DETERMINATION OF ECONOMIC THRESHOLD LEVEL FOR *CHILO AGAMEMNON* BLES. INFESTATION IN RICE PLANTS, BASED ON SIMULATED DEAD HEARTS

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Abstract

A field experiment was carried out at the Experimental Farm of Sakha Agricultural Station in 2014 rice season using two cultivars, Giza 178 (high tillering capacity) and Egyptian Jasmine (medium tillering capacity) to determine the economic threshold level for control measures of stem borer *Chilo agmemnon* Bles. in rice. Seven simulated levels of dead hearts; 0, 5, 10, 15, 20, 25 and 30% were adopted to find out their effects on rice yield and yield components. In Giza 178 cultivar, dry matter content was significantly reduced at 25% detillering. Panicle weight, 1000-grain weight and filled grains increased as the detillering level increased. This could be attributed to the compensation phenomenon, as the rice hills that suffered from high detillering produced heavier grains in the remaining tillers. This trend was also obtained with the Egyptian Jasmine. The rice yield was significantly reduced at 15% in the former cultivar and at 20% in the latter one. Economic analysis showed that the economic threshold is 25% damaged tillers in Giza 178 rice cultivar and 20% in the Egyptian Jasmine. This might be due to that Giza 178 is higher tillering cultivar than the Egyptian Jasmine. Thus, control measures, particularly insecticides, should not be applied before dead hearts reach 25% in case of Giza 178 cultivar and 20% in case of Egyptian Jasmine.

Key words: Rice, stem borers, dead heart simulation, yield, yield components, economic threshold.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops all over the world, and it is the staple food of over half of the global population. It is the principal source of energy, carbohydrates, proteins, minerals and vitamins in human diets of several developing countries (Anonymous, 1993). In Egypt, rice is a cash money crop for most of the growers, and it is a permanent favorable dish.

Rice plants are liable to attacks of several insect pest species, however, the rice stem borer, *Chilo agmemnon* Ble., is the most important that results in annual yield losses of 5.8% (El-Malky *et al.,* 2013). This insect pest infests rice plants, almost all the rice season round, inducing "dead hearts" symptom during the vegetative stage, and "white heads" during the reproductive stage.

Reports about the level of dead heart that significantly reduces rice yield are conflicting. Dyck *et al.* (1978) assessed the level of economic threshold of stem borer infestation in rice as more than 10% dead hearts. Rubia *et al.* (1987) simulated dead hearts occurring by the rice stem borers in rice plants, during vegetative stage, and found that 10 – 30% detillering had no significant effect on yield, but 60% tillers removal reduced yield by 12 – 82%. Sherawat *et al.* (2007) induced artificial infestation levels in rice plants to mimic natural infestation, and considered 7.5% dead hearts as the economic threshold level. The lowest economic threshold was calculated by Suhail *et al.* (2008) as only 5% dead hearts, and more than this level they obtained significant reduction in grain yield as comparable to stem borer control measures.

Estimating economic threshold level for rice stem borer infestation is highly required because the growers are worried about stem borer infestation whatever the infestation level is. These perceptions of growers lead them to use insecticides whenever it is not needed. Development and implementation of economic thresholds are rational approaches to pest management designed to aid growers in making pest control decision (Way *et al.,* 1991). Thus, yield loss data are useful to farmers, extension workers, researches and policy makers (Selvaraj *et al.,* 2012).

The objective of the current study was to find out the relationship between simulated rice stem borer infestation (as dead hearts) and yield losses to assess the economic threshold level of the borer. In addition, the effects of simulated dead heart levels on some rice growth characteristics, and yield components were investigated.

Because the determination of economic threshold levels using simulation technique is not influenced by environmental conditions, the current investigation was conducted for only one year. However, applying this technique on two rice cultivars, differing in their genetic background, can lead to dependable conclusions.

MATERIALS AND METHODS

This experiment was carried out at the Experimental Farm of Rice Research and training Center, Sakha Agricultural Research Station in 2014 rice season. The experiment aimed at assessing the effect of detillering (tiller removal) in rice hills on yield and yield components, and evaluating the economic threshold level of rice stem borer infestation based on dead heart simulation, in two rice cultivars.

