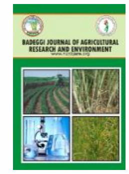
BADEGGI JOURNAL OF AGRICULTURAL RESEARCH AND ENVIRONMENT, 2019, 01(01), 58–65

NCRI Press

Available online: www.ncribjare.org
ISSN 2695-2122, e-ISSN: 2695-2114
DOI: https://doi.org/10.35849/BJARE201901007
Journal homepage:www.ncribjare.org



Research Article

Habitat Management Influence of *Orseolia oryzivora* and its Parasitoids on Rice

Mohammed, I. G.[1], Osipitan, A. A.[2], Pitan, O. R.[2] and Adigbo, S. O.[2]
[1]National Cereals Research Institute, Baddegi, Nigeria
[2]Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
Corresponding Author E-mail:*babaisakoko@yahoo.com*

Abstract
Cultural methods of managing insect pests of crops is an environmentally friendly option, it is a cheap, easily adoptable and safe to both human and natural enemies of insect pests. The study was conducted at Research Field of National Cereal Research Institute, Niger State to determine the influence of habitat management on the population density of African Rice Gall Midge (*Orseoliaoryzivora),* its parasitoids and yield of rice (*Oryza sativa).* The experiment was laid out in split-plot design and replicated three times. The two main plots were susceptible (FARO37)and resistant (FARO51) rice varieties, while the sub-plot treatments were three habitat managements with three alternative hosts of gall midge (Rice ratoon, *Oryza longistaminata*, *Paspalumscrobiculatum*) and the control was the plot free of any alternative host. Data were collected on number of tiller per hill, plant height, days to 50% flowering, percent incidence and severity of *O. oryzivora,* parasitism of *O. oryzivora*, panicle per metre square, grains per panicle and yield of rice. Plant height was not significantly (p>0.05) different in all the treatments. The number of days to 50 percent flowering was significantly (p<0.05) higher in the plot surrounded by *P. scrobiculatum*. Plots treated with *P.scrobiculatum* had significantly higher yield and lower incidence and severity of O. *oryzivora*. The parasitism of *O.oryzivora* by *Platygasterdiplosisae* and *Aprostocetusproceraewas* significantly higher in the plot of *P.scrobiculatum*. The study concluded that planting of *P. scrobiculatum* could enhance build-up of parasitoids and reduce infestation and damage of rice by *O. oryzivora*

Keywords: Rice, *Orseolia oryzivora*, Parasitoids, *Paspalum scrobiculatu*, *H*abitat

Introduction

Rice (*Oryza sativa*) has become the most popular food in Sub-Saharan Africa (Mohapatra, 2006; AfricaRice, 2008). Rice is now the main staple food for about 35 million people or 20% of the Nigerian population, and consumption is increasing faster than that of any other food crop in many countries in Africa (Kormawa *et al*., 2004; AfricaRice, 2005). In spite of rice becoming an important cereal and staple food crop, its production in Africa is still the lowest in the world and cannot meet the increasing demand for rice in many African countries (Hossain, 2006; FAOSTAT, 2009; AfricaRice, 2010). In Nigeria, rice is produced almost exclusively by small-scale farmers who have little or no hope of increasing their land-holding capacity. Africa accounted for 32% of global rice imports in 2006 (Akinbile*et al*., 2007; AfricaRice, 2008). Unless this situation is reversed, food dependency will continue to increase in the continent. The increase in rice production observed in the recent years has been attributed to increase in area cropped rather than quantitative increase (AfricaRice, 2007). The production-consumption gap in this region is due to low yield of rice (AfricaRice, 2007). This situation is due to both abiotic and biotic constraints and many technical, management, socio-economic, health, and policy constraints that restrict rice production (Balasubramanian*et al*., 2007). In Africa, rice is affected by a wide range of abiotic and biotic factors that harm

