Fig. 1). The greenbug is yellow to green in color with a dark green stripe down the middle of its back. The greenbug can be found occasionally on sorghum and other grain crops, and there is no record of it causing significant damage to crop in Arizona.

Sugarcane aphids colonize the underside of mature sorghum leaves on the lower portion of the plant and progressively move upward infesting all leaves and eventually move to the seedheads (Fig. 2). Small colonies quickly grow into larger colonies, which produce large amounts of sticky honeydew on the leaf surfaces. Voracious sugarcane aphid feeding on the plant causes leaves to turn from green to yellow to red, eventually killing tissues locally turning them brown and necrotic (Fig. 2). After a colony is established, it multiplies at a prolific rate. Populations exceeding 1,000 sugarcane aphid per leaf were observed in Tonopah, AZ, and in research plots at the University of Arizona's Maricopa Agricultural Center. Large infestations can kill young sorghum seedlings and can also prevent the formation of grain in maturing sorghum. Additionally, the high amount of honeydew deposited on the foliage supports the growth of black,

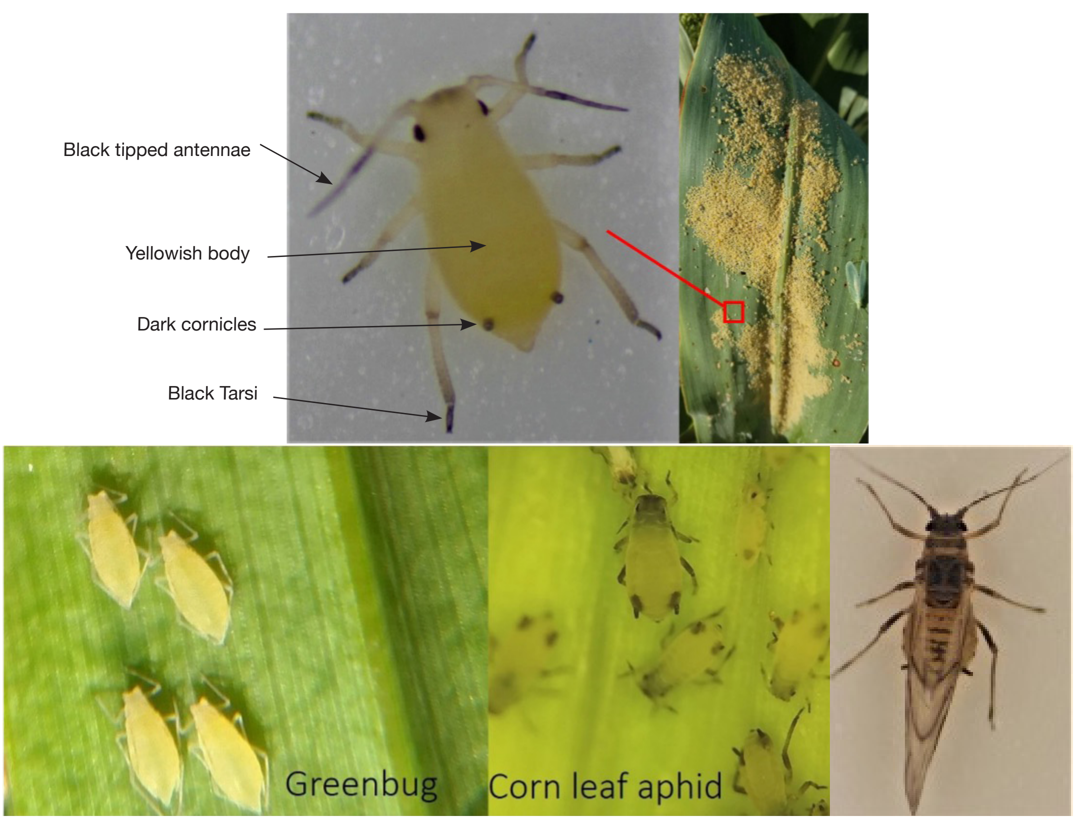

Fig. 1. Morphological characteristics of sugarcane aphid, and other aphids in sorghum including corn leaf aphis and green bug

Fig. 2. Leaf discoloration and damage associated with sugarcane aphid feeding on sudangrass (Top) forage sorghum (Bottom-left) and grain sorghum (Bottom-right) in Arizona in 2016.

sooty mold (which interferes with photosynthesis). Also, it decreases harvesting efficiency by gumming up harvesting equipment. Arizona's warm and dry weather is particularly conducive for populations to rapidly increase on sorghum. A few alates of sugarcane aphid were observed on silage corn plants in adjacent fields in Tonopah, AZ, but they did not appear to be actively feeding – the same can be said for large numbers of dispersing alates found in cotton and other non-host plants. In sorghum producing areas with mild winters, the sugarcane aphid overwinters on remnant and ratoon sorghum. Johnsongrass (*S. halepensis*), a common alternative host weed, is more cold-tolerant than sorghum and can also serve as a winter refuge plant. Alate sugarcane aphid, carried by the wind, can spread locally to nearby fields as well as over long distances to infest sorghum coming into production.