1. Nursery preparation:

The seed bed was prepared as recommended by rice agronomists (Anonymous 2013). During tillage, calcium superphosphate (15.5%

P_2O_5) was incorporated into the soil at a rate of 150 kg /fed. Just before wet leveling, 4 kg urea (46.5% N) was added to the nursery that measured 150 m^2. After leveling, 2 kg/ kerat of zinc sulphate were broadcasted, followed directly by

broadcasting pregerminated rice seeds (50 kg/fed) of Giza 178 or Egyptian Jasmine (two separate nurseries) on 10th of May. Ten days later, the herbicide Saturn at a rate of 2 l/ fed., mixed with sand, was broadcasted onto the nursery. Irrigation and drainage were conducted according to agricultural recommendations.

2. Permanent field:

The permanent field was prepared as recommended. The experimental area was divided into 56 plots, each of 2 m^2. Twenty-eight plots were assigned for Giza 178 cultivar, and 28 plots for Egyptian Jasmine cultivar. The experimental area was laid-out in a completely randomized block design, with four replicates. One month after seed broadcasting, rice seedlings were pulled out and transplanted (20 x 20 cm) in the permanent field. Fertilization and other cultural practices were followed as recommended till harvest.

3. Treatments:

One month after transplanting, seven detillering levels; 0, 5, 10, 15, 20, 25 and 30% were adopted. The tillers were removed at the base of the plants, as they were cut by a sharp cutter. To determine the number of tillers needed to be removed according to detillering levels, total tillers in each plot ($2m^2$) were counted and multiplied by the detillering percentage.

4. Considered parameters:

Dry matter, panicle length, panicle weight, 1000-grain weight, percentage of filled grains and grain yield were evaluated.

5. Statistical analyses:

Data were subjected to ANOVA, and means were compared using Duncan's Multiple Range Test (1955).

RESULTS AND DISCUSSION

Data in Tables (1 & 2) present the effect of detillering levels on rice yield and yield components in Giza 178 and Egyptian Jasmine rice cultivars.

1. Dry matter:

Variable levels of detillering induced differences in rice dry matter content of Giza 178 cultivar (Table, 1). The highest values of dry matter were obtained at 5% detillering (2511.33 g / m^2) and at the check treatment (2418.20 g / m^2). However, detillering at levels of 0, 5, 10, 15 and 20% resulted in non significant differences among each other, with values ranging between 2190.22 and 2511.33 g / m^2. On the other hand, the lowest amounts of dry matter resulted from 25 and 30% detillering, with values of 1712.13 and 1690.18 g / m^2, respectively. Statistical analysis revealed that dry matter contents due to 0 up 20% detillering differed significantly from those due to 25 and 30% detillering. This indicates that rice plants compensated for damage up to 20%, but more than that level, the dry matter, which represents an important

component of rice yield, was significantly reduced and the damage could not be compensated.

In Egyptian Jasmine cultivar (Table, 2), the highest dry matter content (2630.58 g / m^2) was at the check treatment, followed gradually by those at 5, 10, and 15% detillering, without significant differences among each other. The levels 20, 25 and 30% detillering induced the lowest dry matter contents, ranging between 1677.40 and 1930.35 g / m^2. This means that rice plants of Egyptian Jasmine cultivar compensated
for detillering (simulated dead heart) damage up to 15% only, and more than that level, the dry matter contents were significantly reduced.

2. Panicle length:

It was obvious, in both cultivars, that panicle length was not significantly affected by detillering treatments. This may be due to that
this characteristics is higher controlled by genetics more than by the environment (El-Malky, 2013).

3. Panicle weight:

In Giza 178 rice cultivar (Table, 1), significant differences in panicle weights were obtained due to detillering levels. The heaviest panicles were recorded at 15, 20, 25 and 30% detillering, with values of 3.68, 3.84, 3.95 and 3.99 g / panicle, respectively. Panicle weights at these four levels differed significantly from panicle weight at 0, 5 and 10% detillering which induced 3.18, 3.22 and 3.21 g / panicle, respectively.