Date Received 09/11/18, Revised 09/01/19, Accepted 24/02/19 and Published 28/03/19

productivity. The abiotic constraints include: drought, flooding and variable rainfall, extreme temperatures, salinity, acidity/alkalinity and poor soils, soil erosion and high phosphorus fixation. The biotic constraints include weeds, blast leaf spots, Nematodes which are a serious problem in continuously mono cropped dry land rice fields (Coyne *et al*., 2004) and termites which are critical in some areas. Rodents and birds do also cause damage to rice crop in all ecosystems. Stem borers, leaf hoppers and rice midges are the major insect pests (AfricaRice, 2007). Insect pests are one of the major constraints in achieving the yield potential of many varieties of rice.African rice gall midge (AfRGM) *Orseolia oryzivora* Harris and Gagné (Diptera: Cecidomyiidae), appears to be the most serious insect pest of lowland and irrigated rice in the recent times (Williams *et al*., 1999, Ogah *et al.*, 2006; Nwilene *et al*., 2006). *Orseoliaoryzivora* is an insect pest indigenous to Africa (Ukwungwu and Misari, 1997; Harris *et al*., 1999). Since the establishment of its existence as a distinct species from the Asian rice gall midge *Orseolia oryzae* (Wood - Mason), its pest status and distribution have been on the increase. The status of AfRGM has changed in the recent years, from minor to major pest recorded in many African countries (Ukwungwu and Misari, 1997). African rice gall midge attacks rice at the vegetative stage and destroys the growing primordia, resulting in the formation of a tubular gall or onion shoot. Any tiller attacked is irreversibly damaged and does not produce any panicle. Losses caused by this pest couldreach 80% and total crop failure is common in endemic areas (Heinrichs and Barrion, 2004). Many indigenous bio-control agents have been recorded in the field for the control of AfRGM. Of all the natural enemies of AfRGM, the most common parasitoid in Nigeria are *Platygasterdiplosisae*Risbec (Hymenoptera: Platygastridae) and *Aprostocetusprocerae* (Nwilene 2006, WARDA-AfricaRice 2000, Umeh and Joshi 1993, Ogah; *et al.,* 2010). *Platygaster diplosisae* is an indigenous and gregarious egg-larval endoparasitoid of AfRGM. It lays its eggs within the gall midge eggs or neonate larva on plant surfaces (Nacro and Nenon, 2009). The adults then emerge from the fully-grown corpse of the gall midge larva. It can parasitize up to 80% of galls on rice plants, but mostly towards the end of the wet season and so fails to prevent economic damage (Ogah *et al.*,2010). Though the impact of *P. diplosisae* in the control of AFRGM appears to be limited by delays in its response to increasing host density early in the season, it has been discovered that it attacks another species, *Orseoliabonzii* Harris which infests *Paspalumscrobiculatum*, a common grass but not rice, in rice growing areas in both forest and savanna agro-ecological zones (Harris and Gagné, 1982). This suggests a new way of enhancing its effectiveness (WARDA-AfricaRice 2000, Harris and Gagné 1982). On average, galls of *O. bonzii*on *P. scrobiculatum* are more common in late April/May than those of *O. oryzivora* on cultivated rice, which reaches very high levels on rice crops latter in the wet season (Williams, 1999). Also *Oryza longistaminata* and rice ratoonharborAfRGM and similar parasitoids with cultivated rice thus earlier establishment of these weeds and ratoon can be used to attract *P.diplosisae* early in to rice production. Management of insect pests of rice in Africa for the past two decades has been dominated by the use of insecticides and likely use of insecticide will still dominate pest management strategy in the nearest future. However, insecticide applications pose danger to the environment, human health and also destroy beneficial organisms, such as pollinators and parasitoids. Thus, there is need to examine other alternative pest management methods which affects less the naturally occurring parasitoids that augment control of pest organisms. Also much emphasis in biological control which is considered to be more environmentally friendly has been on classical bio-control with little or no attention on conservative bio-control. Hence the need to examine, habitat management in conservation of natural parasitoids for bio-control of African rice gall midge. The main aim of this work was to assess integration of variety and habitat management in optimum control of Africa rice gall midge, to assess damage to the rice tillers by AfRGM infestation and to assess the effect of habitat manipulation on the conservationof parasitoids in bio-control of AfRGM