Rapid Population Increase

All sugarcane aphids are females that give live birth and new aphids are born pregnant. They exhibit telescoping generations that allow immature aphids to develop inside their not-yet-born mothers, which have an average lifespan of 28 days in mid-summer. The newborn aphids only take 4 to 12 days to become an adult and can start giving birth to one to three offspring per day. Sugarcane aphid populations can build to damaging levels quickly during the summer under hot and dry conditions. The common occurrence soon after the aphids become established is an incredibly rapid increase in their populations. In one week, 10 to 40 sugarcane aphids per leaf can multiply to hundreds the following week when they become challenging to control. Initial sugarcane aphid populations can be barely noticeable and advance to exceeding the economic threshold in as little as 5 days. In Texas, an infestation of 50 sugarcane aphid per leaf increased to 500 per leaf in two weeks (Bynum 2015). In Arizona, an infestation of 100 sugarcane aphid per leaf increased to more than 1,000 in 1 to 2 weeks.

Damage of Sugarcane Aphid to Sorghum

Literature indicates that sugarcane aphid feeding causes plant damage that is a combination of direct loss of plant nutrients and sugars, which can be exacerbated by plant water stress, and reduction in photosynthetic efficiency from sooty mold growing on the excreted honeydew (Singh et al. 2004, Kerns et al. 2015). The number of sugarcane aphids necessary to cause yield reductions in sorghum varies based on the plant growth stage and duration of infestation and even what type of sorghum is being grown, grain or forage.

Damage to Grain sorghum

Yield loss ranging from 10 to over 50 percent has been reported on susceptible sorghum hybrids in the southern grain sorghum belt. As much as 80 to 100 percent crop loss can happen if sugarcane aphid feeding occurs while plants

Fig. 3. Map of treated (Trt) fields at different application time and untreated area (UTC) near Tonopah (Maricopa County), Arizona in 2016.

are still in the preboot stage, and the field is left untreated in Texas (Bynum 2015). At the boot stage, sugarcane aphids can cause losses as high as 52 to 69 percent. At seedhead emergence, potential yield loss can reach 67 percent. Research also indicates that yield losses in grain sorghum ranged from 100 to 400 pounds per acre (112 to 447 kg/ha) when plants are infested with sugarcane aphids at densities between 50 and 500 per leaf in Texas (Bynum 2015). The economic threshold in Texas, Oklahoma, and Louisiana is 50 to 125 sugarcane aphids per leaf for grain sorghum.

Damage to Forage sorghum

The number of leaves and height of the forage sorghum is greater, and it has more leaf surface area than grain sorghum. Hence, a higher population of sugarcane aphid per plant is tolerated on forage sorghum. Preliminary research determined the population of sugarcane aphid to be thousands per leaf on forage sorghum near Tonopah, AZ. In 2017, findings revealed that sugarcane aphids infested more than 90% of the number of leaves per plant in the untreated plots compared with the less than 10% leaves infested on the insecticides treated plots. Time of planting had significant effects on sugarcane aphids on forage sorghum. In early plantings in March 2017, there were no sugarcane aphids on the sorghum when it reached maturity in July. In the May 2017 planting, sugarcane aphid populations built up to more than 700 per leaf by early August.

Research in Arizona

2016 On-Farm Trial

We conducted an on-farm exploratory experiment to attempt chemical control of an outbreak of sugarcane aphid on sorghum near Tonopah, AZ. We planted two sorghum fields each about 80 acres in size on June 6 and June 28, 2016. We collected leaf samples throughout August and September to monitor sugarcane aphid populations. Weekly in September, we collected leaves from five randomly selected plants targeting the lower half of the plant. We cut each leaf into 6 to 7-inch segments with scissors, placing each sample into a labeled plastic bag (Uline™) and transported them to the lab in a cooler with ice. Leaf samples were then processed using a leaf brushing machine (Bioquip™) to remove sugarcane aphid from leaves onto a prepared circular clear glass plate for viewing and counting under a microscope.

