Motivating Factors of Aphid Behavior

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Abstract

Aphids are small, soft-bodied insects with long slender mouthparts used to pierce leaves and extract fluids; to check for aphid infestation, one must check the underside of the leaf as this is the preferential side for many aphid species [1].
Sugarcane Aphids, *Melanaphis sacchari*, cause serious damage to sorghum growth, development and productivity in many countries [2].
We hoped to find with this experiment what factors can best explain why Sugarcane Aphids colonize on the underside of sorghum.
We found that the only two treatments that were statistically significant (mesh top/cardboard bottom, and mesh top/mesh bottom flipped) meaning that with further research we may be able to prove light is the most motivating factor of aphid colonization behavior.

Purpose

The purpose of this experiment was to determine if orientation of the leaf (normal or "flipped") or orientation of light source (above or below) best signals sugarcane aphids to move to the underside of leaves.

Questions, Hypotheses, and Predictions

Question: What factors signal aphids to move to the underside of leaves?
Hypothesis: We believe that under any orientation of a leaf, aphids will move away from the side where the light is being shone, to the light absent side. When there is equal light distribution, (either mesh on both sides, or cardboard on both sides of the cage), we believe that the aphids will be equally distributed on both sides of the leaf.
Prediction:
P1 – If gravity is the factor that most motivates aphid behavior, then despite orientation of the leaf and/or of the light source, aphids will prefer the bottom of the leaf.
P2 – If light source is the factor that most motivates aphid behavior, then despite orientation of the leaf and location of the light source (relative to above or below the cage) aphids will prefer the side that is in absence of light.
P3 – If the physiology of the leaf is the factor that most motivates aphid behavior, then no matter the presence or absence of light, aphids will prefer the true bottom of the leaf when "flipped."

Study System

Aphids are soft-bodied insects that use their piercing sucking mouthparts to feed on plant sap. They usually occur in colonies on the undersides of tender terminal growth. Heavily-infested leaves can wilt or turn yellow because of excessive sap removal. [3]
Sorghum is primarily used for livestock feed and ethanol production, and has recently become popular in human consumption. In the U.S. sorghum is traditionally grown throughout the Sorghum Belt, which runs from South Dakota to Southern Texas, primarily on dryland acres with Kansas being the top producer in 2015. [4.]

Figure 1. Colonization of sugarcane aphids, *Melanaphis sacchari*, on the underside of sorghum leaf [5]

Figure 2. Sorghum in the field [6]

Methods and Experimental Design

24 single sorghum plants were lined on a platform directly under a florescent light. (Fig. 4) The plants were randomly chosen to be in one of 6 groups, each group receiving a different treatment:

Mesh top/Cardboard bottom, Normal orientation of leaf (MC-N)
Cardboard top/Mesh bottom, Normal orientation of leaf (CM-N)
Mesh top/Mesh bottom, Normal orientation of leaf (MM-N)
Cardboard top/Cardboard bottom, Normal orientation of leaf (CC-N)
Mesh top/Mesh bottom, Leaf flipped (MM-F)
Cardboard top/Cardboard bottom, Leaf flipped (CC-F)

5 aphids were placed inside each cage on the topside of the leaf.
The leaf was sandwiched between two 3M foam "cages" and were enclosed with mesh or cardboard based on the treatment. (Fig. 3)
After 24 hours, the cages were opened and the position of the aphids was recorded.

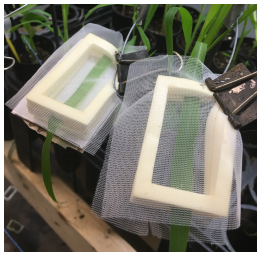
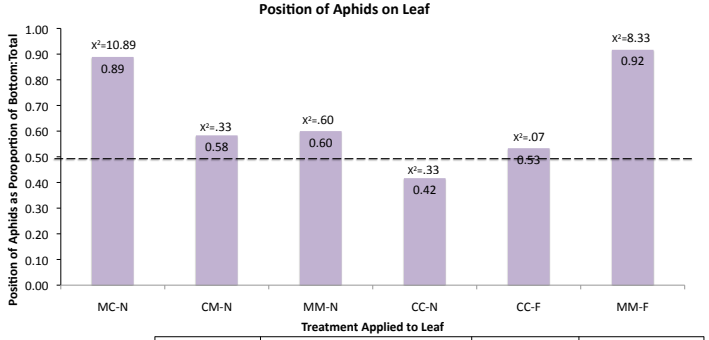


Figure 3. Example of MC-N (left) and MM-N (right)

Figure 4. Sorghum with cages in place on platform

Results

As not all 5 aphids were recovered on each plant, results the graph are shown as proportion of aphids on the bottom divided by the sum of aphids after 24 hours in each treatment. The dashed line at 0.5 shows expected (equal) distribution.
The only two treatments whose results were statistically significant were MC-N and MM-F, where $X^2>3.84$ when df=1 and alpha =.05.



	Rep 1		Rep 2		Rep 3		Rep 4			
Orientation	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	TOTAL TOP	TOTAL BOTTOM
Mesh Top/Cardboard bottom	0	5	1	4	0	5	1	2	2	16
Cardboard Top/Mesh Bottom	1	2	0	0	3	2	1	3	5	7
Mesh Top/Mesh Bottom Normal	3	1	1	3	0	5	2	0	6	9
Cardboard Top, Cardboard Bottom Normal	1	2	3	2	0	0	3	1	7	5
Cardboard Top/Cardboard Bottom Flipped	3	0	1	3	2	3	1	2	7	8
Mesh Top/Mesh Bottom Flipped	1	1	0	0	0	5	0	5	1	11

Conclusions

The data show that the only treatments with distributions significantly different than expected are the MC-N and the MM-F. The lack of significant correlation in other treatments makes it difficult to compare the factors affecting aphid behavior, but the data from when light came from the top but was excluded from the bottom (MC-N) and when light came from the top and bottom but the orientation of the leaf was flipped (MM-F) are suggestive that further experiments with more repetitions and better control of variables, such as light, light will be the most significant factor in affecting aphid behavior.
In treatments absent of light (CC-N and CC-F) results match the expected outcome. Two treatments receiving light from the bottom (CM-N and MM-F) did not produce the distributions expected if light was the primary motivating factor. However, this could possibly be due to the light on the light on the bottom not being high enough intensity to elicit a response.

Future Directions

If orientation of light source is the most motivating factor, then the distribution of MM-F and MM-N are inconsistent with each other. To better understand if these unexpected results are contributed to unequal intensities of light sources, future experiments should include a light of equal intensity on each side of the platform.
Reusable clip-on cages would be of great benefit to improve efficiency and accuracy in order to run more repetitions and ensure that aphids are not shaken from leaves when the cages are removed.
More repetitions are also needed to determine whether variances are random or due to the manipulated factors.
While this experiment sheds light on the motivating factor in why sugarcane aphids tend to move to the underside of leaves, the benefit this serves to aphids is still up to speculation.
With the assumption that light is the motivating factor of aphid behavior, we can conduct future experiments to see if this holds true under varying light intensities; with different species of aphids, such as corn leaf aphids; with crops other than sorghum; or in the presence of natural enemies.

References

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