Journal of
Entomology

Influence of Cropping and Irrigation Systems on Population Fluctuation of the African White Rice Stem Borer (*Maliarpha separatella* Rag) and Damage on Rice

[1]V.M. Kega, [2]J.H. Nderitu, [3]M. Kasina and [4]F. Olubayo

[1]Kenya Agricultural and Livestock Research Organization, Mwea Centre, P.O. Box 298-10300, Kerugoya, Kenya
[2]Mount Kenya University, P.O. Box 342-01000, Thika, Kenya
[3]Kenya Agricultural and Livestock Research Organization, Crop Health and Biotechnology, National Agricultural Research Laboratories, P.O. Box 14733-00800, Nairobi, Kenya
[4]Department of Plant Science and Crop Protection, College of Agriculture and Veterinary Services, University of Nairobi, P.O. Box 29053-00800, Nairobi, Kenya

Corresponding Author: V.M. Kega, Kenya Agricultural and Livestock Research Organization, Mwea Centre, P.O. Box 298-10300, Kerugoya, Kenya

ABSTRACT

Information on the population fluctuation of African white rice stem borer (*Maliarpha separatella* Ragonot), which is a major rice pest in Kenya, is not known. Availability of such information can assist in the development of an integrated management strategy for the pest. Therefore, a study was conducted at Mwea irrigation scheme in Central Kenya, to investigate the influence of irrigation water provision and cropping systems on population of *M. separatella*. Farmer fields in different parts of the scheme were sampled every fortnight. The farms represented three irrigation water provision schedules and three cropping systems regimes. The irrigation water provision schedules were, System of Rice Intensification (SRI), flood irrigated (conventional method) and sporadic irrigation. The cropping systems were main season crop (conventional method), double crop and ratoon. Water provision schedules were treated as main plots, while cropping systems were the sub plots. Results showed that the highest percentage of white heads (13.66) occurred in areas, where rice was double-cropped and where, there was sporadic water provision (9.70). There were no significant differences in the number of white heads (empty panicles) between the on-season (6.37) and ratoon (4.25) cropping system. There were also no differences between flood (4.42) and System for rice intensification (5.48) methods of irrigation. This study demonstrates that irrigation methods and cropping systems greatly influence fluctuation of *M. separatella* infestation and suggests that in case of double cropping it will be necessary to control the stem borer and efforts should be made to ensure that farmers synchronize planting dates.

Key words: Rice, cultural practices, African white rice stem borer, population

INTRODUCTION

Stem-borer species are considered to be the most important insect pests of rice in Africa (Heinrichs and Barrion, 2004). In Kenya stem borer species are members of four moth families Noctuidae, Pyralidae, Diopsidae and Cecidomyidae. The first two are in the order Lepidoptera and

the last two are in order Diptera (CABI., 1996). In flooded rice cultivation, the most important species is *Maliarpha separatella* (Pyralidae), which attacks rice at the full tillering stage, preventing grains from filling up and ripening. This damage results in empty panicles known as "white heads" (Rahman *et al.*, 2007). Reports indicate that the most susceptible rice variety at Mwea to *M. separatella* is Basmati 370, which also happens to be the most popular rice variety due to its long grains and aroma (Kimani *et al.*, 2010). Stem borers can be controlled by cultural methods, biological control agents and use of insecticides (Riba, 2007). Harvesting at ground level, ploughing in, the stover, which are the dried stalks and leaves left in the field after harvesting the rice panicles and flooding the rice fields have been reported to destroy majority of larvae in the stubble and any diapausing (dormant) larvae (Riba, 2007). Riba (2007) also reported that since adult moths lay eggs near the tip of the leaf blade, clipping the seedlings before transplanting reduces the carry-over of eggs from the nursery to the main rice field.

Trichogramma chilonis., egg parasitoids, have been identified as suitable biological control agents and are extensively used in India against lepidopteran pests where they are marketed as Tricho-cards® (Khan *et al.*, 2005). However, use of systemic pesticides is the best option when there are pest outbreaks of resurgences (Riba, 2007).