Commercial aircraft aerially treated these fields with flupyradifurone at 0.56 kg a.i./ha (Sivanto® 200SL at 8 oz product/A) on September 3, 9, and 19, 2016). The aerial passes skipped an untreated area on the edge of each of the fields. Early application of Sivanto 200SL dramatically decreased the sugarcane aphid population and resulted in better plant performance. Sugarcane aphid populations increased almost 8X over the course of the growing season in the untreated plot (Fig. 4). Re-infestation of populations occurred 3 weeks after treatment, suggesting the needs

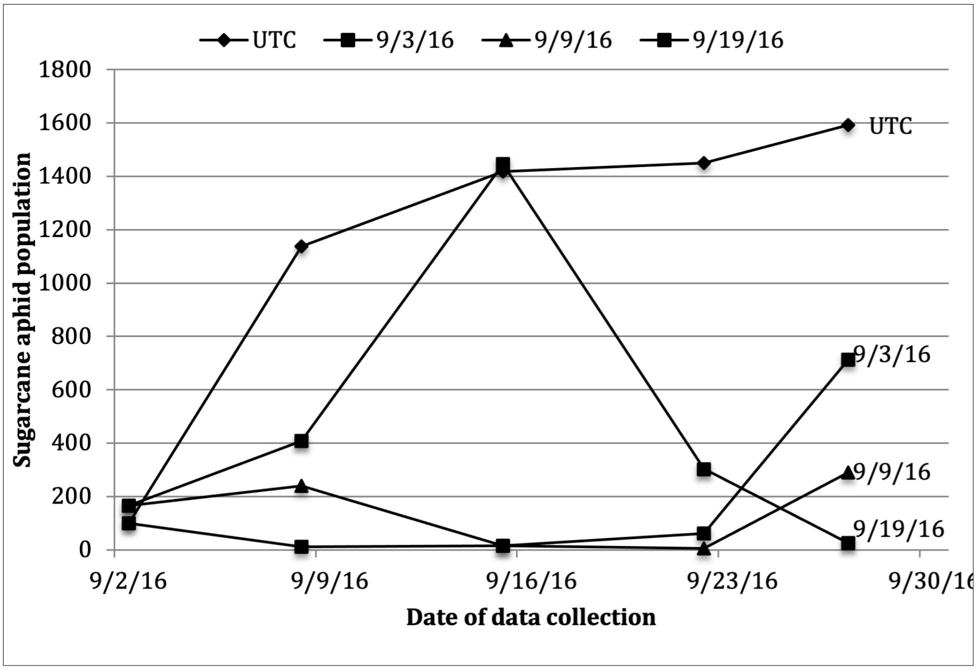

Fig. 4. Efficacy of flupyradifurone at 0.56 kg a.i./ha (Sivanto® 200SL at 8 oz product/A) on sugarcane aphid per leaf in an on-farm trial at Tonopah, AZ. Insecticide applied on September 3, 9, and 19, 2016).

for a second application. Allowing the sorghum to remain untreated for 1 or 2 weeks resulted in significant damage to the sorghum's leaves, stalks and grain filling. This damage eventually led to yield reduction, or even total yield loss. We recorded 48% fresh weight per plant advantage when the plants were treated early and a 23% advantage when sprayed a week later compared with non-sprayed plots. The weight loss was most likely related to aphid-induced leaf desiccation and feeding throughout the entire plant due. Weight loss translates almost directly to yield loss since this is a crop harvested for its forage.

Our findings agree with those in Texas (Bowling et al. 2016) that showed the time of infestation and early treatment was crucial for sugarcane aphid control (Bynum 2015). Their research revealed that when infestations initiated in the whorl stage and no treatment was applied to protect the sorghum, as much as 80 to 100 percent yield loss in the grain sorghum occurred. In Arizona, delaying treatment for one week allowed for the sugarcane aphid infestation to reach the leaves at the top of the plants. Two weeks later, the lower leaves were completely desiccated due to sugarcane aphid pressure.

A robust community of biological control insects, lady beetles and lacewings were noticed approximately 2 weeks after Sivanto® 200SL was applied. These beneficial predators may be effective in preventing sugarcane aphid resurgences. Unfortunately, the sugarcane aphid populations increased so quickly that the beneficial insects could not prevent damage and yield losses. This experiment demonstrated reduced and lower sugarcane aphid populations due to insecticide applications compared with untreated sorghum.

