INFLUENCE OF PLANT ARCHITECTURE OF OKRA-LEAF COTTON ON CROP MICROCLIMATE, SOLAR RADIATION AND *HELICOVERPA ZEA* (BODDIE) EGG HATCH

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Introduction

With resistance to Bt cotton developing in lepidopterous pests it's important to find alternative methods of control. In Semi-arid cotton growing areas low relative humidity and high temperatures can have an impact on hatch rates helping to control insect pests but late season the microclimate of the cotton canopy is more conducive to higher hatch rates and potential yield losses (Pierce and Monk 2010 and Hake et al 1991). Use of okra-leaf cotton may help reduce hatch rates by allowing greater air and light penetration into the canopy producing a microclimate less conducive to high egg hatch. (Andres et al 2016, Jones et al 1976, and Mahan et al 2016).

Figure 1. Left: from left to right: standard, sub-okra /sea-island, okra, and super okra (Andres et al, 2016). Right: Fabric with sentinel *H. zea* eggs used in field trials.

Materials and Methods

Two cotton varieties were planted on in 2020 and 2021, the palmately lobed okra leaf cotton (UA107, University of Arkansas) and standard broad leaf cotton (Bollgard® 3- DP1845B3XF, Monsanto Corporation). In 2020, experimental plots consisted of 6 rows, 15.2 meters in length with okra leaf treatment replicated 5 times and the standard leaf replicated 4 times (n=9) on a randomized block design. In 2021, experimental plots consisted of 8 rows, 15.2 meters in length replicated 4 times for each variety in a randomized block design.

Sentinel *H. zea* eggs laid on fabric were stapled to leaves at mid-canopy and left in plots for 48 hours to access predation and impacts on *H. zea* egg hatch. Eggs were retrieved, brought into the laboratory where eggs were examined for signs of predation and categorized based on the remains. Hollow eggs with holes on each side are typical of green lacewing or immature ladybug predation. Collapsed tent-like eggs are typical of predation by sucking insects such as nabids. Eggs that have been chewed with little remains are typical of predators with chewing mouthparts such as adult ladybugs, spiders or collops beetles. Intact eggs were then monitored for hatching every 24 hours to determine total hatch rates.

Figure 2. Left: Fabric with sentinel *H. zea* eggs placed on a cotton leaf. Right: Hobo temperature and relative humidity datalogger in canopy near fabric with sentinel *H zea* eggs.

Results

H. zea Hatch in Okra-leaf vs. Standard Leaf Cotton

Mean egg hatch was reduced over 50% in okra leaf cotton compared to standard leaf cotton on two of four dates July 13 and August 17, 2020.There was only 19% and 27% hatch in okra leaf plots compared to 51% and 52% hatch in standard leaf plots on July 13 and Aug 17 respectively. (Figure3). Egg hatch was less impacted in 2021 with significantly lower egg hatch in okra-leaf cotton on one of three dates in 2021 with 25% lower egg hatch, 45% hatch in okra-leaf plots vs 60% in standard cotton on July 25. There were no differences in hatch rates on July 6 and August 10, 2021.

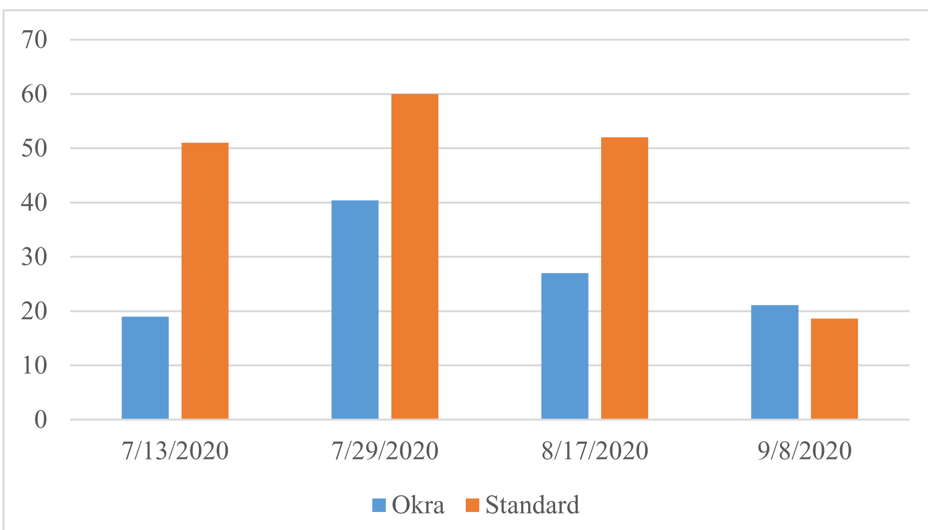

Figure 3: Percent Egg Hatch at 96 hours after 48 Hours in Okra-leaf vs. Standard Cotton Plots.

Mean egg hatch in okra leaf cotton across all trials was 20% vs 36% in the standard leaf 72 hours after the eggs were introduced to the field. The difference was more evident after 96 hours with the egg hatch almost twice as high in standard leaf cotton vs. Okra-leaf cotton.

Temperature and Relative Humidity in the Cotton Canopy

Relative humidity was similar in okra-leaf and standard plots. Surprisingly, temperature was significantly higher by 3-4^{o}C in standard leaf plots on 2 of 6 dates; July 20th and July 29th with higher temperatures observed in standard leaf cotton vs okra-leaf cotton (Table1).