Insecticides like OGOR 40 EC® (Dimethoate 400 g L^{-1}) is used to routinely spray against *M. separatella* at Mwea irrigation scheme (PCPB., 2013).

Pest management in irrigated rice production systems has been reported to be compromised by cultivation practices, such as monoculture of similar varieties, intensive use of chemical inputs (fertilizers and pesticides) and asynchronous planting (CABI., 1996; Heinrichs and Barrion, 2004). It has been reported that high *M. separatella* infestation occur in areas where two crops of rice are grown per year. It has also been found that stem borer moths are active fliers and can migrate and infest new rice fields 5 km distant and that they are attracted by standing water bodies (CABI., 1996). This implies that in an irrigation scheme with wide hectarage it is possible to achieve non-uniform *M. separatella* infestation across the seasons. The aims of this study were to investigate the effect of farming practices (water provision and cropping system) on fluctuation of *M. separatella* at Mwea irrigation scheme.

MATERIALS AND METHODS

The study was carried out at Mwea Irrigation Scheme (0°40'S; 37°18'E) (Jaetzold *et al.*, 2006) in Kirinyaga County, Central Province, Kenya. It is in the low altitude agro ecological zone, Lowland Midland zone 4 and 1,100-1200 meters above sea level (Jaetzold *et al.*, 2006). The study was from 22 September, 2010-29 June, 2011 and represented two dry and two wet periods. Description of treatments (irrigation water provision and cropping system) is given in Table 1.

Rice farms with these factors were randomly selected in the whole scheme with help from the management of Mwea Rice Growers Multi-Purpose Cooperative Society. The study was arranged as a 2×3 factorial design and each treatment replicated three times. The first factor was irrigation water provision at three levels flood, sporadic and System for Rice Intensification.

This is alternate wet and dry irrigation where the crop is maintained in semi aerobic conditions during the vegetative phase, followed by shallow flooding after panicle initiation (Nyamai, 2012). The second factor was cropping system also at three levels (main crop, double crop and ratoon). Sampling was done using 1 m² quadrants, which were placed randomly in the farm. Three

Table 1: Irrigation water provision and cropping system categories involved in the Mwea irrigation scheme during the study from September 2010- July 2011

Categories	Description
Water provision (1st factor)	
Flood irrigated	Conventional method at Mwea. Rice grown under continuous flooded conditions (Nyamai, 2012)
Sporadic irrigation	Frequent water shortages and application of irrigation water varied from time, there being in most cases prolonged dry spells
System of rice intensification	Alternate wet and dry irrigation. The crop is maintained in semi aerobic conditions during the vegetative phase, followed by shallow flooding after panicle initiation (Nyamai, 2012)
Cropping system (2nd factor)	
Main season crop	Conventional crop which was planted normally and within the main cropping season with the following cropping sequence (rice-fallow period-rice)
Double crop	Rice crop planted immediately after the harvest of the main crop and in most cases was planted late in the following sequence (rice -rice-rice)
Ratoon crop	Main crop was harvested when the stems were still green and the stalks cut before the main crop was fully mature, leaving main crop stubble with 2-3 nodes which sprouted to form the next crop in the following sequence (rice-ratoon-rice)

quadrants were undertaken in each farm. Sampling was done after every 14 days starting from 22 September, 2010 to 2 July, 2011. A different part of the farm was sampled on the subsequent sampling date. The average size of sampled farms was 0.4 ha.

Data taken included, number of *M. separatella* larva, white heads and tunneled tillers. At harvest 20 hills in a quadrant were randomly selected and from these, yield components data was taken. All the tillers from each experimental plot were dissected and the number of tunneled tillers and *M. separatella* immatures (larvae and pupae) counted. The count of white hands and tunneled tillers at each sampling was subtracted from previous total and expressed as a percentage. Prior to analysis pest data was normalized using square root transformation (SQRT(X+0.5) while percent white heads and percent stem tunneling were arcsine-square root transformed (arc_p = arcsin (SQRT (p)). Data were subjected to ANOVA and means separated by Fishers Least Significance Difference (LSD) at $p<0.05$ where differences were significant by use of GENSTAT Version 12 statistical software.

