THE IMPACT OF DEFOLIATION ON SELECT GROWTH STAGES IN RICE

L. D. McCullars
University of Arkansas
Fayetteville, AR
G. M. Lorenz
University of Arkansas
Lonoke, AR
Jarrod Hardke
Nick Bateman
University of Arkansas
Stuttgart, AR
Andrew Plummer
Nicki Taillon
Kevin McPherson
Joe Black
University of Arkansas
Lonoke, AR
Tara Clayton
University of Arkansas
Stuttgart, AR
Aaron Cato
University of Arkansas
Fayetteville, AR

Abstract

Fall armyworm, *Spodoptera frugiperda*,, (FAW) has recently become a major pest in rice grown in the MidSouth. While insecticide applications are commonly made, there are no extension recommendations on when control is needed. The first objective of this study was to evaluate the impact of damage caused by the FAW at three different growth stages of rice using both live infestations with cage studies and simulated defoliation. The second objective of this study was to determine the ability of FAW to damage rice through feeding on developing heads, as well as their affinity for head feeding compared to foliage feeding. Larvae were infested at 6 and 12 per ft^2 in caged plots at the 2-3 leaf, 2^{nd}-3^{rd} tiller, and heading growth stage. Additionally, manual defoliation of rice was utilized to simulate feeding of FAW by defoliating 25, 50, and 100% of plants or leaves alone at the same growth stages. Yield was impacted at the 2^{nd}-3^{rd} tiller when infested with live larvae, and when the plant was manually defoliated 100% at the 2-3 leaf stage. A choice assay determined that the FAW preferred feeding on the foliage of the plant, but head feeding occurred when it had no other choice. These and future studies will be used to provide producers in the MidSouth with a basis to make economically sound decisions for FAW in rice.

Introduction

In Arkansas, rice is produced in 40 of the 75 counties (Lorenz and Hardke 2017). Across this area insect pest complexes differ for rice, but generally the most serious pests are grape colaspis, *Colaspis brunnea* (F), rice water weevil, *Lissorhoptrus oryzophilus* (Kuschel), and rice stink bug, *Oebalus pugnax* (F). A large amount of research has created proper management strategies including economic thresholds for these pests. However, over the past few years the fall armyworm, *Spodoptera frugiperda*, (J.E. Smith), (FAW) has become more common in rice, and can be found in rice at high levels throughout the entire growing season. Although much is known about FAW in other crops including corn, grain sorghum, and soybeans, little research has been done to determine the level of damage that defoliation from this pest can cause in rice. Arkansas' current recommendation for FAW in rice is to treat at 6 larvae per square foot, and treatment is recommended when the FAW is seen feeding on the flag leaf, panicle, or stem (University of Arkansas System Division of Agriculture, 2017). Even though a recommendation is available, it is based off of observations of its potential to damage other crops similar to rice, when economic damage is actually occurring is still relatively unknown. Although the impact of feeding is unknown, a large number of insecticide applications are commonly made early in the season when defoliation is high and large numbers of larvae are present in the field, and late in the season when FAW is seen feeding on the flag leaf. Therefore, it is important to understand what level of defoliation leads to economic losses in rice. Also, it is important to understand to what extent damage is caused by feeding on the panicle. The first objective of this study was to evaluate the impact of defoliation caused by the FAW at three different growth stages of rice using both live infestations with cage studies and simulated defoliation. The second objective of this study was to determine the ability of fall armyworm to damage rice through feeding on developing heads, as well as their affinity for head feeding compared to foliage feeding.

Materials and Methods

Fall Armyworm Damage

To assess the impact of defoliation by the FAW, two separate methodologies were used: (1) cage studies with live infestations; and (2) manual defoliation to simulate FAW damage. For the cage study, 2 factors were used: infestation timing and infestation level. Infestation timings were: plots infested at 2-3 leaf, 2nd and 3rd tiller, and heading growth stages, and infestation levels were 0, 6, and 12 larvae per square foot. Four replications were completed for all levels of infestation timing by infestation level, with a full factorial of 48 plots being evaluated using a randomized complete block design. Plots of 3 foot by 3 foot were used for the cage study, with a 6 foot by 6 foot cage being placed over all plots prior to the 2-3 leaf stage. Once the growth stage was reached for each plot, FAW larvae were infested and then monitored until no living larvae could be found. For the 2-3 leaf and 2nd-3rd tiller growth stage, larvae were placed in cups and placed in the middle of the plot and allowed to disperse on their own. Metal sheet flashing lined with petroleum jelly was secured around the outside of the plot, prior to infestation, to ensure the larvae stayed in the plot. For the heading growth stage, larvae were placed individually on the foliage scattered throughout the plot, as plots were flooded and larvae could not be placed on the ground. Data was analyzed using an ANOVA using PROC GLIMMIX (SAS version 9.4) and LSD post hoc analysis at $\alpha=0.05$. The response variable of the yield harvested from each plot was used to compare treatments.