A similar trend was obtained with Egyptian Jasmine cultivar, as the heaviest panicles were detected at 30% detillering (6.70 g / panicle) and at 25% detillering (5.03). The lightest panicles were found at 0 and 5% levels, with values of 3.66 and 3.91 g / panicle, respectively.

The high values of panicle weight in case of high detillering could be interpreted in the light of compensation phenomenon (Rubia *et al.,* 1996). They explained that the assimilates specified to injured tillers are translocated to the sound adjacent ones, thus, the remaining tillers have a chance to get more nutrients than normal and consequently become more vigorous. Also, Ahmed (1984) reported that rice plants may compensate for damage during early growth stages.

Table 1. Effect of detillering on Giza 178 rice cultivar yield and yield components, during 2014 season at Sakha Agricultural Research Station

Detillering %	Dry matter g/m2	Panicle length cm	Panicle weight g	1000-grain g	Filled grains %	Grain yield Gm/ $2m^2$
0	2418.20 a	22.36 a	3.18 b	20.33 c	86.37 c	2095 a
5	2511.33 a	21.15 a	3.22 b	20.91 c	89.59 b	2090 a
10	2368.58 a	22.09 a	3.21 b	20.77 bc	90.19 b	2045 ab
15	2415.90 a	22.54 a	3.68 a	21.77 b	91.46 ab	2085 a
20	2190.22 a	21.33 a	3.84 a	22.05 a	91.83 ab	2010 b
25	1712.13 b	22.14 a	3.95 a	22.92 a	92.88 a	1880 c
30	1690.18 b	21.60 a	3.99 a	22.83 a	94..23 a	1800 d
L. S. D.	460.30	1.42	0.43	1.01	3.02	61.24
Significance	*	ns	*	*	*	*

* Means followed by the same letter are not significantly different at the 5% level

Table 2. Effect of detillering on Egyptian Jasmine rice cultivar yield and yield components, during 2014 season at Sakha Agricultural Research Station

Detillering %	Dry matter g/m2	Panicle length cm	Panicle weight g	1000-grain g	Filled grains %	Grain yield gm / $2m^2$
0	2630.58 a 2521.15 ab	26.11	3.66 c	23.59 c	75.10 c	1780 ab
5	2424.66 abc	25.01	3.91 bc	25.27 b	74.99 c	1805 a
10	2177.04 abcd	26.30	4.04 bc	25.82 b	77.81 bc	1830 a
15	1930.35 bcd	26.42	4.15 bc	25.76 b	77.83 bc	1750 ab
20	1817.22 cd	26.75	4.92 b	26.24 ab	83.70 ab	1705 b
25	1677.40 d	26.01	5.03 b	26.28 ab	83.71 ab	1560 c
30		26.25	6.70 a	26.95 a	89.50 a	1590 c
L. S. D.	620.15	1.98	1.26	1.18	8.12	86.72
Significance	*	ns	*	*	*	*

* Means followed by the same letter are not significantly different at the 5% level

4. 1000 – grain weight:

The grain weights were, in both cultivars, higher at levels of 20, 25 and 30% detillering, ranging between 22.05 and 22.92 g in Giza 178 cultivar, and between 26.24 and 26.95 g in Egyptian Jasmine cultivar. These grain weights were significantly higher than those at 0, 5, 10, and 15% detillering. These results could be interpreted in the light of previously mentioned phenomenon of compensation.

5. Filled grains:

In Giza 178 cultivar (Table 1), the high values of filled grains were obtained at 25 and 30%, with 92.88 and 94.23%, respectively., while the low values were obtained at the check (86.37) and at 5% (89.59%).

The same trend was observed with the Egyptian Jasmine cultivar, as the high percentages of filled grains were those at 25 and 30% and the low ones were at 0 and 5% detillering. Differences in filled grain percentages of both cultivars were significant.