RESULTS

The number of white heads/m^2 was low in areas of flood water provision and in the Systems for Rice Intensification (SRI). High *M. separatella* infestation occurred in sporadic water provision farms.

Highest number of white heads occurred in areas where rice was double-cropped and the lowest in the ratoon crop. Analysis of variance revealed no significant differences in the number of white heads between the on-season crop and ratoon cropping system and between flood and SRI methods of irrigation water provision. It was also shown that irrigation water provision (df 2, 17, p = 0.034) and cropping system (df 2, 17, p = 0.002) had significant effects on the number of white heads and there was no interaction between irrigation water provision and cropping system (df 2, 17, p = 0.076). Cropping system (df 2, 17, p = 0.028) had significant influence on the number of tunneled tillers m^{-2} but the effects of water provision on this parameter were not significant (df 2, 17, p = 0.059) (Table 2).

The number of *M. separatella* larvae was highest in the sporadic irrigation water provision and where rice was double cropped. Larvae were present in the double-cropped rice irrespective of method of irrigation. There were no larvae in on- season and ratoon crop where rice cultivation was under flood water and SRI water provision. The ANOVA showed that irrigation water provision (df 17, 2, p = 0.04) and cropping system (df 17, 2, p = 0.015) significantly influenced the number of larvae/m^2. There was significant interaction between irrigation water provision and cropping system (df 17, 2, p = 0.037) (Table 3).
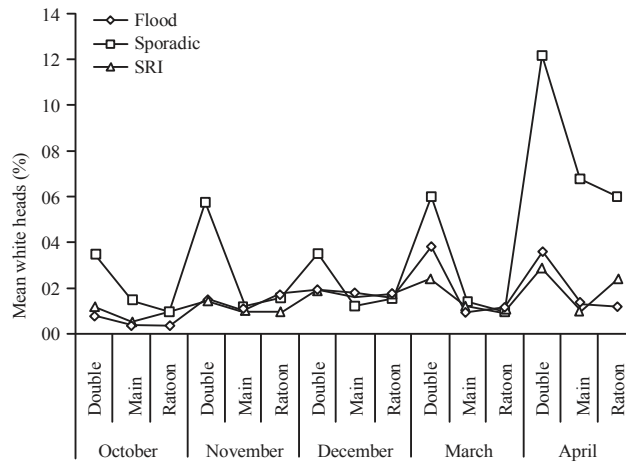
Fig. 1: Mean number of whiteheads in different water provision and cropping systems at Mwea irrigation in October-December, 2010 and March and April, 2011

Table 2: Number of white heads and tunneled tillers in different irrigation water provision schedules and cropping systems at Mwea irrigation scheme

Parameters	White heads/m^2	Tunneled tillers/m^2
Irrigation water provision		
Sporadic	9.70[a]	8.87[a]
System of rice intensification	5.48[b]	4.48[b]
Flood	4.42[b]	4.27[b]
p	0.034	0.05
LSD	4.37	2.21
Cropping system		
Double	13.66[a]	12.63[a]
On- season	6.37[b]	6.02b
Ratoon	4.25[b]	3.78[b]
p	0.002	0.028
LSD	4.37	2.21

Means in a column with the same letter are not significantly different by Fishers LSD (p<0.05), ns: Not significant

Table 3: Number of larvae in different irrigation water provision schedules and cropping systems at Mwea irrigation scheme

Parameters	Cropping system	Larvae/m^2
Irrigation water provision		
Sporadic	Double	3.000[a]
Sporadic	Ratoon	2.700[a]
Sporadic	On-season	2.100[ab]
Flood	Double	0.580[bc]
System of rice intensification		
Double	0.12[c]	
Flood	On-season	0.0000[c]
Flood	Ratoon	0.0000[c]
SRI	On-season	0.0000[c]
SRI	Ratoon	0.0000[c]
p	00.037	
LSD	07.57	
CV (%)	42.8	

Means in a column with the same letter are not significantly different by Fishers LSD (p<0.05)

High *M. separatella* infestation in the scheme occurred in double cropped rice in November, 2010 (6%) and April, 2011 (12%). The October peak was in the double cropped rice while the April peak was in the crop trans-planted in early February. Similar trends occurred in the other two systems (Fig. 1).

