UNDERSTANDING THE IMPORTANCE OF IMPROVED SAMPLING RECOMMENDATIONS FOR RICE STINK BUG, *OEBALUS PUGNAX*, IN ARKANSAS RICE.

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Abstract

Sampling recommendations for the rice stink bug (RSB) in rice are relatively ambiguous, and do not specifically recommended an exact area that needs to be sampled. Considering that a large amount of variation in sweep length has been observed, it is important to understand whether this variation could lead to differences in the number of RSB being sampled. The objective of this study was to determine the role that sweep length plays in sampling for RSB. In 2016 sweep lengths were measured for a range of rice samplers including consultants, producers, extension agents, and rice researchers. Measurements of sweep length were paired with the number of RSB collected, and this data was then used to explain how much variation in stink bug catch could be explained by sweep length. In 2017 sweep length was controlled at 3 levels, 3ft, 6ft, and a 180° sweep, to determine if clear differences could be observed in the number of stink bugs being caught at these lengths. When considering the height of the canopy and the height of the sweeper as significant interactions with sweep length, 51% (R^2=0.51) of the variation in the number of stink bugs caught could be explained by sweep length according to data from 2016. When sweep length was controlled at three levels, strong significant differences were observed. These data from 2016 and 2017 suggest that sweep length plays an important factor in sampling for the rice RSB, and that recommending a specific sweep length is vital.

Introduction

The rice stink bug, *Oebalus pugnax* (Fabricius) (RSB), is a major pest of heading rice in many rice producing states east of the Rocky Mountains. Sampling for this pest is performed using a 38cm sweep net, with 10 sets of 10 sweep samples recommended for identification of the population in the field. In Arkansas RSB is controlled with two different thresholds depending upon the growth stages present in each rice field (Lorenz and Hardke 2017). During the first two weeks of heading, from 75% emergence to the beginning of milk growth stages, it is recommended to apply an insecticide when RSB averages reach 5 stink bugs on 10 sweeps. After the second week of heading until 60% hard dough, it is recommended to apply an insecticide when RSB populations reach 10 stink bugs on 10 sweeps (Lorenz and Hardke 2017). These thresholds were created using cage trials, which is typical of most RSB damage determination work. The damage in a controlled area of rice within the cage is then related directly to the area sampled with a 15in (38cm) sweep net on 10 sweeps (Bowling 1963; Awuni et al. 2015). The direct or indirect damage incurred upon the rice in the cage paired with the number of stink bugs infested is then used to create economic injury levels.

Although all threshold studies have directly related the area of rice in cages to the area being sampled, there currently exists no recommendation for the amount of area that should be sampled with a sweep net. Current sampling recommendations include the frequency at 10 sets of 10 sweeps and the width of the sweep net at 15in, but the length of the sweep is more ambiguous. Across all rice production states sampling recommendations do not get more specific than to suggest a 180° sweep, from side to side, with at least 1 step per sweep. These non-specific recommendations are a function of the studies that implemented sweep net sampling for RSB. Sweep net sampling was first recommended by Douglas (1939) who found it useful to catch rice stink bug when they were found to be present within rice fields. Bowling (1969) later tested the efficacy of this sampling procedure, and found that the number caught highly correlated with the number of stink bugs that you would observe visually in an area of rice over a short amount of time. Espino et al. (2008) then strengthened our understanding of the efficacy of 10 sets of 10 sweeps, when it was discovered that this regimen would sample within 30% of the mean number of stink bugs in the field. However, none of these studies listed the approximate length of their sweeps, and are the basis for the non-specific recommendations used today.

Considering that threshold studies have to estimate the amount of area sampled to create an insecticide recommendation, it is important to understand the sweep length that growers and consultants are typically using. In Arkansas a large amount of variation has been observed in sweep length at scout schools, field days, in-service training of extension agents, and at the biannual rice college (Personal Observations). With the understanding that a large amount of variation in length does exist, and that we are not recommending a specific or ideal sweep length to base our threshold recommendations, it is important to understand whether this variation could lead to differences in the number of RSB being sampled. The objective of this study was to determine the role that sweep length plays in the number of stink bugs that are being captured when sampling for RSB. In 2016 the goal was to determine the amount of variation that sweep length explained in the number of stink bugs caught, and in 2017 sweep length was controlled to determine if clear differences in the number of RSB captured could be observed.

Materials and Methods

2016

Eight fields in total were analyzed in the summer of 2016. At least 3 sweepers were observed within each field, and for each person sweeping, a partner followed behind and recorded the length of the sweep. Measurements of sweep length were considered the distance from the center of the sweeper to the edge of the net when it exited the crop canopy. To record the sweep length, sweepers took 2 sets of 5 consecutive sweeps, with the left and then the right distance recorded at the end of the two sets of 5 sweeps. At the end of each set of 5, the number of rice stink bugs (RSB) captured was counted and recorded.

