The effect of infestation with rice water weevil (*Helodytes foveolatus* Duval) on the growth and development of rice (*Oryza sativa* L.) in Guyana

Narita Singh[1], Dharamdeo Singh[2], Gyanpriya Maharaj[3] and Mahendra Persaud[4]

[1]*Head of the Post-harvest / Valued-Added Department,*
Rice Research Station, Guyana Rice Development Board
[2]*Lecturer, Faculty of Agriculture and Forestry, University of Guyana, Turkeyen and Tain Campus*
[3]*Lecturer, Faculty of Natural Sciences, University of Guyana, Turkeyen Campus*
[4]*Chief Scientist, Rice Research Station, Guyana Rice Development Board*

**Corresponding author e-mail: singh.narita14@gmail.com*

Rice (*Oryza sativa* L.) production, the largest agricultural sub-sector in Guyana, is greatly affected by insect pests. The rice water weevil (*Helodytes foveolatus* Duval) is an early-season pest of rice at both the adult and larval stages with the latter resulting in the greater yield loss. This study compared the growth and development of rice plants subjected to varying levels of water weevil larvae infestation. Plants were infested with 3, 5, and 7 larvae/plant at two periods: 18 and 30 days after sowing (DAS). Uninfested plants served as the control. Each treatment was replicated five times and plant height, tiller count, panicle emergence and panicle density were recorded. Results showed that there were significant differences in plant height at maturity and throughout the trial, for infestation treatments applied at 18 and 30 DAS. At maturity, a similar trend was observed in the number of tillers produced by the various treatments; plants infested at 18 and 30 DAS with 7 larvae/plant had significantly lower number of tillers than the control and plants infested with 3 and 5 larvae/plant (P=0.03 and P=0.02) respectively. Panicle emergence and panicle density were also influenced by the number of water weevil larvae per plant and the length of time of infestation. This study proves that growth and development of rice plants can be affected by the level of infestation and the time of infestation of rice water weevil larvae. This can be useful in determining the amount of damage caused by the pest and therefore indicate to farmers whether or not control measures should be applied.

Keywords: Rice water weevil, plant development, panicle emergence, panicle density

Rice, *Oryza sativa* L., is an annual grass in the family Gramineae. It is the second largest cereal produced globally and, together with maize and wheat, provides 50% of the calories consumed by the global population (Zibaee 2013).

The rice industry is the largest agricultural sub-sector in Guyana, with over 91,054 hectares of land under cultivation in Regions 2, 3, 4, 5, and 6 (Pomeroon-Supenaam, Essequibo Islands West Demerara, Demerara-Mahaica, Mahaica-Berbice, East Berbice-Corentyne). It provides income for approximately 100,000 persons, or 14% of the Guyanese population and accounts for approximately 4% of the country's total gross domestic product (Guyana Rice Development Board 2016a). Most importantly, more than 70% of the total rice produced is exported and contributes approximately 12.6% of the country's annual foreign exchange earnings (Bureau of Statistics 2017).

An average of 37% of the rice crop is lost annually due to pest and diseases (IRRI 2017). Over 100 species of insects are considered as pests to the rice crop worldwide (IRRI 2017); while in Guyana approximately 50 invertebrates have been identified as being field pests of rice (Kennard 1976). These pests attack the crop at all stages of growth, from sowing to harvesting (Kennard 1976).

The rice water weevil (*Helodytes foveolatus* Duval) is considered an early-season pest of rice in Guyana (Guyana Rice Development Board 2016c). Both the adults and larvae feed on rice but it is generally the larval stage that causes higher yield loss (Way 1990). Studies have shown that root feeding by the larvae can result in yield losses exceeding 10% if not controlled (Tindall et al. 2012). Neonate larvae feed on the leaf sheaths and move downward into the soil where they begin to feed on the outside of the roots. The larvae move and feed on several roots and complete the larval stage in one month (Tindall et al. 2012).

Laval feeding can result in stunted growth (reduction in plant height) and leaf chlorosis which is due to reduced nutrient uptake and causes plants to be easily uprooted. Larval feeding also results in a reduction in tillering and grain yield (Saichuk 2012). Zou (2004) found that yield losses resulted from decreases in panicle densities, number of grains per panicle and grain weights.