Materials and Methods

The experiment was carried out under irrigated lowland ecology in 2016 and 2017 wet season at an identified hot spot (Edozhigi) for AfRGM in Nigeria. Edozhigi in Niger State falls within the southern Guinea savanna agro-ecological zone at latitude 09°45' N, longitude 06°07' E and altitude 50.57 m above sea level. The location is chosen because AfRGM occurs naturally and regularly at the site and at levels that often result in severe damage to rice (Ukwungwu and Misari, 1997). The site has bimodal rainfall patterns with an average annual rainfall of about 900-1050 mm per annum, distributed between May and October of each season. The site has an annual mean temperature of 26.5^0,the relative humidity ranges between 52 - 73%.The experiment was laid out in split-plot arranged in Randomized Complete Block Design (RCBD) and replicated three (3) times. There were two main plot treatments consisting of susceptible (FARO37) and resistant rice variety (FARO51). While, the sub plot treatments were four (4) habitat managements. Establishment of three alternative host of gall midge:*Paspalumscrobiculatum* (T1), *Oryza longistaminata*(T2), rice ratoon (T3) at the boarder edge of the net plots and the control which was a meter free of any alternative host (T4) around the net plot. The sub plot size measured 4mx 3m While, main plots measured 16m x12m. Data were collected on the following parameters: tiller count, plant height (cm), number of days to 50 percent flowering, panicle count (m^2), grains per panicle, grain yield, percentage incidence and severity of AfRGM, which was done by randomly selecting twenty hills of rice per plot for assessing the incidence and severity of damage due to AfRGM (tillers with galls) at 21, 42 and 63 days after transplanting according to standard evaluation system of International Rice Research Institute (IRRI 2002).The damage injury rates was calculated as follows:

$$\text{Incidence} = \frac{\text{No. of hills with galls x 100}}{\text{Total no. of hills}}$$

$$\text{Severity} = \frac{\text{No. of tillers with galls x 100}}{\text{Total no. of tillers}}$$

AfRGM Parasitism by parasitoids was recorded by dissecting twenty (20) galls formed from each treatment using SH-ZT binocular dissecting microscope with 100X magnifications to check for presence of parasitized larva and pupae at 21, 42 and 63 days after transplanting. Collected data was subjected to analyses of variance (ANOVA). An arcsine transformation was carried out on percentage tiller infestation and percentage parasitism data prior to ANOVA (SAS, 2003). The significant means were separated using least significant difference (LSD).