Along with the sweep distance measurement, data relating to the field being swept and each individual sweeper was also recorded for each field. The height of the crop canopy and the height of each sweeper was also measured and considered as potential predictors. A total of the left and right sweep lengths was considered the sweep length of each replication, and then this total of each replication was then paired with the total RSB caught from the 2 sets of 5 sweeps. For each field sampled, 3-4 areas were chosen to be blocks containing each set of sweepers. These blocks were at least 30ft (9 m) from the edge of the field and a greater distance was left between each block. In each field and within each block the assignment of sweeper location was randomized, using a randomized complete block design. Data was then assessed using regression analysis using R statistical software version 3.4.1 (R Core Team 2017). Multiple regression was utilized for this data with two blocking variables, field and block within field. The total number of stinkbugs caught on ten sweeps was used as the response variable, and sweep length, sweeper height, and canopy height were all utilized as predictors. Additionally, data was found to be non-normal, so the response was log-transformed.

2017

Ten Arkansas rice fields with a RSB infestation were sampled in the summer of 2017. Three factors were considered for this study: cultivar, growth stage, and sweep length. Canopy height was also recorded for each set of 10 sweeps, but will not be discussed in this paper. Cultivar was considered at two levels, hybrid or conventional, and growth stage of each field was considered either as early, from newly emerged until milk, or late which included soft to hard dough. Within each field three levels of sweep length were used in this study: 3ft, 6ft, and a 180° sweep. These sweep lengths were chosen as representatives of sweep lengths commonly observed among different sweepers, with the 180° sweep being a direct interpretation of recommendations. Two sweepers took at least 12 sets of 10 sweep samples per pass, which encompassed 3 replications of each sweep length level per sweeper. Overall each pass consisted of at least 24 sets of 10 sweeps across the two sweepers, and at least 4 passes were completed in each field. Sweeps were taken slightly in front of the sweeper with the ring of the net positioned with the rice heads in the center, at a quick pace, with more at least 1-2 steps being taken between each sweep. In total 922 sets of 10 sweep samples were taken across the ten fields that were sampled. Of those 10 fields sampled, 6 were considered to be at the early growth stage, and 4 were considered to be at the late growth stage. When considering cultivar, 5 of the fields were hybrid and 5 were conventional fields.

Data were analyzed using SAS version 9.4 using PROC GLIMMIX. Growth stage, cultivar, and sweep length were considered fixed factors, with the number of RSB caught in 10 sweeps being used as the response variable. Additionally field, pass within field, and the sweeper within each pass were considered as random variables for these analyses. The effect of each fixed factor was analyzed using an ANOVA, and all possible interactions of these variables were considered for interpretation. Means were then separated using Tukey's HSD post hoc analysis at $\alpha=0.05$.

Results and Discussion

Sweep lengths measured in 2016 ranged widely, from around 3ft (36in) to over 9ft (108in) (Figure 1). The corresponding RSB catches were found to increase exponentially as the length of the sweep increased. A significant correlation was observed between sweep length and RSB catch alone ($p<0.05$), but interactions between other predictors were also observed. When considering interactions between canopy height and sweep length, as well as sweeper height and sweep length, an R^2 of 0.51 indicated that over 50% of the variation could be explained. This indicates that sweep length, when considering the height of the sweeper and the height of the rice canopy, explains a large amount of variation in the number of RSB sampled (Figure 1).