2017 Research Trial

We conducted a field trial from March to September 2017 to evaluate the effect of time of planting and insecticide treatments for sugarcane aphid management in forage sorghum under growing conditions of the low desert at the UArizona Maricopa Agricultural Center. The objectives of the study were (1) to determine the effect of time of planting on sugarcane aphid populations and (2) to evaluate the efficacy of various insecticides against sugarcane aphid. We planted sorghum in a single row on 40-inch beds and treatment plots measured four rows (13.3 ft) by 30 ft arranged in a randomized complete block design with four replications. Treatments were six insecticides (Table 1) and an untreated check. The insecticide treatments were applied on August 11, 2017 with a modified John Deere 6500 Hi-Cycle with a 4-row broadcast boom with 2 nozzles per row and operating with a compressed air system at 30 psi delivering 20 gpa water through TeeJet twinjet flat fan 8003 nozzles. We collected five leaves per plot from the middle height of randomly selected plants from the central two rows on a weekly basis. We also counted the number of dead and alive leaves on those plants, as well as the number of visibly sugarcane aphid infested leaves per plant. We used this information to calculate percent

Table 1. List of insecticide used against sugarcane aphid in forage sorghum, 2017

Trade Name	Formulation	Active Ingredient	Formulation	Manufacturer	Application product Rate
Transform 50	WG	Sulfoxaflor	50%	Corteva AgriScience	1 oz/A
Lorsban 4E	EC	Chlorpyriphos	44.9%	Corteva AgriScience	32 oz/A
Dimethoate 4E	EC	Dimethoate	43.5%	Cheminova	16 oz/A
Beleaf 50	SG	Flonicamid	50%	FMC Corporation	2.85 oz/A
Sivanto 200	SL	Flupyradifurone	17.09%	Bayer Crop Science	7 oz/A
Magister	SC	Fenazaquin	18.79%	Gowan Company	36 oz/A

*EC, emulsifiable concentrate. SG, soluble granule. SC, suspension concentrate.

infested leaves per plant. We followed the same leaf brushing and counting procedures as in the 2016 on-farm trial. We harvested the two middle rows of each plot by green chopping plants with a Hesston 7155 chopper on September18, 2017. We calculated yields as tons of fresh weight per acre. Statistical analyses were conducted using JMP 13 software. Means comparisons were made for each pair using Student's t-test at LSD < 0.05.

The pre-treatment data on 8/11 showed that there were about 700 sugarcane aphid per leaf. Following the insecticide treatments, the populations of sugarcane aphid were reduced (Fig. 5). Some of the chemistries such as flupyradifurone (Sivanto® 200SL) and sulfoxaflor (Transform® WG) provided rapid control of sugarcane aphid. One week after application of insecticides, Sivanto 200SL and Transform® WG reduced the population of sugarcane aphid to under 118 and 164 per leaf, respectively. In the second week, Sivanto® 200SL further controlled the sugarcane aphid populations While Transform® WG and chlorpyrifos (Lorsban® 4E) treated plots has higher numbers of aphids. Three weeks after treatment, only Sivanto® 200SL maintained sugarcane aphid populations. It appeared Sivanto® 200SL consistently and effectively managed the population of sugarcane aphid for 5 weeks until harvest. Transform® WG acted quickly on sugarcane aphid for 2 weeks after which re-infestation of sugarcane