Table 4: Weight of rice grains and percent filled grains in different irrigation methods and cropping systems at Mwea irrigation scheme

Irrigation method	Mean 1000 grains weight	Mean (%) filled grains
Flood	21.270[a]	72.670[a]
Systems of rice intensification	20.430[ab]	38.380[b]
Sporadic	20.000[b]	6.440[c]
p	00.030	0.040
LSD	16.000[4]	0.340
CV (%)	28.000	18.100

Means in a column with the same letter are not significantly different by Fishers LSD (p<0.05), ns: Not significant

Table 5: Number of productive panicles in different water provision and cropping systems at Mwea irrigation scheme

Irrigation water provision	Cropping system	Productive panicles/m^2
Flood	On-season	685.4[a]
System of rice intensification	On-season	617.5[ab]
System of rice intensification	Ratoon	564.0[bc]
Flood	Ratoon	505.0[c]
System of rice intensification	Double	277.0[d]
Flood	Double	180.3[de]
Sporadic	Ratoon	168.5[e]
Sporadic	On-season	129.9[e]
Sporadic	Double	111.5[e]
p		<0.001
LSD		90.590
CV (%)		11.200

Means in a column with the same letter are not significantly different by Fishers LSD (p<0.05)

Table 6: Mean number of white heads/m^2 at different growth stages

Growth stage	Water provision		
	Flood	Sporadic	System of rice intensification
Panicle initiation	01.20	01.60	01.60
Booting	03.90	05.90	03.80
Heading	06.40	10.00	07.00
Flowering	08.90	14.10	10.20
Milky stage	11.40	18.40	13.20
Dough stage	13.80	22.70	16.70
Mature grain	16.10	26.70	18.90
p	00.13	00.09	00.20
SE	00.50	01.20	00.63
CV (%)	35.50	26.20	46.50

The lowest weight of grains and percent filled grains were found in the sporadic irrigation water provision. The ANOVA indicated that irrigation water provision (p = 0.030) had significant effect on the weight of rice grains but the influence of cropping system (p = 0.059) was not significant. Irrigation water provision (p = 0.040) and cropping system (p = 0.050) had significant influence on percent filled grains but there was no interaction between irrigation water provision and cropping system on this parameter (p = 0.096) (Table 4). The least number of productive panicles was in all the cropping systems under sporadic water provision, with the lowest in the double cropped rice. Irrigation water provision (p<0.001) and cropping system (p<0.001) had significant effect on number of productive panicles and there was interaction between irrigation water provision and cropping system (p<0.001) (Table 5).

The number of white heads was high at panicle initiation, peaked at booting and decreased slightly towards maturity. The infestation was highest in the sporadic water provision. There were no significant difference in the number of white heads between rice crops under flood water provision and SRI (Table 6).

DISCUSSION

The influence of different planting regimes at Mwea irrigation scheme was evident: high pest infestations were in areas where rice has been double-cropped. These results are consistent with findings from other studies which indicate that if a rice-growing area comprises a mixture of farms sown at different times, there will be many oviposition periods, leading to overlapping generations (Umeh *et al.*, 1992). Litsinger *et al.* (2009) reported that insect pest damage particularly from stem borers was greater in areas where farmers staggered their planting up to 3 months apart and used a set of varieties that matured in 140-210 days than where farmers planted rice within 1 month, used 120-d varieties and planted at the start of rainy season. In an experiment at Philippine Rice Research Institute (PhilRice) at Agusan del Norte, Batayan *et al.* (2005) found out that the incidence of whiteheads due to white stem borer, *Scirpophaga innotata* Walker, damage was lower in rice planted earlier on December, 15 and that rice that was planted late on February, 15 had the highest whitehead incidence These cultural practices are similar to Mwea, where farmers cultivate rice throughout the year and use medium duration varieties like Basmati 370 which has a maturity period of 122 days and (BW 196) which take 135 days to mature (Anonymous, 2003).