6. Grain yield:

The five abovementioned parameters are the main components of the final yield. Despite that detillering enhanced most of yield components, the stand of rice plants is the main factor affecting the obtained yield. It is true that rice hills can compensate for the injured tillers, but this occurs at a certain level. This phenomenon was demonstrated by Rubia *et al.* (1987) who indicated that 10 and 30% rice detillering had no significant effect on rice yield, but 60% tiller removal reduced the yield by 12 to 82%. The authors explained that the non-injured tillers were not capable of compensating all injured ones.

In the current investigation, higher grain yields of Giza 178 rice cultivar (2085 – 2095 g / m^2) were obtained at 0 – 15% detillering as compared to those at 20 – 30% detillering (1800 – 2010 g/ m^2) and the differences were significant. A similar result was obtained with Egyptian Jasmine, as the high grain yields (1805 and 1830 g / m^2) were obtained at 5 and 10% detillering, while, the low grain yields were obtained at 25 and 30% detillering. Posche *et al.* (2009) reported that no yield losses occurred at 0, 5, 10, 25 and 50% cutting (simulating) stems, when the stems were cut at tillering stage. However, at booting stage, cutting more than 10% of stems resulted in significant yield losses. This result is in the trend of the current investigation. Using simulation technique to evaluate the yield losses due to insects was necessary in the current study, as it is difficult in the open field to find gradual levels, of dead hearts to be correlated with the rice yield and yield components. Reji *et al.* (2008) recommended using rice crop simulation model-based economic injury levels as a useful tool in monitoring the rice stem borer injury and in need assessment for pesticide application. That unnecessary expenditure and environmental contamination could be avoided.

7. Economic analysis:

7.1. Giza 178 rice cultivar:

Data in Table (3) showed the effect of detillering levels adopted in the plots of Giza 178 rice cultivar on yield reduction and calculated as monetary reduction in the income of one feddan. The granulated insecticide, Furadan 10% (the most common) is applied by the growers twice, each at a rate of 6 Kg / fed. But most farmers apply about 4 kg / fed in each application. The average price of one ton of paddy rice is 2000 L.E., and that of Furadan is 40 L.E. per one Kilogram, in addition to 30 L.E. as a labor cost. Calculating these inputs and outputs, it was found that at 20% detillering, the rice yield reduction was 170 Kg / feddan, equivalent to 340 L.E. and the control cost (insecticide + labor) was 350 L.E.. So, at 20% dead hearts, the chemical control is not economic. Behind this level, 25% detillering resulted in yield reduction of 430 kg / feddan, equivalent to 860 L.E. The monetary reduction value is higher than the control cost (350 L.E.). Thus, the economic threshold level for
rice stem borer is considered 25% dead hearts for Giza 178 rice cultivar, depending on the conditions of the current research.

Table 3. Economic analysis of Giza 178 rice cultivar grain yield value compared with application of insecticide.

Detillering %	Yield / 2 m^2 (g)	Yield / feddan (tone)	Yield reduction / feddan	Monetary reduction (L.E.)	Control cost (L.E.)
0	2095	4.190	–	–	350
5	2090	4.180	10	20	350
10	2045	4.090	100	200	350
15	2085	4.170	20	40	350
20	2010	4.020	170	340	350
25	1880	3.760	430	860	350
30	1800	3.600	590	1180	350

Price of paddy rice = 2000 L.E. per ton
Cost of insecticide = 8 kg Furadan (two applications) X 40 L.E. = 320 L.E.
Labor cost = 30 L.E. for insecticide broadcasting
Total control cost = 320 + 30 = 350 L.E.

7.2. Egyptian Jasmine rice cultivar:

Applying the same values of inputs and outputs, it was found that Egyptian Jasmine rice cultivar (Table 4) lost 60 kg / feddan due to 15% detillering which equals 150 L.E. (as a price of 2500 L.E. / ton).

This value of monetary reduction (150 L.E.) is lower than control cost (350 L.E.). More than this level, 20% detillering resulted in a yield loss of 150 kg / feddan, equivalent to 375 L.E. Since the latter value is greater than the control cost, it is concluded that economic threshold level for rice stem borer is 20% dead hearts in

case of Egyptian Jasmine rice cultivar. Because Giza 178 rice cultivar has higher tillering capacity than Egyptian Jasmine has, the economic threshold level was higher (25% detillering) in the former cultivar than in the latter one (20% detillering) .