Results and Discussion

FARO 37 had significantly (P<0.05) higher number of tillers compared to FARO51 in both 2016 and 2017. However, there was no significant difference(P>0.05) in rice tiller in both years among the plots treated with different habitat managements. Also, there was no interaction between varieties and habitat management (Table1). Higher tillers observed in FARO37 may be due to its susceptibility to infestation and damage by African rice gall midge (*Orseolia. Oryzivora)*. It seemed that the ability to compensate, was induced by damage to the primary tillers, hence compensation was higher in susceptible variety (FARO37). This is in line with earlier findings of (Ogah*et al.,* 2012) who reported that gall initiation that mostly takes place at the early vegetative stage of the rice growth stimulates tillering. However, this profuse tillering due to infestation results in stunting, bushy appearance of rice plant and affects yield (Nwilen*et al*., 2006). In both years, there was no significant difference (P>0.05) in plant height between the susceptible variety (FARO37) and resistant variety (FARO51). Also there was no significant difference (P>0.05) in plant height among four plots with different habitat management (Table 1). Uniformity in plant height as shown in Table 1 suggested that these four weeds surrounding the rice field have no influence on rice growth, which is in line with the findings of (Keita and Syu-ichi2017) that not all weeds in rice fields have negative impact on growth and yield of rice The number of days resistant variety (FARO51) takes to attain 50 percent flowering was significantly (P<0.05) shorter compared to takes days the susceptible variety (FARO37) attained 50 percent flowering in 2016. Whereas, in 2017 there was no significant difference in days to attainment of 50 percent flowering among the two varieties evaluated (Table2). However, days to 50 percent flowering of rice in plots *Paspalum scrobiculatum* was established at the border edge and the control plots was shorter in both 2016 and 2017 compared to the days rice in plots surrounded with *Oryza longistaminata* and Rice ratoon at border attend percent flowering (Table2). The delay in attainment of 50 percent flowering observed in susceptible variety and on plots surrounded with *Oryza longistaminata* and rice ratoon may be as a result of higher incidence and severity of African rice gall midge on those plots as it is earlier established by Nwilene *et al.*, (2006) that any tiller attacked by African rice gall midge neither flower nor produce panicle. The resistant variety (FARO51) had significantly lower incidence and severity of African rice gall midge compared to susceptible variety (FARO37). Also, incidence and severity of African rice gall midge inplost where *Paspalum scrobiculatum* was established at the border edge and the control plots was significantly lower in both 2016 and 2017 compared to the plots surrounded with *Oryza longistaminata* and rice ratoon (Table3**).** There was also significant interaction between variety and habitat management on incidence and severity of African rice gall midge in both years (Table 3). From this trend of incidence and severity of African rice gall midge (*Orseolia Oryzivora)* infestation on rice, it shows that FARO51 is a resistant variety. This confirms earlier findings of Wada *et al.*,(2012) that ranked FARO51 as moderately resistant variety to African rice gall midge (*Orseo liaoryzivora).* The higher number of galls in rice plots bound with *Oryza logistaminata* and rice ratoonalso shows that presence of these weeds around the edge of fields will increase infestation of rice fields because they serve as alternative host to African rice gall midge (*Orseolia*. *oryzivora)*. This validates earlier finding of Ukwungwu and Joshi (1992) who listed the two weeds as alternative hosts of African rice gall midge (*Orseo liaoryzivora)* and serve as source for cross infestation of rice fields. There was no significant difference in African rice gall midge parasitism among the two varieties evaluated. Whereas, plots surrounded with *p*. *scrobiculatum* had significantly ($p<0.05$) higher percentage gall midge parasitism (Table 6). Higher parasitism of African rice gall midge (*Orseo liaoryzivora)* byparasitoids in plots bounded with *P*. *scrobiculatum* supported the work of Ogah*et al.*,(2010) who said that the impact of *P*. *diplosisae* in the control of AFRGM can be improved by establishing *Paspalumscrobiculatum* earlier in the field for early build up of parasitoids. The work of Umaru*et al.* (2014) also supported this, which indicated that the presence of galls of *P*. *Scrobiculatum* had moderating influence on the incidence of gall midge signifying that *P*. *Scrobiculatum* galls were able to attract parasitoids to lower the AfRGM infestation. There was no significant difference in grains per panicle between the two varieties and also the four habitat managements evaluated (Table 6).The resistant variety FARO51 had higher panicle in both years. Also plots surrounded with *P.scrobiculatum* and the control plots had higher panicle among the four habitat managements evaluated in both 2016 and 2017 (Table 7). The lower number of panicles in susceptible variety FARO37 can be attributed to higher incidence and severity of African rice gall midge (*Orseolia* o*ryzivora)*. This validates the findings of IRRI (2002) that any tiller that is attacked by African rice gall midge (*Orseolia*. *oryzivora)* is irreversibly damaged and can't produce panicle.The resistant variety FARO51 had higher yield in both years. Whereas, the grain yield in the four habitat management followن this order in both 2016 and 2017. Grain yield in plots with *P*. *scrobiculatum* at the edge was greater than grain yield in plots free of any alternative host at the edge. (Table 7) The lower yield in susceptible variety FARO37 and in plots surrounded with *O*. *longistaminata* and rice ratoon *P*. *scrobiculatum* may be attributed to higher infestation of tillers by African rice gall midge (*Orseolia oryzivora)*, this is in line with the findings of Souleymane*et al.*, (2016).who observed that one per cent of tillers damaged by African rice gall midge (*Orseolia oryzivora)* in rice fields resulted in 2% grain yield loss.