The damage caused by *H. foveolatus* infestation is dependent on cropping system, length of time in rice production, weevil infestation during previous years, plant stand and density, and environmental conditions (Guyana Rice Development Board 2016). In Guyana, most farmers rely on insecticides for control as soon as symptoms of larval feeding appear in their field; Imidacloprid applied at 37 grams per hectare is the most popular insecticide used. Use of synthetic pesticides results in additional challenges and alternative methods are required to reduce pest damage while avoiding the cost and negative impacts associated with their use (Pretty and Bharucha 2015). The Guyana Rice Development Board has been urging farmers to adopt an integrated pest management (IPM) approach. IPM involves numerous methods for pest control and incorporates the simultaneous management and integration of tactics, regular monitoring of pests and natural enemies, the use of thresholds for decision-making and the judicious use of pesticides (Pretty and Bharucha 2015).

Monitoring is a key component in any IPM programme as it reveals the growth stage of the pest, location and population of the pest in the crop and the crop condition (Hines 2002).

A good monitoring programme must include records of the field locations, field conditions, prior pest infestations and control measures utilized (Hines 2002). By analyzing this information, a farmer can determine whether or not control measures should be applied (Hines 2002). In Guyana, monitoring for water weevil larvae is done by scouting at 2 to 3 weeks after sowing. Determination of larval infestation is usually done by removing the rice plants along with the soil that surrounds the root system. The soil sample collected is usually 10.16 centimeters in diameter and 5.08 to 7.62 centimeters deep. The plant, with soil, is washed vigorously in a bucket with a screen at the bottom and the larvae that dislodge from the roots are counted. The number of larvae found can be used to predict the level of damage caused to the crops; however, no such study has been done in Guyana. This experiment seeks to compare the growth and development of rice plants subjected to infestation with water weevil larvae to that of plants with no infestation.

Methods

The study was carried out in a screen-house at the Rice Research Station, Burma Mahaicony. Forty pots were filled with clay soil from the field. Five rice plants (variety G98-196) were transplanted, equal distance apart, into each pot. *H. foveolatus* larvae for the infestation were collected from the rice field located in the Research Station. Pots were infested with 0 larva/plant, 3 larvae/plant, 5 larvae/plant and 7 larvae/plant at 18 and 30 days after sowing (DAS) (Table 1). Each treatment was replicated 5 times.

Table 1: The number of water weevil larvae per treatment

Treatment	Days at Infestation	Number of Water Weevil Larvae
1	Control	0
2	18	3
3	18	5
4	18	7
5	30	3
6	30	5
7	30	7

Plants were monitored to ensure that the larvae did not die or make their way into the soil. Daily observations were made and water was added to pots to ensure they remained filled. General crop husbandry practices were carried out as required and no insecticides were applied. Data collected included plant height, number of tillers, number of plants which demonstrated panicle emergence, and number of panicles at harvesting.

Statistical Analysis

All statistical analyses, including the means were conducted using the Statistics Version 10 programme. One-way analysis of variance tests were performed to detect the statistical differences ($P < 0.05$) of plant height, tiller count and number of panicles. The LSD test was used to perform multiple comparisons ($p < 0.05$).

Results and discussion

Plant heights after infestation of 18 and 30 days after sowing (DAS)

Guessan et al. (1994) noted that infestation with water weevil larvae resulted in significantly reduced rice plant height of the various lines tested for tolerance (Guessan et al. 1994). In the current experiment, significant differences were observed in the height of the plants for the various treatments infested with larvae at 18 DAS. The plant heights for the control treatments were the highest throughout the duration of the trial and were significantly different from plant heights from plants infested with 7 larvae/plant at 2, 4 and 10 weeks after infestation (Table 2).

A similar trend was observed for treatments infested with larvae at 30 DAS (Table 3). Plants from the control treatments again had the largest plant height which was significantly different from plants infested with 5 larvae/plant at 2, 4 and 6 weeks after infestation (($P = 0.0149$, $F = 9.45$), ($P = 0.024$, $F = 7.89$) and ($P = 0.001$, $F = 11.87$) respectively). Plants infested with 7 larvae/plant had the lowest average plant height which was significantly lower than that of control plants and those infested with 3 larvae/plant at 6 and 8 weeks after infestation ($P = 0.004$, $F = 11.87$) and ($P = 0.0229$, $F = 8.63$), respectively (Table 3).

