SIMULATING DAMAGE OF LEAFMINER, *HYDRELLIA PROSTERNALIS* AND ITS EFFECT ON RICE GROWTH CHARACTERISTICS AND GRAIN YIELD

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Abstract

Rice is a vital food crop, in Egypt, particularly with the shortage of wheat production. Rice plants are subjected to several insect infestations which impair the productivity, consequently the growers tend to use insecticides for pest control. Unfortunately, they use these chemical insecticides regardless of insect infestation level. The current investigation was carried out at the Experimental Farm of Rice Research and Training Center, Sakha Agricultural Research Station during 2013 and 2014 rice seasons. Six defoliation levels; 0, 20, 40, 60, 80 and 100% were applied one month after transplanting to find out the effect of leaf removal on rice growth characteristics and yield. The whole leaves, at certain levels, were cut by hand. Leaf chlorophyll content was not affected by any of simulation levels. Plant height, leaf area index and dry matter content were not reduced due to defoliation up to 40 or 60%. These characteristics displayed significant reduction at 80 or 100% defoliation. As for yield components, the panicle weight was not significantly reduced up to 40% defoliation, but at levels of 60, 80 or 100% defoliation, the panicle weight was significant negatively affected. Also, the 1000-grain weight was significantly reduced at higher levels of defoliation (80-100%) compared to lower ones (20-60%). The grain yield was reduced by 14-17%, 21 and 34% at 60, 80 and 100% defoliation, respectively. Thus, rice leafminer infestation up to 40% could be considered not alarming to the rice growers.

Keywords: Rice, leafminer, simulation, defoliation, growth, yield, yield components.

INTRODUCTION

The Egyptian rice is a vital food crop, particularly with the big gap between wheat production and consumption. This gap is annually fulfilled by large amounts of wheat imports. Unfortunately, the land area and irrigation water required to expand rice production are limited, thus, most increases of the crop production should come from enhancing yield potentiality.

Insect pests are among the most important biotic constraints limiting rice yield potentiality. The rice leaf miner, *Hydrellia prosternalis* Deem. is one of these biotic stresses, which impairs rice growth, particularly during early growth stages (Sherif *et al.*, 1997). However, there are conflicting reports about the economic importance of this insect pest to rice plants. In such concern, Shepard *et al*. (1990) obtained no rice yield losses when up to 60% of leaves were damaged by *Hydrellia* spp. Pantoja (1990) reported that despite the damage looked alarming in rice plants due to *H. wirthi* infestation, the plants recovered when infested at early stages of development. Also, Matteson (2000) indicated that most of leaf feeding insects do not appear to cause significant yield losses, despite highly visible damage under most circumstances. On the other hand, Barrion and Litsinger (1987) reported that damage caused by *H. philippina* larvae during the booting stage results in unfilled grains. Heinrichs (2009) advised to collect yield loss data to be utilized by policy makers, extension workers, and even by the growers. Assessing, yield losses could be achieved by several techniques, from which are the artificial insect infestation and damage simulation. Because of complications in laboratory rearing of the ephydrid flies, *Hydrellia* spp. to be used in artificial infestation, simulating the insect damage, by gradual levels of defoliation becomes an appropriate alternation. Fokoshima *et al*. (1985) assessed the defoliation effect on the rice yield by clipping half of every leaf blade, and obtained for reductions in yield components, except for the tiller number, resulting in a decrease of grain weight per plant. Timing of rice defoliation is a limiting factor in rice yield losses. Thus, Rao and Divakar (1998) recorded no yield losses at 25% defoliation 15 and 35 days after transplanting (DAT). Fifty percent defoliation at 15, 30 or 45 DAT caused 7.0, 18.7 and 45.2% yield losses, respectively.

Determination of insect infestation level, either by real infestation or simulation of insect infestation is important to apply or not, control measures including chemical control which is toxic to natural enemies, leading to environmental imbalance. Natural enemies proved to be of a good impact in *Hydrellia* spp. control. Webber *et al*. (1988) recorded up to 30% of *H. griseola* pupae parasitized by *Opius* sp. Also, Moreno *et al*. (1994) reported that *H. wirthi* pupae are parasitized by *Opius* sp. as 28% with the integrated pest management, compared to 23% parasitism with chemical control.

The current study was carried out to find out the effect of levels of simulated defoliation on rice growth and yield. These data are necessary to conclude at which level of *H. prosternalis* infestation, control measures are required, which leads to stop insecticidal application up to a certain level of insect damage.