Conclusion

The nature of weeds at the boarder of rice field was observed to have influence on population of Africa rice gall midge infestation on rice, as lowest population was found on plots with *Paspalum scrobiculatum* at the boarder edge.

Conservation of parasitoids and subsequent parasitism of Africa gall midge (parasitized larva) was also more on plots bounded with *Paspalumscrobiculatum.* Presence of *Oryza longistaminata* and rice ratoon at the boarder encouraged higher incidence and severity of Africa gall midge, hence should be discouraged.

References

AfricaRice (2010).*New Breeding Directions at AfricaRice: Beyond NERICA.* Africa Rice Center, Cotonou, Benin: p24

AfricaRice.(2008). *Africa Rice Trends 2007*. Africa Rice Center (WARDA), Cotonou, Benin. p84

Africa Rice Center (2005). Africa Rice Center (WARDA) Annual Report 2003–2004: Towards new horizons. Cotonou, Benin, p56

Africa Rice Center (2007). Africa rice Trends; Overview of recent developments in the sub- Saharan Africa rice sector, Africa Rice Center (WARDA) Brief , Cotonou, Benin. p8

Balasubramanian, V., Sie, M., Hijmans, R.J. and Otsuka, K. (2007).Increasing rice production in Sub-Saharan Africa: challenges and opportunities.*Advances in Agronomy*,94,55-103.

Coyne, D.L., Sahrawat, K.L. and Plowright, R.A. (2004).The influence of mineral fertilizer application and plant nutrition on plant-parasitic nematodes in dry land and wetland rice in Côte d'Ivoire and its implications in long-term agricultural research trials.*Experimental Agriculture*,40,245-256

FAOSTAT (2009). (www.faostat.fao.org)/Agriculture and Food Trade/ last accessed June 2010.

Harris, K.M. and Gagné, R.J. (1999). Description of African rice gall midge, *Orseoliaoryzivora*sp. with comparative notes on Asian rice gall midge, *O. oryzae*(Wood-Mason) (Diptera: Cecidomyiidae). *Bulletin of Entomological Research*,72, 467-472.

Heinrichs, E.A. and Barrion, A.T. (2004) Rice feeding insects and selected natural enemies in West Africa, Biology, Ecology Identification. Hettel, G. P. (Ed.). *International Rice Research Institute*. PP237

Hossain, M. (2006). Rice in Africa: Can rice help reduce hunger and poverty in Sub-Saharan Africa? *Rice Today*,5, 41.

International Rice Research Institute (2002).Standard Evaluation System for Rice, International Rice Research Institute. Los Banos, Philippines. p71

Keita, H, andSyu-ichi, S. (2017) Weed communities and their negative impact on rice yield in no-input paddy fields in the northern part of Japan *Journal of Biological Agriculture and Horticulture*. An International Journal for Sustainable Production Systems Volume 33

Kormawa, P.M., Keya, S. and Toure, A.A. (2004).Rice research and production in Africa. Rice Outlook 2004. Marseille, France, 29-30 June 2004.

Nacro, S. and Nénon, J. P. (2009). Comparative study of the morphology of the ovipositor of *Platygasterdiplosisae*(Hymenoptera: Platygasteridae) and *Aprostocetusprocerae*(Hymenoptera: Eulophidae) two parasitoids associated with the African rice gall midge, *Orseoliaoryzivora*(Diptera: Cecidomyiidae). *Psyche* 2009:1-7

Nwilene, F.E., Nwanze,K. F. and Okhidievbie, O. (2006). African Rice Gall Midge: Biology, Ecology and Control—Field Guide and Technical Manual. Africa Rice Center (WARDA), Cotonou, Benin. p24

Mohapatra, S. (2006). Putting rice on the African agenda, *Rice Today, Publication of the* International Rice Research Institute, Manila, Philippines 5, 50.