Table 2: Plant heights after infestation of 18 days after sowing

Treatments	Average Plant Height (cm)				
	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks
Control – 0 larva	50.52±3.03a	71.10±2.04a	78.70±5.10a	85.00±2.79a	89.00 ±3.12a
3 larvae/plant	49.63±3.7a	69.26±1.89a	77.29±3.22a	82.31±3.47a	87.06±5.29ab
5 larvae/plant	47.50±5.98ab	63.47±2.21b	73.87±5.25a	80.27±3.76a	84.29±3.78ab
7 larvae/plant	40.52±8.23b	62.60±4.98b	73.01±1.82a	78.83 ±6.21a	80.90±5.82 b
Grand Mean	47.04±5.99	66.61±4.65	75.72±4.40	81.60±4.50	85.31±5.21
SEM	2.57	1.35	2.19	2.35	2.51
P – Value	0.0082	0.0036	0.270	0.998	0.019

*Results are expressed as mean ± standard deviation
*Means with the same letter are not significantly different from each other; *SEM = Standard Error of Mean

Number of tillers in plants infested at 18 and 30 DAS

The average number of tillers differed statistically among treatments infested at both 18 and 30 DAS (Table 4 and Table 5). For plants infested with larvae at 18 and 30 DAS, those infested with 7 larvae/plant had the lowest average number of tillers throughout the trial and was significantly different from the control plants. Plants infested with 5 larvae/plant at 18 DAS also had significantly lower mean number of tillers than the control plants at 6 weeks and 10 weeks (P = 0.05, F = 4.01) and (P = 0.03, F = 4.55) respectively.

Previous studies have demonstrated that larval infestation of water weevil resulted in reductions in tillering of the rice plants (Grigarick 1984; Hesler et al. 2000). In this experiment it was confirmed that the number of tillers produced by a plant was influenced by the number of larvae per plant but not the time of infestation (Table 5).

Panicle emergence for treatments infested at 18 and 30 DAS

Feeding of the water weevil larvae on the roots is known to, not only affect the tiller count and yield, but has been shown to delay maturity also (CABI 2017, Shi et al 2008, Carol 2001). In this experiment, panicle emergence was influenced by both the pest density and time of infestation.

All plants in the control treatment had panicle emergence by 80 DAS. The average number of plants with panicles was higher for plants infested at 30 DAS than for those infested at 18 DAS throughout the trial. At 92 DAS, all treatments had 5 plants with panicles except for the treatment with plants infested at 18 DAS with 7 larvae/plant (Table 6).

Table 3: Plant height of treatments infested at 30 DAS

Treatments	**Average Plant Height (cm)**			
	2 weeks	**4 weeks**	**6 weeks**	**8 weeks**
Control – 0 larva	69.50±3.68 a	76.93±3.88 a	85.73 ±2.87a	83.65±4.12 a
3 larvae/plant	65.01±2.30 b	73.64±2.42 ab	82.97±4.02 a	81.15±4.96 a
5 larvae/plant	63.05±2.12 b	72.13±0.88 b	77.83±2.07 b	75.78± 4.97a
7 larvae/plant	62.74±2.55 b	70.36±3.36 b	70.34± 4.53c	63.12±12.96 b
Grand Mean	65.07±3.70	73.26±3.58	79.22±6.82	75.92±10.67
SEM	1.26	1.22	1.58	2.86
P – Value	0.0149	0.0235	0.004	0.0229

*Results are expressed as mean ± standard deviation
*Means with the same letter are not significantly different from each other; *SEM = Standard Error of Mean

Table 4: Tiller count for plants infested at 18 DAS

Treatments	**Average Number of Tillers**			
	4 weeks	**6 weeks**	**8 weeks**	**10 weeks**
Control – 0 larva	6.25±0.50 a	11.00±2.16 a	12.25± 3.10a	15.00±3.83 a
3 larvae/plant	6.00±2.71 a	10.25±4.11 ab	11.50± 4.20a	10.25± 3.30ab
5 larvae/plant	4.50±1.29 ab	5.50± 2.65c	7.75± 3.77ab	6.50±2.38 b
7 larvae/plant	2.00±2.31 b	5.00±1.41 bc	5.00±2.16 b	6.25±4.27 b
Grand Mean	4.69±2.44	7.94±3.73	9.13±4.28	9.50±4.83
SEM	1.01	1.56	1.2	1.922
P – Value	0.0544	0.0456	0.0081	0.0335

*Results are expressed as mean ± standard deviation
*Means with the same letter are not significantly different from each other; *SEM = Standard Error of Mean