MATERIALS AND METHODS

A 2-year experiment was conducted at the Experimental Farm of Rice Research and Training Center, Sakha Agricultural Research Station during 2013 and

2014 rice seasons. The experiment aimed at assessing the effect of rice leaf removal at different levels on rice growth characteristics, yield and yield components.

1. Nursery preparation:

The land of nursery was prepared, as recommended, with incorporating calcium superphosphate (P_2O_5) during tillage at a rate of 150 kg/fed. The nursery bed was wet leveled, and zinc sulphate was added at a rate of 2 kg/kerate, before seed broadcasting. The pregerminated seeds of Giza 179 cultivar (indica x japonica type) was broadcasted on 10th of May and 12th of May in the first and second seasons, respectively. Weeds were controlled with thiobencarb (Saturn) herbicide at a rate of 3 L/fed.

2. Permanent field:

The permanent field was prepared as 24 plots (6 treatments x 4 replicates), using a completely randomized block design. One month after seed sowing, seedlings of Giza 179 rice cultivar were pulled out, and distributed in the permanent field in plots; each of two rows and 5 m long. Thus each plot was occupied by 50 rice hills (2 m^2). The cultural practices were applied as recommended, including herbicide application. In addition, the plots were sprayed twice with Malathion 57 EC, at a rate of 1.5 L/fed., one week after transplanting, and 20 days later to avoid any insect infestation.

3. Defoliation treatments:

Defoliations were practiced on 15th and 12th of July in 2013 and 2014 rice seasons, respetively. The levels of defoliation were 0, 20, 40, 60, 80 and 100%, each in four replicates. To count number of leaves in each plot, average of leaves per hill was multiplied by 50 (number of hills per plot). The required defoliation percentage was multiplied by total number of leaves per hill to calculate the number of leaves to be removed. Leaf removal was achieved by hand.

4. Rice growth and yield parameters:

4.1. Leaf chlorophyll content (SPAD) was assessed in ten random leaves per hill at maximum tillering stage, using chlorophyll meter (Model SPAD 502). The sample haboured five hills.

4.2. Plant height (cm) was measured, at maturity stage in 10 random hills. The plants were measured from the soil surface up to the longest extended leaf.

4.3. Leaf area index was measured according to **Palaniswamy and Gomez (1974)** formula**:**

Leaf area (LA) = K (L x W)

Where:

L = Leaf length (cm)

W = Maximum leaf width (cm)

Constant K = 0.75

Leaf area index (LAI) = leaf area / area occupied by one hill.

4.4. Dry matter content (g/m^2):

The dry matter was calculated in a sample of three hills, when Giza 179 rice cultivar reached maturity. The leaves of the three hills were detached from the stem. The leaves and stems, separately, were oven dried at 70^{o}C for 72 hr. Weight of the leaves was summed with the weight of the stems, and then, the total weight was multiplied by the constant 8.33 to obtain the dry matter as grams per square meter.

4.5. Panicle weight (g):

Average of 10 weighed panicles was computed after complete panicle air drying.

4.6. 1000-grain weight (g):

Samples of one thousand air dried rice grains were weighed in grams.

4.7. Grain yield (g):

Twenty- five hills in each plot were manually harvested, and air dried. The plants were threshed and the weight of the grains was adjusted to 14% moisture content.

Statistical analysis:

Data were subjected to ANOVA and means were compared using Duncan's Multiple Range Test (1955). Correlations among defoliation levels and growth and yield parameters were calculated. In addition, linear regression and equation were found.

RESULTS AND DISCUSSION

1. Effect of defoliation on rice growth characteristics:

1.1. Chlorophyll content:

Leaf chlorophyll content (Tables 1 and 2) did not differ significantly due to different levels of defoliation. Values of this characteristic had a narrow range in both seasons; 36.05-37.65 SPAD in the first season and 36.77-38.25 SPAD in the second season.

1.2. Plant height:

The rice plants of the check (non-defoliated) plots exhibited, almost, the tallest plants; 92.60 and 91.55 cm, in the first and second seasons, respectively. Defoliation at 20 or 40% in the first season, and at 20, 40 or 60% in the second one induced slightly shorter rice plants, ranging between 91.80 and 92.64 cm and 89.50-90.65 cm, respectively, but without significant differences compared to the check. However, the plant heights ranged 90.00-90.50 cm when 60, 80 or 100% of the leaves were removed in the first season, and ranged 87.00-87.05 cm when 80 or 100% of the rice plants were defoliated in the second season. In general, it could be reported that the rice plant heights were not negatively affected up to 60% defoliation.