Ogah, E.O., Umeh, E. D.N. and Oselebe, H.O. (2006).Effect of time of transplanting and spacing on the incidence of African rice gall midge H and G in Abakaliki.*Journal of the Science of Agriculture, Food Technology and the Environment, 6, 110 - 113*

Ogah, E. O.,Odebiyi, J. A.,Omoloye, A. A. and Nwilene, F.E. (2012).Evaluation of some rice genotypes for incidence of African rice gall midge and its parasitoid(*P. Diplosisae*)*.African Crop Science Journal*, 20, 2, p137 – 147

SAS, (2003).SAS Systems for Windows.Version 9.1 Edition. SAS Institute Inc. Cary, NC, USA.

Souleymane, N.,Elvis, A. H and Dona, D. (2016). Estimation of rice yield losses due to the African rice gall midge, Orseoliaoryzivora Harris and Gagne *International Journal of*

Pest Management, 42(4),331-334.

Ukwungwu, M.N. and Joshi, R.C. (1992).Distribution of the African rice gall midge, *Orseolia oryzivora* Harris and Gagné and its parasitoids in Nigeria. *Tropical Pest Management*,38,241-244.

Umaru, A.B, Dike, M. C.,Onu, I. and Ukwungwu, M.N. (2014).Effects of parasitoids on the severity of African rice gall midge *Orseolia oryzivora* H. & G. (Diptera: Cecidomyiidea) in Koda millet, *Paspalum scrobiculatumL* infested rice genotypes at Edozhigi in Central agro-ecological zone of Nigeria *International Research Journal of Agricultural Science and Soil Science*, 4(6) p101-106,

Umeh, E.D.N. and Joshi, R.C. (1993). Aspects of the biology, ecology, and natural biological control of the African rice gall midge, *Orseolia oryzivora* Harris and Gagne (Dipt. Cecidomyiidae) in south east Nigeria.*Journal of Applied Entomology*,116,391-398.

Wada, A.C.,Bakare, S. O., Mohammed, M. and Ukwungwu, M.N (2012).Integrated management of African rice gall midge (AfRGM) *(Orseolia oryzivora*, Harris and Gagné), weeds and diseases of lowland rice.*Agricultural Sciences*, 486-490

Williams, C. T., Okhidievbie, O., Harris, K. M. and Ukwungwu, M.N. (1999). The host range, annual cycle and parasitoids of the African rice gall midge *Orseoliaoryzivora* (Diptera: Cecidomyiidae) in Central and South East Nigeria. *Bulletin of Entomological Research*,89,585-597.

Table1. Tiller count and plant height as affected by habitat management in 2016 and 2017

Treatments	Tiller count		Plant height	
	2016	2017	2016	2017
Variety				
FARO37	16.50	18.00	95.73	98.47
FARO51	13.42	14.00	96.10	96.10
LSD $_{(0.05)}$	0.72*	1.08*	NS	NS
Habitat mgt.				
p. scrobiculatum	14.83	16.17	95.95	98.77
O. longistaminata	15.17	16.00	95.82	98.92
Rice ratoon	14.83	15.83	96.60	97.98
Control	15.00	16.00	95.50	97.50
LSD $_{(0.05)}$	NS	NS	NS	NS
Interaction				
V x H	NS	NS	NS	NS

NS= No Significant Difference, LSD= Least Significant Difference, * = Significant different, V x H= Interaction

Table2. Days to 50 % flowering as affected by habitat management in 2016 and 2017

Treatments	Days to 50% flowering 2016	2017
Variety		
FARO37	90.58	91.00
FARO51	85.58	88.50
LSD $_{(0.05)}$	1.64*	NS
Habitat mgt.		
p. scrobiculatum	82.67	84.67
O. longistaminata	92.83	94.50
Rice ratoon	94.33	95.67
Control	82.50	84.17
LSD $_{(0.05)}$	0.83*	1.95*
Interaction		
V x H	NS	NS