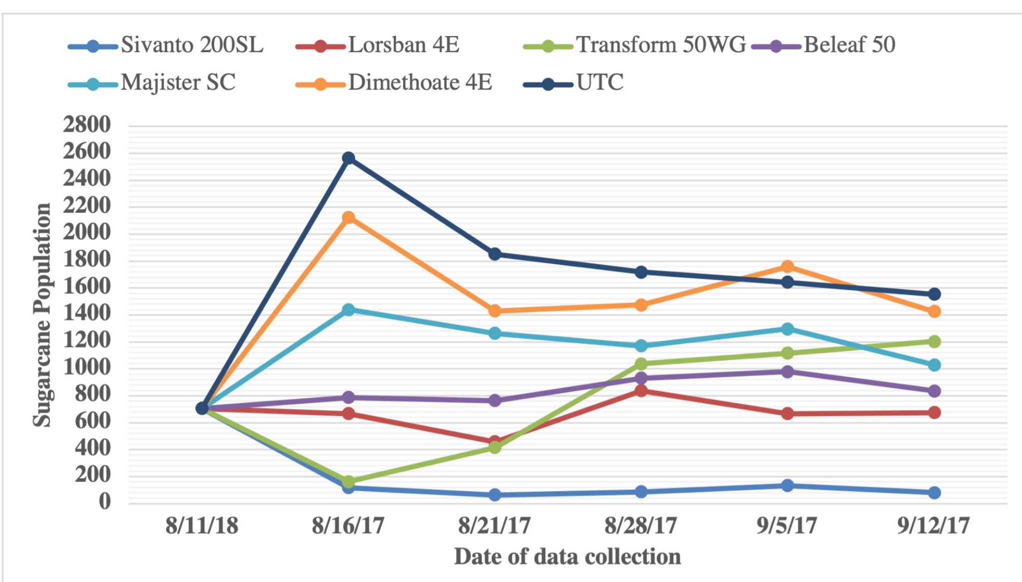

Fig. 5. Efficacy of various insecticides against sugarcane aphid populations per leaf at Maricopa Agricultural Center trial in 2017. Insecticides applied on 8/11/2017.

aphid occurred. This suggested the need for a second application. Lorsban® 4E was also moderately effective for a shorter 2-week window. Sorghum yield was significantly affected by sugarcane aphid infestation (Fig. 6). All insecticide treated plots resulted in higher sorghum yields than the untreated check. Plots treated with Sivanto® 200SL had sorghum with the highest yield because the plots treated with it had the lowest numbers of sugarcane aphid throughout the experimental period. About 30% sorghum yield increase was recorded in Sivanto® 200SL treated plots compared with untreated plots. Lorsban® 4E and Transform® WG treated plots gave a 16% and 15% sorghum yield advantage over the untreated check (Fig. 7). This was the first field study in Arizona that exhibited the impact of insecticides on sugarcane aphid control and improved sorghum yields with sugarcane aphid control.

Managing sugarcane aphid in Sorghum.

To reduce economic losses caused by sugarcane aphid, research-based guidance includes proper identification of sugarcane aphid as a new pest, scouting to observe population densities, and insecticide treatment options. These options will be using of a suite of efficacious insecticides, the preservation and use of natural enemy predators and parasitoids of the sugarcane aphid, and planting sorghum cultivars with sugarcane aphid resistance. A treatment threshold level for sugarcane aphid in forage sorghum in Arizona has not been adequately determined. Treatment threshold levels for sugarcane aphid in grain sorghum have been developed for Texas, Mississippi, Louisiana, and Oklahoma. Until further

Fig. 6. Performance of forage sorghum with and without insecticides treatment to control sugarcane aphid. The performance of sorghum on treated plots exhibited uniform heading and healthier looking appearance (left) as compared with sporadic heading and infested dry leaves with honeydew on untreated plots (right) in the 2017 research conducted in Arizona.

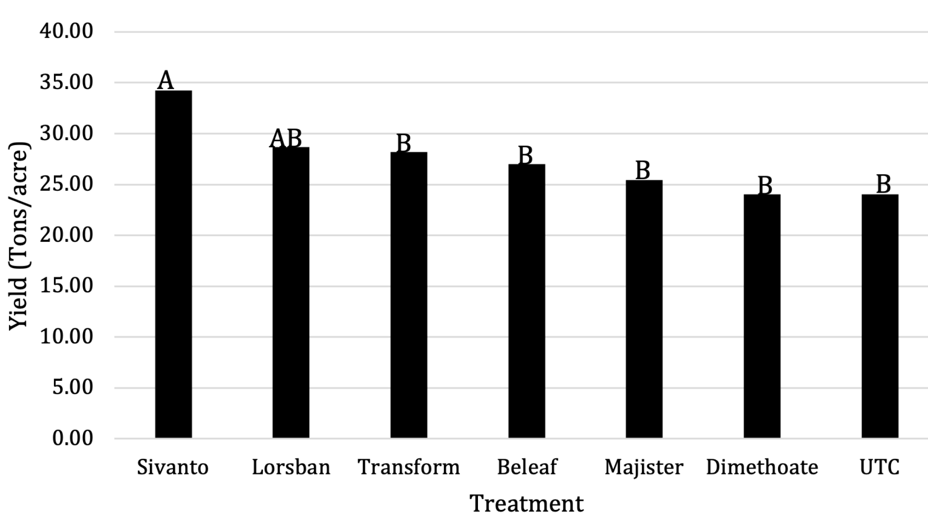

Fig. 7. Effect of various insecticide treatment on forage sorghum yield of the sugarcane aphid efficacy trial at Maricopa Ag Center in 2017. Bars with the same letter are not significantly different at alpha 0.05. using LSD

research is conducted in Arizona, we may refer to the information from other states to assist with local decision-making and management practices.