Table 5: Tiller count for plants infested at 30 DAS

Treatments	Average Plant Height (cm)			
	2 weeks	4 weeks	6 weeks	8 weeks
Control – 0 larva	9.25±2.36 a	10.50±2.08 a	13.50±1.91 a	13.50±1.91 a
3 larvae/plant	8.75±1.50 a	10.00±1.83 ab	13.25±3.50 a	13.25± 3.50a
5 larvae/plant	4.75±2.22 b	6.50±3.11 bc	9.00±3.92 ab	9.00± 3.92ab
7 larvae/plant	4.00±2.94 b	4.50±2.89 c	4.75±3.20 b	4.75±3.20 b
Grand Mean	6.69±3.18	7.88±3.42	10.13±4.69	10.13±
SEM	1.13	1.15	1.79	1.79
P – Value	0.0178	0.0143	0.022	0.0220

*Results are expressed as mean ± standard deviation
*Means with the same letter are not significantly different from each other
*SEM = Standard Error of Mean

Table 6: Panicle emergence of plants infested at 18 and 30 DAS

Treatment		DAS								
		76	78	80	82	84	86	88	90	92
Not-infested	0 larva	2.50±1.29^{ab}	4.50±1.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
Infested at 18 DAS	3 larvae/plant	0.00±0.00^{c}	0.25±0.50^{c}	1.75±0.96^{d}	2.50±0.58^{b}	3.50±0.58^{b}	4.25±0.50^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
	5 larvae/plant	0.00±0.00^{c}	0.00±0.00^{c}	0.00±0.00^{e}	0.25±0.50^{c}	0.75±0.96^{c}	2.00±1.63^{b}	3.75±1.26^{bc}	5.00±0.00^{a}	5.00±0.00^{a}
	7 larvae/plant	0.00±0.00^{c}	0.00±0.00^{c}	0.25±0.50^{e}	0.25±0.50^{c}	0.50±0.58^{c}	1.50±1.29^{b}	3.25±1.5^{c}	4.25±0.96^{b}	4.75±0.50^{a}
Infested at 30 DAS	3 larvae/plant	3.50±1.29^{a}	3.75±0.50^{a}	4.75±0.50^{ab}	4.75±0.50^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
	5 larvae/plant	1.25±0.96^{bc}	2.50±0.58^{b}	3.50±1.00^{bc}	3.50±1.00^{b}	3.75±0.50^{b}	4.50±0.58^{a}	4.75±0.50^{ab}	4.75±0.50^{ab}	5.00±0.00^{a}
	7 larvae/plant	1.00±0.82^{c}	2.00±1.15^{b}	2.75±1.71^{cd}	2.75±1.71^{b}	3.50±1.00^{b}	4.50±0.58^{a}	4.50±0.58^{ab}	4.75±0.50^{ab}	5.00±0.00^{a}
Grand Mean		1.18±1.49	1.86±1.84	2.57±2.04	2.71±1.96	3.14±1.82	3.82±1.56	4.46±0.96	4.82±0.48	4.96±0.19
SEM		0.45	0.35	0.43	0.42	0.29	0.42	0.37	0.21	0.10
P – Value		0.001	0.001	0.001	0.001	0.001	0.001	0.016	0.018	0.4552

*Results are expressed as mean ± standard deviation
*Means with the same letter are not significantly different from each other
*SEM = Standard Error of Mean