NS= No Significant Difference, LSD= Least Significant Difference, * = Significant different, V x H= Interaction

Table 3. Percentage incidence and severity of AfRGM as affected by habitat management in 2016 and 2017

Treatments	Percentage incidence		Percentage severity	
	2016	2017	2016	2017
Variety				
FARO37	11.85	10.73	13.61	12.54
FARO51	7.87	7.62	7.46	7.85
LSD $_{(0.05)}$	0.40*	1.49*	1.46*	3.42*
Habitat mgt,				
p. scrobiculatum	2.16	2.07	1.59	3.02
O. longistaminata	14.59	13.95	15.76	14.78
Rice ratoon	14.89	13.07	16.92	15.29
Control	7.81	6.62	7.87	7.69
LSD $_{(0.05)}$	0.63*	0.91*	0.79*	1.03*
Interaction				
V x H	0.89*	1.29*	1.09*	1.46*

NS= No Significant Difference, LSD= Least Significant Difference, * = Significant different, V x H= Interaction

Table 4. Interaction between the Variety and habitat management on percentage AfRGM incidence in 2016and 2017

Habitat mgt.	Percentage incidence		Percentage incidence	
	FARO37	FARO51	FARO37	FARO51
	2016		2017	
p. scrobiculatum	2.69	1.62	2.33	1.81
O. longistaminata	17.60	11.68	16.66	11.23
Rice ratoon	17.40	12.39	16.22	11.91
Control	9.72	5.89	7.72	5.52
LSD $_{(0.05)}$	0.89*		1.29*	

LSD= Least Significant Difference, * = Significant different

Table 5. Interaction between the Variety and habitat management on percentage AfRGM severity in 2016 and 2017

Habitat mgt.	Percentage severity		Percentage severity	
	FARO37	FARO51	FARO37	FARO51
	2016		2017	
p. scrobiculatum	2.22	0.97	3.51	2.53
O. longistaminata	20.41	11.10	18.46	11.10
Rice ratoon	22.19	11.66	18.92	11.66
Control	9.62	8.12	9.26	6.12
LSD $_{(0.05)}$	1.09*		1.46*	

LSD= Least Significant Difference, * = Significant different

Table 6. Gall midge parasitism and grains per panicle as affected by habitat management in 2016 and 2017

Treatments	Gall midge parasitism		Grains per panicle	
	2016	2017	2016	2017
Variety				
FARO37	0.75	0.94	294.50	296.08
FARO51	0.83	0.92	292.25	293.42
LSD $_{(0.05)}$	NS	NS	NS	NS
Habitat mgt,				
p. scrobiculatum	2.11	2.78	296.33	297.83
O. longistaminata	0.17	0.17	296.50	297.67
Rice ratoon	0.33	0.28	294.67	295.83
Control	0.56	0.50	280.00	287.67
LSD $_{(0.05)}$	0.34*	0.41*	NS	NS
Interaction				
V x H	NS	NS	NS	NS

NS= No Significant Difference, LSD= Least Significant Difference, * = Significant different, V x H= Interaction

Table 7. Panicle per meter square and grain yield as affected by habitat management in 2016 and 2017

Treatments	Panicle per meter square		Grain yield (kg/h)	
	2016	2017	2016	2017
Variety				
FARO37	254.58	252.90	2570.13	2584.56
FARO51	286.33	276.90	2712.10	2769.56
LSD $_{(0.05)}$	23.10*	22.73*	132.9*	63.25*
Habitat mgt,				
p. scrobiculatum	324.00	307.50	2977.62	3089.58
O. longistaminata	252.83	253.50	2453.90	2453.90
Rice ratoon	227.17	227.80	2415.75	2415.75
Control	277.83	272.20	27.17	2750.87
LSD $_{(0.05)}$	13.52*	15.99*	81.79*	78.86*
Interaction				
V x H	NS	NS	NS	NS

NS= No Significant Difference, LSD= Least Significant Difference, * = Significant different, V x H= Interaction