Detection, Scouting and Control

1. Plant early to avoid infestations. Our trials showed that planting in late April instead of late May can mitigate sugarcane aphid population and scape its damage to forage sorghum crop in Arizona.
2. Early harvest may be the best alternative if good insecticide coverage cannot be achieved for optimal sugarcane aphid control.
3. Detection sampling to determine if sugarcane aphids are present:
   - Soon after crop emergence, on a weekly basis, populations were assessed (Knutson et al, 2016) and (United Sorghum Checkoff Program, 2022). Walk at least 25 feet into the field and examine plants along 50 feet of row in four locations;
   - If honeydew is observed, look for sugarcane aphids on the underside of leaves;
   - Inspect the underside of leaves from the upper and lower canopy from 20 to 25 plants per location;
   - If johnsongrass exists nearby, sample all sides of the field as well as the 4 locations in the field;
   - Check at least 4 locations per field for a total of 80 to 100 plants,
   - If no sugarcane aphids are present, continue once-a-week scouting (Knutson et al, 2016) and (United Sorghum Checkoff Program, 2022).
4. If sugarcane aphids are detected, then begin the second sampling protocol to determine if the infestation has reached 50-125 sugarcane aphids per leaf for grain sorghum or more for forage sorghum. The action threshold of greater than 50-150 sugarcane aphids per leaf will trigger the need for an insecticide treatment.
   - If sugarcane aphids are detected, scout the field twice a week;
   - Examine the underside of one fully developed green leaf from the lower canopy and the uppermost developing leaf;
   - Count the number of infested leaves per plant to determine percentage of plants infested;
   - Estimate and record the number of sugarcane aphid per leaf;
   - Examine two leaves from each of the five randomly selected plants for a total of 10 leaves per location;
   - Repeat at five locations for a total of 50 leaves per field;
   - Calculate the average number of sugarcane aphid per leaf for the field (total sugarcane aphid counted/ total number of leaves inspected);
   - An action threshold of greater than 50-150 sugarcane aphid per leaf will trigger the need for an insecticide treatment;
   - Because counting exact numbers of sugarcane aphid per leaf is impractical, an sugarcane aphid scouting estimation tool is expected to be developed through further research.
5. Selection of an insecticide treatment:
   - There are several insecticide options to control sugarcane aphid. Transform® WG was approved for use on grain and forage sorghum in 2016 and 2017 under an emergency exemption, Section 18 registration. (Peterson et al, 2016). The Section 18 registration had restrictions to prevent bee exposure and prohibited the application of Transform® WG from three days before bloom until seed set.
   - Sivanto® 200SL was newly labeled for use in sorghum and has proven effective against sugarcane aphid. It is systemic and has a 7-day pre-harvest interval.
   - Contact a local Cooperative Extension expert or pest control advisor (PCA) for detailed information about insecticide selection and application timing.
   - Controlling sugarcane aphid with insecticides requires good coverage of the entire sorghum canopy including the lower leaves.
6. Natural enemies of sugarcane aphid such as lady beetles, syrphid fly larvae, and green and brown lacewings feed on sugarcane aphid to help suppress the rapid increase of sugarcane aphid infestations. Several species of parasitic wasps also attack sugarcane aphid. These tiny wasps deposit their egg into the sugarcane aphid and the egg hatches into a larva that feeds on and soon kills the host aphid. Once the larva has completed development to the adult stage, the adult wasp emerges from the dead aphid. Aphids killed by parasites are called mummies. Parasitism by the Aphelinus wasp results in black or blue-black mummies. While these parasitic wasps are tiny and difficult to see in the field, the presence of aphid mummies is evidence of their impact. Selecting insecticides specific to aphids or insects with piercing/sucking mouthparts can help conserve these natural enemies.

Acknowledgements

We thank Gadelhak Ahmed for his technical assistance. We thank Greg Green in Tonopah, AZ for providing the experimental sites and help in 2016. Labor, technical assistance in the 2017 trial From members of Arizona Pest Management Center are much appreciated. This project was partially funded by multiple agrochemical companies.

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