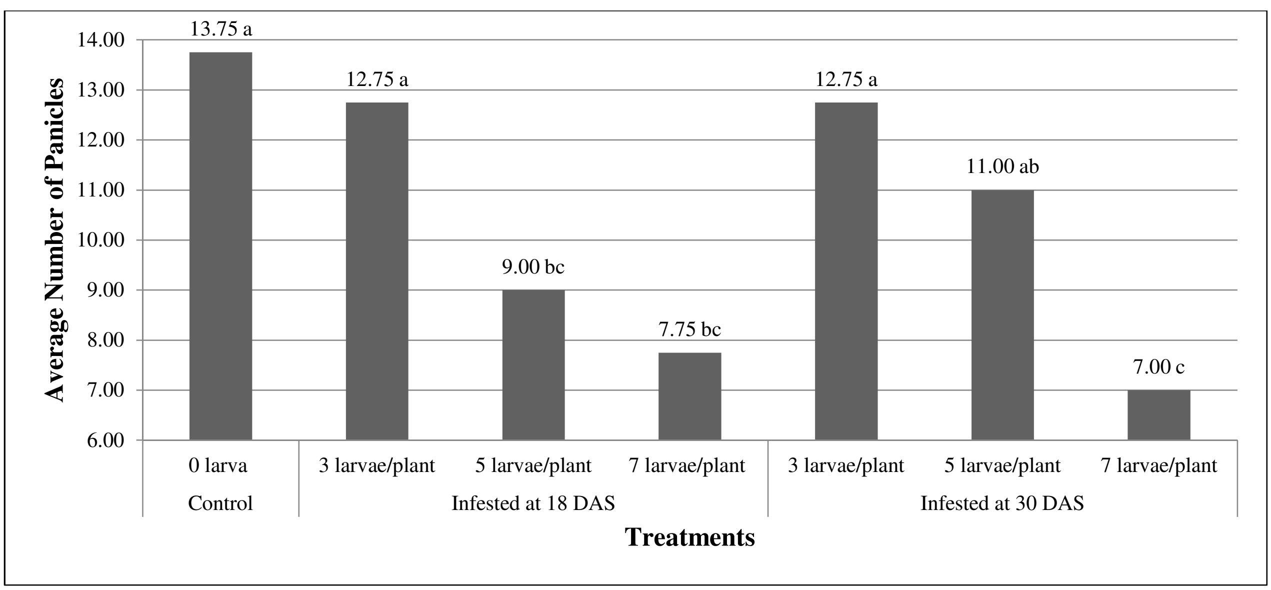

Figure 1: The Average number of Panicles per Treatment

Average number of panicles

Zou et al. (2004) found that reduction in yield occurred as a result of decreases in panicle densities, number of grains per panicle and overall grain weights. The reduction in the number of tillers has been shown to significantly influence the production of panicles in rice plants (Miller et al. 1991; Wu et al. 1998) and, in turn, the panicle density of that plant, which is correlated with grain yield (Counce and Wells, 1990; Gravois and Helms, 1992). For both periods of infestation, the average number of panicles was significantly higher in control plants and plants with the lowest level of infestation (3 larvae/plant) than in plants with the higher levels of infestation (7 larvae/plant) at 18 DAS and at 30 DAS ($p = 0.0023$, $F = 5.43$) (Figure 1).

Conclusion

Larval feeding on the root system of the plants can significantly reduce growth and yield parameters of rice plants. Reduction in plant height, tiller count, panicle emergence and panicle density can be affected by the pest density. The stage of the crop when the infestation occurs can also influence these factors.

References

Bureau of Statistics. 2017. “External Trade.” Accessed August 17, 2018. http://www.statisticsguyana.gov.gy/trade.html.

CABI (The Centre for Agriculture and Bioscience International). 2017. “*Lissorhoptrus oryzophilus* (Rice Water Weevil) – Datasheet.” Accessed August 11, 2018. https://www.cabi.org/isc/datasheet/30992

Carol, B. 2001. “Rice Water Weevil Control Timing Critical.” Accessed August 22, 2018. http://www.westernfarmpress. com/rice-water-weevil-control-timing-critical.

Counce, P.A., and B.R. Wells. 1990. “Rice Plant Population Density Effect on Early Season Nitrogen Requirement.” *Journal of Production Agriculture* **3 (3):** 390-393. Accessed August 24, 2018. https://dl.sciencesocieties.org/publications/jpa/abstracts/3/3/390?access=0&view=pdf

Gravois, K.A. and R.S. Helms. 1992. “Path Analysis of Rice Yield Components as Affected by Seeding Rate.” *Agronomy Journal*. **84 (1):** 1-4. Accessed August 28, 2018. https://dl.sciencesocieties.org/publications/aj/abstracts/84/1/AJ0840010001?access=0&view=pdf

Grigarick, A.A. 1984. “General Problems with Rice Invertebrate Pests and their Control in the United States. Protection Ecology.” *Journal of Protection Ecology* **7 (2):** 105-114. Accessed September 3, 2018. https://www.cabdirect.org/cabdirect/abstract/19850520494

Guessan, F.K.N., S.S. Quisenberry, R.A. Thompson, and S.D. Linscombe. 1994. “Assessment of Louisiana Rice Breeding Lines for Tolerance to the Rice Water Weevil (*Coleoptera: Curculionidae*).” *Journal of Economic Entomology*. **87 (2)**: 476-481. https://doi.org/10.1093/jee/ 87.2.476

Guyana Rice Development Board. 2016. “Rice in Guyana.” Accessed September 13, 2018.http://grdb.gy/

Guyana Rice Development Board. 2016. “Insect Pests of Rice.” September 1, 2018. http://grdb.gy/entomology/