1.3. Leaf area index:

Leaf area index is an important parameter, as the plants with a high leaf area index value could be considered efficient in photosynthesis. In Tables (1 and 2), the highest values were measured in the check (non-defoliated) plants in both seasons, or those suffered only 20% defoliation. These values were 5.17 and 4.54 in the first season and 6.61 and 7.28 in the second one. However, the least leaf are indices were detected in plants defoliated as 80% (3.89 and 4.15) and as 100% (2.88 and 4.65) in the first and second seasons, respectively. Significant differences were found among leaf area indices due to different levels of defoliation.

Table 1. Growth characteristics of Giza 179 rice cultivar as influenced by defoliation levels in 2013 season, at Sakha Agricultural Research Station

Defoliation level %	Chlorophyll content SPAD	Plant height (cm)	Leaf area index	Dry matter content (g/m^2)
0	36.18 a	92.60 a	5.17 a	1215.00 a
20	37.65 a	92.64 a	4.54 a	1103.60 abc
40	36.30 a	91.80 a	4.15 a	943.05 bc
60	37.50 a	90.50 b	4.69 a	1105.05 ab
80	36.53 a	90.05 b	3.89 ab	938.15 c
100	36.05 a	90.00 b	2.88 b	765.05 c
L.S.D	2.25	1.28	1.15	41.30

Table 2. Growth characteristics of Giza 179 rice cultivar as influenced by defoliation levels in 2014 season, at Sakha Agricultural Research Station

Defoliation level %	Chlorophyll content SPAD	Plant height (cm)	Leaf area index	Dry matter content (g/m^2)
0	38.25	91.55 a	6.61 a	1061.10 b
20	36.90	90.65 a	7.28 a	1164.94 a
40	37.03	89.80 a	7.38 b	929.65 c
60	37.25	89.50 a	7.36 b	866.11 d
80	37.26	87.05 b	4.15 b	861.26 d
100	36.77	87.00 b	4.65 b	840.04 e
L.S.D	2.11	2.37	1.86	36.09

1.4. Dry matter content:

Dry matter content expresses the ability of the plants to create metabolites, which are later translocated from the leaves as a source to the panicles as a sink. Data showed that the biggest dry matter content were found in the check or 20% defoliation, with levels of 1215.00 and 1103.60 g/m^2 in the first season (Table 1). The corresponding values of dry matter in the second season were 1061.10 and 1164.94 g/m^2 (Table 2). The sharp reduction in dry matter content was observed in the first season at 80 or 100% defoliation (938.15 and 765.00 g/m^2, respectively). In the second season, defoliations at 60, 80 or 100% resulted in low levels of dry matter content; 866.11, 861.26 or 840.04 g/m^2, respectively. These results indicate that the dry matter contents were impaired due to defoliation beginning from 60 or 80% leaf removal.

2. Effect of defoliation on rice yield and yield components:

2.1. Panicle weight:

Data in Tables (3 and 4) show that different levels of defoliation negatively affected the panicle weight. The heaviest panicles were obtained in the check plots (non-defoliated) with values of 23.35 and 32.40 g/10 panicles in the first and second seasons, respectively. Gradual decreases were detected due to gradual increases in defoliation levels. At 80 and 100% defoliation, the panicle weight reached minimum with 19.33 and 18.55 g/10 panicles in the first season, and with 22.63 and 22.58 g/10 panicles in the second season.

2.2. 1000-grain weight:

Defoliation at 0, 20, 40 or 60% induced statistically the same values of 1000-grain weights, which ranged between 21.87 and 23.18 g in the first season, and ranged between 27.47 and 29.21 g/1000 grains in the second season. The least 1000-grain values were obtained at 80% (20.73 and 26.67 g) and at 100% (20.28 and 24.71 g) in the first and second seasons, respectively (Tables 3 and 4).

2.3. Grain yield:

In the first season (Table 3), the rice grain yields were not significantly different from zero up to 60% defoliation with a range of 815.92 – 949.44 g / 25 hills. The lowest grain yields were recorded at 80% defoliation (734.59g) and at 100% defoliation (623.53 g). Reduction percentages were slight (7.25 and 4.34%) at 20 and 40% defoliation, medium (14.06%) at 60% defoliation, but highest (22.63 and 34.33%) at 80 and 100% defoliation, respectively.

In the second season (Table 4), the highest grain yields were detected at zero defoliation (922.32 g/ 25 hills) and at 20% (916.24 g/25 hills). The lowest grain yields were recorded at 80% defoliation (727.33 g) and at 100% defoliation (726.40

g/25 hills). The yield reduction was negligible (0.66%) at 20% defoliation, but highest (21.1 and 21.24%) at 80% and 100% defoliation, respectively.

Table 3. Yield and yield components of Giza 179 rice cultivar as influenced by defoliation levels in 2013 season, at Sakha Agricultural Research Station.