Manual defoliation was also conducted utilizing 2 main factors: defoliation timing and percentage of plant defoliated. Defoliation timings included the 2-3 leaf, 2nd-3rd tiller, and heading stage. Defoliation levels were 0%, 25%, 50%, and 100%, where each plant from the plot was manually defoliated using shears. Four replications were completed for all levels of defoliation timing by defoliation level, with a full factorial of 48 plots being evaluated using a randomized complete block design. Plots of 3 foot by 3 foot were used for this study, but no cages were placed over the plots. The method of defoliation differed depending upon the defoliation timing. At the 2-3 leaf and tiller the entire plant was measured and the defoliation percentage was applied to that plant height, with 50% defoliation meaning that the entire plant was cut in half. At the heading stage, only the flag leaf was defoliated. Defoliation of the rice plant was simulated using shears, and agronomic practices before and after defoliation were the same for each plot. Data was analyzed using ANOVA in PROC GLIMMIX (SAS version 9.4) and LSD post hoc analysis at $\alpha=0.05$. The response variable of the yield (percent of the untreated) was used to compare treatments.

Fall Armyworm Feeding Choice Assay

Sleeve cages were used to both determine the ability of FAW to feed on and damage the developing heads of rice, as well as to determine preference of larvae. Sleeve cages were placed around the flag leaf alone, the head alone, and both the flag leaf and the head together. Cages were placed on the rice plant just after plants reached flowering, and each sleeve cage was infested with one FAW. Each larva was allowed to feed for 7 days and mortality was checked every 24 hours, where larvae were supplemented if mortality was discovered. For the cages that contained both a flag leaf and panicle, the location of the larvae was recorded every 24 hours to determine preference. A total of 15 replications were performed for each of the preference levels that were infested and 5 replications were performed for each uninfested preference level. Cages were then left on the plants until harvest. After being harvested the flag leaf was evaluated and rated for defoliation. The rice head was also evaluated and the number of blank seed in each head were used as a metric to determine the level at which the larvae were able to successfully feed on and damage the rice head. The location of the larvae when cages were checked and the amount of defoliation on each flag leaf were used to determine the feeding preference of the FAW. Data were analyzed using ANOVA in PROC GLIMMIX (SAS version 9.4) and LSD post hoc analysis at $\alpha=0.05$.

Results and Discussion

In the cage trial the 2-3 leaf infestation timing had significantly less yield than the untreated check, at both 6 and 12 larvae per ft^2 (Table 1). No significant difference was observed at the other growth stages when compared to the untreated. In the manual defoliation trial, when plots were defoliated 100% at the 2nd-3rd tiller stage, yield was reduced to 73.94% of the untreated check (Table 2).

Table 1. Comparison of Yield of Caged Plots with Infestations of FAW Larvae at Three Different Growth Stages of Rice

Growth Stage	FAW Density/ft^2	Yield*(±SEM†) (% of Untreated)	P-Value
2-3 Leaf	0	100.0 (0.0) a	0.03
	6	91.7 (1.8) b	
	12	89.6 (3.7) b	
2nd-3rd Tiller	0	100.0 (0.0) a	0.81
	6	124.4 (72.1) a	
	12	94.2 (16.2) a	
Heading	0	100.0 (0.0) a	0.64
	6	101.9 (12.7) a	
	12	90.8 (10.9) a	

*Yields followed by a different letter are significantly different according to Fisher's protected LSD post hoc analysis at α=0.05.

† Standard error of the mean.

Table 2. Comparisons of Yield with Simulated Defoliation at Three Different Growth Stages of Rice.

Growth Stage	Percentage Defoliated	Yield*(±SEM†) (% of Untreated)	P-Value
2-3 Leaf	0	100.0 (0.0) a	0.44
	25	106.3 (4.6) a	
	50	100.5 (4.0) a	
	100	99.7 (5.1) a	
2nd-3rd Tiller	0	100.0 (0.0) a	0.01
	25	94.1 (4.9) a	
	50	91.3 (1.5) a	
	100	74.0 (6.3) b	
Heading	0	100.0 (0.0) a	0.63
	25	103.8 (2.1) a	
	50	101.2 (1.0) a	
	100	98.8 (5.9) a	

* Yields followed by a different letter are significantly different according to Fisher's Protected LSD post hoc analysis at α=0.05.

† Standard error of the mean.

In the preference trial, no differences were observed for blank seeds at 33% (Table 3). However, when the FAW only had the head to feed on, the number of blanks increased to 38.81%, which was larger than the untreated check at 20.98%. When given a choice, FAW spent 63.5% of the time on the flag leaf (Table 4).

Table 3. Comparisons of Percent seed blanks associated with FAW feeding on Rice Heads

Treatment	Location	Percent Blanks (±SEM†)
Uninfested	Both	35.4 (5.8) a
	Flag Leaf	20.8 (4.3) a
	Head	21.0 (3.5) a
Infested	Both	33.0 (4.7) a
	Flag Leaf	16.5 (2.4) a
	Head	38.8 (6.1) b

* Yields followed by a different letter are significantly different according to Fisher's Protected LSD post hoc analysis at α=0.05.

† Standard error of the mean.

Table 4. Preference test between the leaf and head for the sleeve cage with both plant parts

Location	Percent of Time (±SEM†)
Leaf	63.5 (6.4) a
Head	36.5 (6.4) b

* Yields followed by a different letter are significantly different according to Fisher's Protected LSD post hoc analysis at α=0.05.

† Standard error of the mean.

Summary

In the preference trial, no differences were observed for blank seeds at 33% (Table 3). However, when the FAW only had the head to feed on, the number of blanks increased to 38.81%, which was larger than the untreated check at 20.98%. When given a choice, FAW spent 63.5% of the time on the flag leaf (Table 4).

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