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

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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) 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
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 flyers 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 (Nyangai, 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 (Nyangai, 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/m² 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/m². 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/m² | Tunneled tillers/m² |
|-----------------------------------|----------------|---------------------|
| **Irrigation water provision**    |                |                     |
| Sporadic                          | 9.70<sup>a</sup> | 8.87<sup>a</sup>    |
| System of rice intensification     | 5.48<sup>b</sup> | 4.48<sup>b</sup>    |
| Flood                             | 4.42<sup>a</sup> | 4.27<sup>b</sup>    |
| p<sub>0.034</sub>                 | 0.034          | 0.05               |
| LSD                               | 4.37           | 2.21               |
| **Cropping system**               |                |                     |
| Double                            | 13.66<sup>a</sup> | 12.63<sup>a</sup>  |
| On-season                         | 6.37<sup>b</sup> | 6.02<sup>b</sup>   |
| Ratoon                            | 4.25<sup>a</sup> | 3.78<sup>b</sup>   |
| p<sub>0.002</sub>                 | 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/m² |
|-----------------------------------|-----------------|-----------|
| **Irrigation water provision**    |                 |           |
| Sporadic                          | Double          | 3.000<sup>a</sup> |
| Sporadic                          | Ratoon          | 2.700<sup>a</sup> |
| Sporadic                          | On-season       | 2.100<sup>b</sup> |
| Flood                             | Double          | 0.580<sup>a</sup> |
| System of rice intensification    |                 |           |
| Double                            | 0.12            |           |
| Flood                             | On-season       | 0.0000<sup>c</sup> |
| Flood                             | Ratoon          | 0.0000<sup>c</sup> |
| SRI                               | On-season       | 0.0000<sup>c</sup> |
| SRI                               | Ratoon          | 0.0000<sup>c</sup> |
| p<sub>0.037</sub>                 | 0.0037         |           |
| LSD                               | 0.0757         |           |
| 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 transplanted 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\(^b\)            |
| p                                     | 0.030                   | 0.040                  |
| LSD                                   | 16.000\(^a\)           | 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/m² |
|----------------------------|-----------------|-------------------------|
| Flood                      | On-season       | 685.4\(^a\)            |
| System of rice intensification | On-season       | 617.3\(^a\)            |
| System of rice intensification | Ratoon         | 564.0\(^a\)            |
| Flood                      | Ratoon          | 505.0\(^a\)            |
| System of rice intensification | Double        | 277.0\(^b\)            |
| Flood                      | Double          | 180.3\(^a\)            |
| Sporadic                   | Ratoon          | 168.5\(^a\)            |
| Sporadic                   | On-season       | 129.9\(^a\)            |
| Sporadic                   | Double          | 111.5\(^a\)            |
| 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/m² 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**

The authors are grateful to Mwea rice farmers in the study sites for their willingness and cooperation. The funding from the Director, Kenya Agricultural Research institute (KARI) now Kenya Agricultural and Livestock Research Organization (KALRO) and the Secretary/Chief Executive Officer, National Council for Science and Technology (NCST) is acknowledged.

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