Defoliation	Ten-panicle weight		1000-grain weight		Yield of 25 hills	
level %	g	Red. %	g	Red. %	g	Red. %
0	23.35 a		23.18 a		949.44 a	
20	20.93 ab	10.36	23.01 a	0.78	880.59 ab	7.25
40	22.60 abc	3.21	22.05 ab	4.92	908.27 ab	4.34
60	20.53 abc	12.08	21.87 ab	5.69	815.92 abc	14.06
80	19.33 bc	17.22	20.73 bc	10.61	734.59 bc	22.63
100	18.55 c	20.56	20.28 c	12.55	623.53 c	34.33
L.S.D.	3.57		1.44		193.18	

Table 4. Yield and yield components of Giza 179 rice cultivar as influenced by defoliation levels in 2014 season, at Sakha Agricultural Research Station.

Defoliation	Ten-panicle weight		1000-grain weight		Yield of 25 hills	
level %	g	Red. %	g	Red. %	g	Red. %
0	32.40 a		29.21 a		922.32 a	
20	30.98 ab	4.38	28.98 a	0.79	916.24 a	0.66
40	30.20 b	8.79	28.10 a	4.14	816.80 b	11.44
60	29.60 b	8.64	27.47 ab	5.96	761.19 bc	17.47
80	22.63 c	30.15	26.67 b	8.70	727.23 c	21.15
100	22.58 c	30.31	24.71 b	15.41	726.40 c	21.24
L.S.D.	2.17		2.68		88.31	

4. Correlations among defoliation levels and growth and yield characteristics:

Data in Table (5) present the correlations among rice defoliation levels and rice growth and yield characteristics. In 2013 season, the correlation coefficient values were significant negative with plant height, leaf area index, dry matter and panicle weight, and highly significant negative with 1000-grain weight and grain yield. In 2014 seasons, the correlations were highly significant negative with plant height, panicle weight, 1000-grain weight and grain yield.

. Linear regression between defoliation levels and rice grain yield:

Rice grain yield at a given defoliation level (Fig. 1) could be computed according to the following formulae:

In 2013 season: Grain yield = - 0.9427x + 915.86

In 2014 season: Grain yield = - 2.2889x + 926.14

Table 5. Correlation coefficient values among rice defoliation levels and growth and yield characteristics

Item	"r" value	
	2013	2014
Defoliation levels x Leaf chlorophyll content	-0.216	-0.656
Defoliation levels x Plant height	-0.955*	-0.967**
Defoliation levels x Leaf area index	-0.868*	-0.762
Defoliation levels x Dry matter	-0.883*	-0.848*
Defoliation levels x Panicle weight	-0.894*	-0.922**
Defoliation levels x 1000-grain weight	-0.981**	-0.952**
Defoliation levels x Grain yield	-0.948**	-0.956**

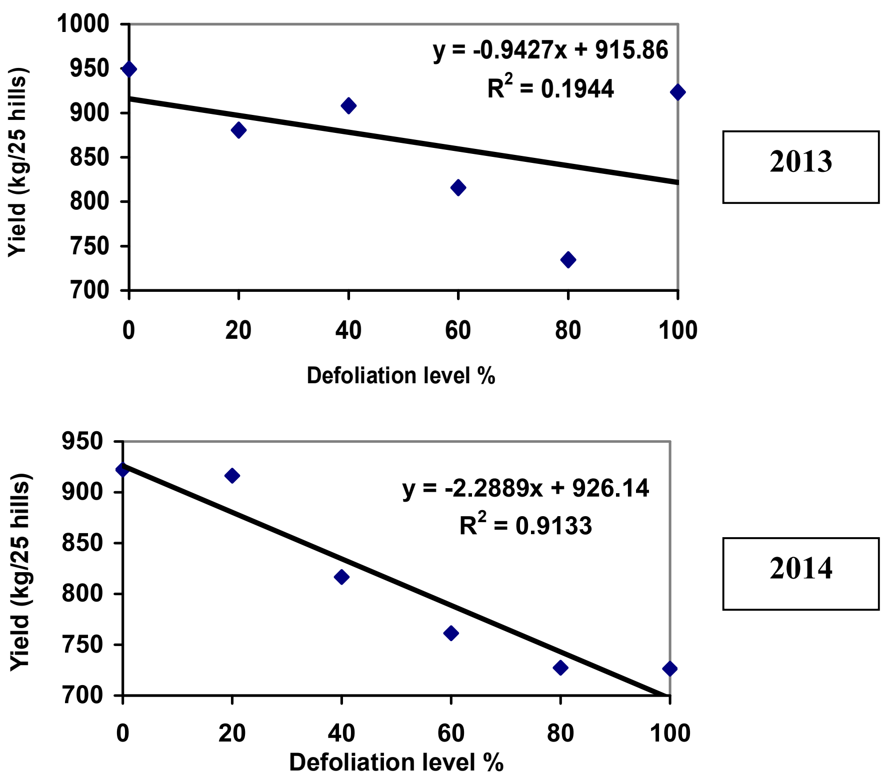

Fig. 1. Linear regression between defoliation level and rice yield in two seasons.