Table 1. Average Daily High Temperatures and Relative Humidity in Six Microclimate Trials with Okra-Leaf and Standard Leaf Cotton

	Temperature ^{o}C			Relative Humidity (%)		
	Okra-Leaf	Standard Leaf	Difference	Okra-Leaf	Standard Leaf	Difference
7/13/2020[1,2]	40	41	1	82	79	-3
7/20/2020[2]	36	39	3	85	83	-2
7/29/2020[1,2]	43	47	4	98	100	2
8/2/2020[2]	42	45	3	94	97	3
8/12/2020[2]	41	43	2	90	88	-2
8/17/2020[1,2]	38	37	-1	100	100	0
Average	40	42	2.5	91	91	-0.3

Temperature and relative humidity statistically significant between varieties pd 0.05.

Egg Tests at Artesia 2020: *H. zea* Predation

Egg predation was similar in okra-leaf and standard leaf cotton with a mean 41% predation of eggs across seven field to lab bioassays (Table 2). The highest number of egg remains showed evidence of predation by predators with chewing mouthparts, such as adult ladybugs with 22-23% mean predation season long. There was 12% predation by predators such as ladybug and green lacewing larvae evidenced by hollow eggs with two holes on alternate sides. The lowest predation was by insects with piercing/sucking mouthparts such as nabids which produce collapsed tent shaped egg remains.

Table 2. Predation of *H.* zea Eggs After 48 Hours in Field Plots From 7 Field to Lab Assays

	2020		2021	
	Okra-Leaf (%)	Standard Leaf (%)	Okra-Leaf (%)	Standard Leaf (%)
Sucked out	7.2	5.7*	13.2	17.2
Chewed	21.7	22.9	23.6	20.4
Hollow Eggs	11.7	11.6	0.01	0
Total Predation	41.3	41.2	36.8	37.2

*Egg predation statistically significant $P<=0.05$.

Egg predation was similar in okra-leaf and standard leaf cotton in 2020 and 2021 with a mean 41% and 37% predation of eggs across okra-leaf and standard leaf cotton plots in ten field to lab bioassays (Table 2). There were also no significant differences in any species of predators collected in sweep samples in okra-leaf vs standard leaf plots. The most significant predation was by predators with chewing mouthparts such as ladybug adults with 20-24% predation of all eggs in both years and both leaf types. Predators with chewing mouthparts were the most abundant in sweep samples collected with for example spiders and ladybugs representing 39% and 23% of predators collected in 2020. There were significantly more eggs with sucking damage okra-leaf plots in 2020 but not in 2021. Interestingly, there were virtually no hollow eggs in 2021 despite hollow eggs representing 12% of all eggs in okra-leaf and standard leaf plots in 2020. Overall, it is promising that there was no reduction in predation in okra-leaf cotton plots.

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In 2020-2021 there were lower hatch rates in okra-leaf cotton on some dates despite okra-leaf not having higher temperature or lower relative humidity. An alternative reason for lower hatch rates in okra cotton could be direct radiation on the eggs producing higher egg temperatures that are not reflected in the canopy temperature. To determine if difference in radiation would produce different hatch rates a field trial was conducted in 2021 with shade cloths that reduce light penetration by 30, 60 and 90%.

The degree of shading had a dramatic impact on hatch rates with only 25% hatch in control and 30% shade vs 41 and 56% hatch in 60 and 90% shade treatments respectively (Figure 4).

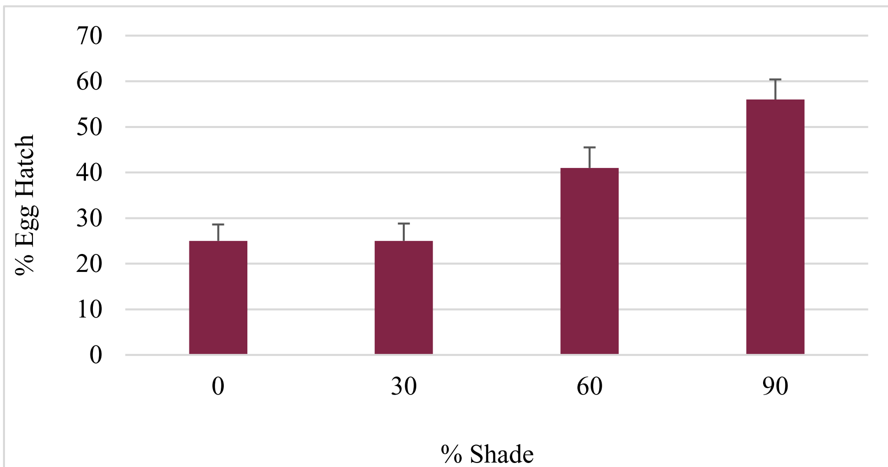

Figure 4: Percent egg hatch of *H. zea* under different shade treatments.

Figure 5. Left: NMSU Assoc. Dean of ACES with a graduate student discussing microclimate trial. Right: Shade cloth treatments in our cotton trials.

Conclusions

With developing resistance to Bt cottons and resistance to some insecticides, it is important to develop alternative controls for lepidopterous pests. Cotton varieties with okra-leaf cotton can be useful in helping to suppress populations by reducing egg hatch in arid or semi-arid environments. The impact is not as dramatic or consistent against insects in canopy as opposed to insects like boll weevil in infested squares on the soil surface. (Pierce et al. 2001). However, in two of seven trials eggs hatch was reduced over 50% after only 48 hours exposure. Eggs generally hatch in 96 hours so greater exposure to desiccating conditions would have a higher impact than demonstrated here. Okra-leaf cotton should be considered for use in breeding programs targeted at areas with semi-arid to arid climates as part of cotton IPM programs.

Acknowledgements

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