The high *M. separatella* infestation in a sporadic double crop is in agreement with work of Litsinger *et al.* (2009) who reported that expanded growth period favoured vegetative pest build up in flooded rice cultivation. They also found out that rain fed wetland rice system which may be equated with sporadic irrigation at Mwea was more prone to physiological stresses than flood irrigated crop and this minimizes crop compensation and accentuates losses (Litsinger *et al.*, 2009). It was reported from Philippines that losses of 5-71% were highest in the sites with the smallest rice area in which pests were concentrated and in the poorest soils, which constrained yield compensation (Litsinger *et al.*, 2009). Similarly, high *M. separatella* occurred in sporadic irrigated areas at Mwea, which were areas with unsuitable soils for rice growing and inadequate supply of water for flooded rice cultivation.

The findings in this study of two *M. separatella* population peaks at Mwea are consistent with reports of CABI. (1996) of a major peak in November and a minor peak in April. However in this study, the major peak was in April and the minor peak in October. This shift is possibly due to continuous cropping of rice which was not previously, the case before 1998 (Kuriah *et al.*, 2003) which result in the presence of the pest throughout the year. The presence of low pest infestations in the ratoon, contradicts previous findings of high *M. separatella* infestation in the study area (CABI., 1996). Possible reasons for this may be that due to the recent importance of rice straw as fodder for livestock, there has been a reduction of straw being left standing or stacked in the fields and thus a substantial reduction of the reservoirs for the pest. The ratoon crop also matures much earlier than the double crop and thus, may escape attack.

The evidence of reduction in weight of the grains and productive panicles and increase in number of empty panicles is consistent with other findings that *M. separatella* infestations cause a reduction in productive tillers and yield components (Litsinger *et al.*, 2006). The 15% white heads damage in this study is within the range observed by Sarawar on stem borer damage on aromatic rice (Sarwar, 2011). The presence of high *M. separatella* infestations in the double crop planted rice irrespective of whether the rice culture was conventional or SRI, underpinned the importance of double cropping, which can be equated to late planting, on stem borer infestations. This is consistent with findings from a study that tested three planting times, first planting, 14 days before farmers' planting time, the second, simultaneous with farmers and the third, 14 days after farmer planting. They found out that at three weeks after transplanting, stem borer infestation in the third planting time was significantly higher than the other two (Suharto and Usyati, 2005).

Reports have also been made of low stem borer infestation in rice grown under the System of Rice Intensification (SRI) (Uphoff, 2007) but in this study there was no evidence that *M. separatella* population infestation was lower in the SRI system than in the conventional flooded method of growing paddy rice.

CONCLUSION

Irrigation methods and cropping systems greatly influence fluctuation of *Maliarpha separatella* infestation and in case of double cropping it will be necessary to control the stem borer. Efforts should be made to ensure that farmers synchronize planting dates and to include a rice break between two consecutive rice seasons, by growing a suitable dry land crop. Attempts should also be made to research on the influence of System for Rice Intensification on *M. separatella* infestations.

ACKNOWLEDGMENTS

REFERENCES

Anonymous, 2003. Varieties in Kenya. http://dev.infonet-biovision.org/content/rice.

Batayan, E.H., A.B. Estoy, A.A. Ortiz and R.T. Cruz, 2005. Management options for white stem borer, *Scirpophaga innotata*, walker in irrigated lowland rice in Agusan del Norte. Philippine Rice Research Institute-Agusan del Norte, Bureau of Agricultural Research, June 2005.