Several investigations evaluated the economic threshold levels of stem borers in rice and determined variable levels. These variations could be attributed to: 1) price of paddy rice, 2) price of insecticides, 3) yield reduction as influenced by dead heart level, and even, 4) labor cost. Rubia *et al.* (1987) found that no rice yield losses were obtained before 60% tillers removal which reduced the yield by 12.82%. Afzal *et al* (2002) reported that between 7.5 and 10% infestation level, cost of chemical control of rice stem borers was equal or less than rice yield reduction in yield, and this level can be considered as the economic threshold. Sherawat (2007) assessed 7.5% stem borer infestation as the economic threshold, while (Suhail, 2008) considered 5% as the economic threshold.

Table 4. Economic analysis of Egyptian Jasmine rice cultivar grain yield value compared with two times of insecticide applications.

Detillering %	Yield / 2 m^2 (gm)	Yield / feddan (tone)	Yield reduction / feddan	Monetary reduction (L.E.)	Control cost (L.E.)
0	1780	3.560	–	–	350
5	1805	3.610	–	–	350
10	1830	3.660	–	–	350
15	1750	3.500	60	150	350
20	1705	3.410	150	375	350
25	1560	3.120	440	1100	350
30	1590	3.180	380	950	350

Price of paddy rice = 2500 L.E. per ton
Cost of insecticide = 8 kg Furadan (two applications) X 40 L.E. = 320 L.E.
Labor cost = 30 L.E. for insecticide broadcasting
Total control cost = 320 + 30 = 350 L.E.

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تقدير الحد الاقتصادى الحرجه لإصابة الأرز بثاقبة الساق بمحاكاة القلب الميت. Chilo agamemnon Bles

على محمود سليمان[١] ، أحمد سمير هنداوى[١] ، أمانى سامى الحفنى[١] ، محمود رمزى شريف[٢]

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أجريت التجربة فى المزرعة البحثية بمحطة البحوث الزراعية بسخا ٢٠١٤ باستخدام صنفى الأرز جيزة ١٧٨ (عالى التفريع) والياسمين المصرى (متوسط التفريع) لتقدير الحد الاقتصادى الحرج لمكافحة ثاقبة ساق الأرز. تمت محاكاة مظهر لإصابة بالقلب الميت، وذلك بازالة الخلفات بالمعدلات الآتية: صفر، ٥، ١٠، ١٥، ٢٠، ٢٥، ٣٠% و إيجاد العلاقة بين هذه النسب ومحصول الأرز ومكوناته. فى الصنف جيزه ١٧٨ تأثرت المادة الجافة سلبيا وبشكل معنوى عند ازالة ٣٠% من الخلفات. ولكن زاد وزن السنبلة ووزن الألف حبة كما زادت نسبة الحبوب الممتلئة بزيادة معدلات الاصابة، وذلك راجع الى ظاهرة التعويض حيث أن الخلفات المتبقية تحصل على كمية أكبر من الغذاء مقارنة بالجور التى تتم فيها ازالة نسب منخفضة من الخلفات. وكانت هذه الظاهرة موجودة فى كلا الصنفين وبالأخذ فى الاعتبار ثمن الارز الشعير كما هو سائد فى ا لأسواق وكذا تكاليف عملية المكافحة (ثمن المبيد + أجر العامل). ووجد أن نسبة ٢٥% تعتبر حدا اقتصاديا حرجا لصابة فى الصنف جيزه ١٧٨، بينما وجد نسبة ٢٠% هى الحد الاقتصادى الحرج للاصابة فى صنف الياسمين المصرى . وقد يرجع انخفاض الحد الاقتصادى الحرج فى الياسمين عنه فى الجيزه ١٧٨ الى قدرة الصنف الأخير على انتاج خلفات أكثر وبالتالى يكون أكثر تحملا للاصابة بالثاقبة. وعلى هذا لا يجب البدء فى اجراءات المكافحة قبل وصول الاصابة الى ٢٠% قلب ميت فى الأصناف متوسطة التفريع و٢٥% فى الأصناف عالية التفريع.