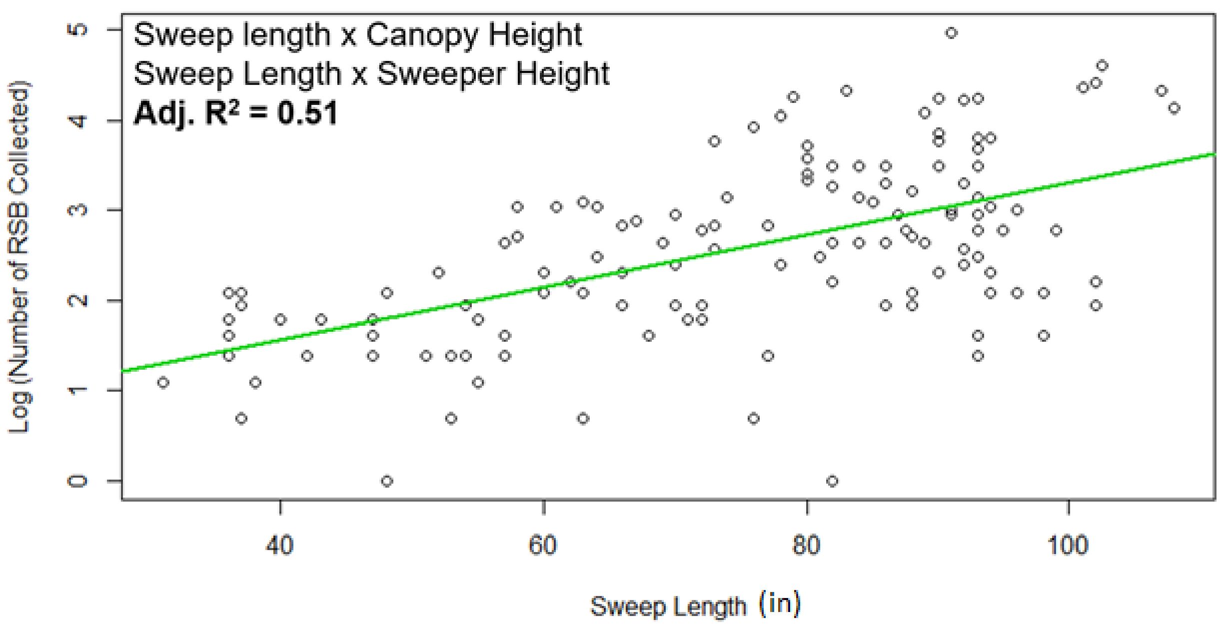

Figure 1. The Relationship between Sweep Length and RSB Catch when also considering Canopy Height and Sweeper Height

When considering the sweep length alone and controlling the other factors, large differences in the number of stink bugs collected were observed (Table 1). All three sweep lengths were found to be significantly different, with the 180° sweep capturing the most at 10.24 rice stink bugs (RSB) on 10 sweeps. The 6ft sweep length averaged significantly less RSB caught at 6.39 on 10 sweeps, and the 3ft length was significantly lower than the 6ft distance at 4.10 RSB on 10 sweeps (Table 1). Overall large differences in these values were observed, with differences being large enough to effect treatment decisions at a threshold of 5 RSB per 10 sweeps.

Table 1. Average Number of Rice Stink Bugs Caught at 3 Sweep Lengths

Sweep Length	10 Sweep Catch*		Std. Error
3ft	4.10	a	0.21
6ft	6.39	b	0.30
180°	10.24	c	0.40

*10 sweep catch values followed by a different letter are significantly different according to a Tukey HSD at α=0.05

A significant three-way interaction was not observed, so data was not reported across the three factors in one table. When considering two-way interactions, no interaction was observed between the cultivar and sweep length (Table 2), but an interaction was observed between the growth stage and sweep length (Table 3). A trend was observed in cultivar, although the main effect was found to be non-significant (Table 2). At each sweep length, an additional 2 or more RSB were captured in the hybrid cultivar when compared to the conventional (Table 2). When comparing the number of stink bugs caught using each sweep length across the growth stages, the largest amount of RSB captured were in the later growth stages at the 180° sweep length (Table 3). The lowest amount captured was at the 3ft sweep length in the conventional cultivar. Although more RSB were observed to be captured at all sweep lengths when comparing the early to the late growth stages, no statistical differences were found between the direct comparisons.

Table 2. Average Number of Rice Stink Bugs Caught at 3 Sweeps Lengths in Conventional and Hybrid Rice

Cultivar*	Sweep Length	10 Sweep Catch	Std. Error
Conventional	3ft	3.08	0.21
	6ft	5.26	0.31
	180°	9.05	0.44
Hybrid	3ft	5.21	0.36
	6ft	7.61	0.51
	180°	11.51	0.67

*No significant interaction was observed between cultivar and sweep length

Table 3. Average Number of Rice Stink Bugs Caught at 3 Sweeps in Early and Later Rice Growth Stages

Growth Stage*	Sweep Length	10 Sweep Catch**		Std. Error
Early	3ft	3.39	c	0.28
	6ft	4.98	bc	0.39
	180°	8.11	ab	0.49
Late	3ft	5.10	bc	0.30
	6ft	8.37	bc	0.40
	180°	13.2	a	0.56

*A significant interaction between growth stage and sweep length was found to be significant at α=0.05
**10 sweep catch values followed by a different letter are significantly different according to a Tukey HSD at α=0.05

Summary

When considering that a large amount of variation was observed in sweep length, it is important to understand how that relates to the number of rice stink bug (RSB) being sampled. When sweep lengths from extension agents, entomologists, and consultants were measured, it was found that the recorded sweep length could explain over 50% of the variation in the number of RSB sampled. This indicated that the targeted sweep length played a vital role in the accuracy of samples. In 2017 it was found that strong statistical differences were observed when 3 different sweep lengths were controlled. These differences were highly significant even when controlling for cultivar and growth stage. A significant interaction between growth stage and sweep length was also observed, where RSB were caught at a high rate in the later growth stage as sweep length increased.

Overall this data indicates that sweep length plays a large role in sampling for the rice stink bug. Considering that we do not recommend a specific sweep length, it is very possible that when sweep length is estimated in relation to cage studies to create thresholds, it may not be accurate for many producers in Arkansas. If someone is sweeping less than estimated, economically significant populations could go unsprayed due to a sample that underestimates the actual population. On the other end of the spectrum, many unnecessary applications could be applied if producers are taking larger samples than are estimated. To avoid these situations, it will be important to recommend a specific sweep length for producers to follow. In Arkansas the sweep length of 6ft has already begun to be recommended at field days, the rice college, and in the newest version of the rice production handbook, based on data from this study. Future work with this data will look to determine the number of 10 sweep samples necessary with 6ft sweeps to accurately estimate the mean.

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