Data obtained, during 2013 and 2014 rice seasons, revealed that most traits of rice growth and rice yield were negatively reduced beginning from 80% defoliation levels, which means that rice defoliation from 20 up to 60% had no negative impacts on the considered traits. These results agree with those of Shepard *et al*. (1990) who reported that damaged rice leaves by *Hydrellia* spp. did not result in yield crosses if the infestation level reached up to 60%. They indicated that rice defoliation at 25 or 50% did not significantly reduce plant height, number of filled grains per panicle and 1000-grain weight, but defoliation at 75% significantly reduced these traits, particularly when defoliation was practiced before maximum tillering stage. Rice plant metabolites may affect damage severity due to *Hydrellia prosternalis*. In such concern, Soliman *et al.* (1997) obtained lower *Hydrellia prosternalis* infestation with higher plant contents of proteins and silica. Rao and Divakar (1998) concluded that 50% defoliation of rice plants induced slight yield reduction if occurred 15 days after transplanting (DAT), but reached about 45% yield reduction if occurred 45 DAT. In the same trend, Heinrichs (2009) revealed that rice plants has the ability to compensate for defoliation if this process occurred before maximum tillering stage, however, no yield losses were found at 25% defoliation. Viajante and Heinrichs (1986) tested the effect of artificial infestation to rice plants as 800 adult flies per 49 plants, and obtained 82% of rice leaves damaged, but did not reduce grain yield of rice cultivars. Some authors indicated that plant response to defoliation by chewing insects may be quite different from the response produced by artificial defoliation techniques. Capinera and Roltsch (1980), Rice *et al*. (1982), Pantoja *et al*. (1986) and Iqbal *et al*. (2012) indicated that artificial defoliation studies indicate that yield reduction estimates are not as reliable as those based on actual insect feeding. However, Litsinger (2009) concluded that artificial defoliation is not as expensive as natural infestation, and the latter technique may be impossible in some cases. He advised to apply simulated infestation to facilitate the duty of the decision makers.

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محاكاة الإصابة بصانعة إنفاق الأرز وتأثيرها على صفات نمو الأرز ومحصول الحبوب

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لمحصول الأرز فى مصر أهمية بالغة ، خصوصا فى ظل عدم كفاية محصول القمح للاستهلاك المحلى. يصاب محصول الأرز بالعديد من الآفات الحشرية ، ومنها صانعة أنفاق الأوراق *Hydrellia prosternalis* Deem. ، والتى تسبب خسائر فى المحصول ، إذا تأخرت الزراعة عن المواعيد الموصى بها.

أجرى البحث الحالى فى مزرعة مركز بحوث الأرز (محطة بحوث سخا) ، خلال موسمى ٢٠١٣، ٢٠١٤ لدراسة تأثير نسب الإصابة بالحشرة على صفات نمو ، ومحصول الأرز . ونظرا للصعوبة البالغة فى إجراء عدوى صناعية بالحشرة ، تمت محاكاة الإصابة عن طريق إزالة عدد من أوراق النباتات فى كل معاملة ، وذلك بإزالة الورقة بكاملها باليد بعد شهر واحد من الشتل. وكانت نسب الإزالة (معاملات) كما يلى: صفر ، ٢٠، ٤٠، ٦٠، ٨٠، ١٠٠ %.

أوضحت النتائج أن محتوى الأوراق من الكلوروفيل لم يتأثر بأى من نسب التوريق. أما أطوال النباتات ودليل مساحة الورقة ، ونسبة المادة الجافة ، ووزن السنبلة وكذا وزن الألف حبة ، فإنها تأثرت بالسلب عند معدل توريق ٦٠%. كما أوضحت النتائج أن محصول الحبوب انخفض بمعدل ١٤–١٧ ، ٢١، ٣٤% عند معدلات توريق ٦٠، ٨٠، ١٠٠%. ولهذا يمكن استخلاص أن نسبة إصابة الأرز بصانعة أنفاق الأوراق، حتى ٤٠% تعتبر غير مؤثرة على المحصول ، ولا تحتاج لاستخدام المبيدات.