CABI., 1996. *Maliarpha separatella*. CAB International, Distribution Maps of Plant Pests, Map No. 271, Wallingford, UK.

Heinrichs, E.A. and A.T. Barrion, 2004. Rice Feeding Insects and Selected Natural Enemies in West Africa. In: Biology, Ecology and Identification, Hettel, G.P. (Ed.). International Rice Research Institute, Laguna, Philippines, pp: 237.

Jaetzold, R., H. Schimdt, B. Hornetz and C. Chisanya, 2006. Farm management handbook of Kenya. Part A. West Kenya subpart A1 Western province. Kirinyaga District Agro-ecological zones and subzones, German Agency for Technical Cooperation (GTZ).

Khan, R.A., J.A. Khan, F.F. Jamil and M. Hamed, 2005. Resistance of different basmati rice varieties to stem borers under different control tactics of IPM and evaluation of yield. Pak. J. Bot., 37: 319-324.

Kimani, A.W., N. Kiarie, J.K. Ikahu and J.M. Kimani, 2010. Factors leading to the deterioration of aroma and grain quality in Kenyan Basmati rice. Proceedings of the 12th KARI Biennial Conference, November 8-12, 2010, Nairobi, Kenya.

Kuriah, J.N., H. Ommeh, L. Kabuage, S. Mbogo and C. Mutero, 2003. Technical efficiency of rice producers in Mwea irrigation scheme. Proceedings of the 6th African Crop Science Conference of the African Crop Science Society, October 12-16, 2003, Nairobi, Kenya, pp: 668-673.

Litsinger, J.A., B.L. Canapi, J.P. Bandong, M.D. Lumaban, F.D. Raymundo and A.T. Barrion, 2009. Insect pests of rainfed wetland rice in the Philippines: Population densities, yield loss and insecticide management. Int. J. Pest Manage., 55: 221-242.

Litsinger, J.A., J.P. Bandong, B.L. Canapi, C.G. Dela Cruz, P.C. Pantua, A.L. Alviola and E.H. Batay-An III, 2006. Evaluation of action thresholds for chronic rice insect pests in the Philippines. IV. Stemborers. Int. J. Pest Manag., 52: 195-207.

Nyamai, M., 2012. A comparative assessment of SRI and conventional rice production in Mwea irrigation scheme, Kenya. M.Sc. Thesis, Jomo Kenyatta University of Agriculture and Technology.

PCPB., 2013. Pest Control Products Registered for use in Kenya. 6th Edn., Pest Products Control Board, New York, USA., pp: 156.

Rahman, M., H. Rashid, A.A. Shahid, K. Bashir, T. Husnain and S. Riazuddin, 2007. Insect resistance and risk assessment studies of advanced generations of basmati rice expressing two genes of *Bacillus thuringiensis*. Elect. J. Biotechnol., 10: 240-251.

Riba, T., 2007. Integrated pest management in paddy. Krishi Vigyan Kendra College of Horticulture and Forestry, Central Agricultural University, Pasighat. http://www.afpro.org /naip/wp-content/uploads/sites/4/2013/12/Case%20Study_IPM%20in%20Paddy.pdf.

Sarwar, M., 2011. Effects of Zinc fertilizer application on the incidence of rice stem borers (*Scirpophaga* species) (Lepidoptera: Pyralidae) in rice (*Oryza sativa* L.) crop. J. Cereals Oilseeds, 2: 61-65.

Suharto, M. and N. Usyati, 2005. The stem borer infestation on rice cultivars at three planting times. Indonesian J. Agric. Sci., 2: 39-45.

Umeh, E.D.N., R.C. Joshi and M.N. Ukwungwu, 1992. Biology, status and management of rice insect pests in Nigeria. Crop Protect., 11: 408-413.

Uphoff, N.T., 2007. System of Rice Intensification (SRI): An efficient, economical and ecologically-friendly way to increase production. Pesticide Action Network Asia and Pacific (PANAP), Rice sheets, pp: 5-6. http://www.panap.net/sites/default/files/rs_sri.pdf.