Guyana Rice Development Board. 2016. “Management of Rice Water Weevil.” Accessed August 5, 2018. http://grdb.gy/wp-content/uploads/2016/09/Management-of-Rice-Water-Weevil.pdf

Hesler, L.S., M.J. Oraze, A.A. Grigarick, and A.T. Palrang. 2000. “Numbers of Rice Water Weevil Larvae (*Coleoptera: Curculionidae*) and Rice Plant Growth in Relation to Adult Infestation Levels and Broadleaf Herbicide Applications.” *Journal of Agricultural and Urban Entomology*. 17(2): 99-108. Accessed

August 12, 2018. https://www.researchgate.net/publication/290791705_Numbers_of_rice_water_weevil_larvae_Coleoptera_Curculionidae_and_rice_plant_growth_in_relation_to_adult_infestation_levels_and_broadleaf_herbicide_applications

Hines, R. 2002. "Vegetable Crop Pest Management-Integrated Pest Management." Accessed September 6, 2018. http://www.ipm.msu.edu/pesticide_education_safety/training_manuals/vegetable_crop_pest_management

IRRI (International Rice Research Institute). 2017. "Pest and Diseases." Accessed July 18, 2018. http://www.knowledgebank.irri.org/step-by-step-production/growth/pests-and-diseases/insects

Kennard, C.P., P.W. Croney and A.C. Schaaf. 1976. "Field Pests of Rice in Guyana and their Control." Guyana Rice Development Board.

Lorenz, G. and J. Hardke. 2013. "Arkansas Rice Production Handbook - MP192 - Insect Management in Rice." Accessed August 29, 2018. https://uaex.edu/publications/pdf/mp192/chapter-12.pdf

Miller, B.C., J.E. Hill, and S.R. Roberts. 1991. "Plant Population Effects on Growth and Yield in Water-Seeded Rice." *Agronomy Journal*. **83 (2):** 291-297. Accessed September 29, 2018. https://dl.sciencesocieties.org/publications/aj/abstracts/83/2/AJ0830020291?access=0&view=pdf

Pretty, J. and Z.P. Bharucha. 2015. "Integrated Pest Management for Sustainable Intensification of Agriculture in Asia and Africa." *Insects 2015.* **6 (1):** 152 – 182. Accessed September 2, 2018. doi: 10.3390/insects6010152

Saichuk, J.K. 2012. "Rice Water Weevil." Accessed August 9, 2018. http://www.lsuagcenter.com/topics/crops/rice/insects/presentations/1-rice-water-weevil

Shi, S., Y. He, X. Ji, M. Jiang, J. Cheng, and J. Zhejiang. 2008. "Do Rice Water Weevils and Rice Stem Borers Compete when Sharing a Host Plant." *Journal of Zhejiang University*. **9 (7)**: 572-577. Accessed July 28, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2443354/

Tindall, K.V., J.L. Bernhardt, M.J. Stout, D.H. Beighley. 2013. "Effect of Depth of Flooding on the Rice Water Weevil, *Lissorhoptrus Oryzophilus*, and Yield of Rice." *Journal of Insect Science.* **13** (62). Accessed September 21, 2018 https://www.ncbi.nlm.nih.gov/pubmed/23906324

Way, M.O. 1990. "Pest Management in Rice: Insect Pest Management in Rice in the United States." In *Post Management in Rice,* edited by B.T. Grayson, M.B. Green and L.G. Copping, 181-190. New York: Elsevier Science Publishing Co.

Wu, G.W., L.T. Wilson, and A.M. McClung. 1998. "Contribution of Rice Tillers to Dry Matter Accumulation and Yield." *Agronomy Journal*. **90 (3)**: 317-323. Accessed November 3, 2018. https://dl.sciencesocieties.org/publications/aj/abstracts/90/3/AJ0900030317?access=0&view=pdf

Zou, L. 2004. "Integration of Water Management Tactics for the Rice Water Weevil *Lissorhoptrus Oryzophilus* Kuschel with Particular Emphasis on Use of Plant Resistance: A Dissertation." B.S Kunming Institute of Technology and M.S Kunming Institute of Zoology. Accessed September 30, 2018. http://www.etd./su.edu/docs/available/etd-03172004-203127/unrestricted/Zou-dis.pdf

Zibaee, A. 2013. "Rice Importance and Future." *Journal of Rice Research.* **1**: (2). Accessed September 3, 2018. https://www.omicsonline.org/open-access/rice-importance-and-future-jrr.1000e102.pdf