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LOSSES IN GRAIN YIELD OF SOME RICE CULTIVARS DUE TO BLAST INFECTION AT DIFFERENT GROWTH STAGES

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ABSTRACT

Two Experiments were carried out in 1999 season. The first was at the experimental farm of Rice Research and Training Center (RRTC),Sakha, whereas the second was at the experimental farm of Gemmiza Research Station. The study aimed to investigate the effect of rice blast disease on yield losses at different growth stages of cvs. Giza 171, Reiho and Giza 176. The cultivars were evaluated in split- plot design as a main plots, wheras the treatments (protection by Beam at the rate of 100g/ fed) at both tillering and heading stages, artificial inoculation with spore suspension of *Pyricularia grisea* (5×10^4 spores/m^2) at tillering and or heading stage (milking, soft dough) and natural infection were allocated as Sub-plots. The highest severity and area under disease progress curve (AUDPC) for leaf blast infection were obtained from artificial inoculation at tillering stage. Also, the highest severity and AUDPC of panicle blast infection were recorded from artificial inoculation at milking stage. Giza 171 was the highest susceptible cultivar during vegetative stage, while Giza 176 was the most susceptible cultivar during heading stage. Maximum actual loss due to blast infection in grain yield and 1000- grain weight was obtained from artificial inoculation at milking stage. Panicle blast infection had stronger influence than leaf blast infection. Whereas yield losses due to panicle infection of Giza 171 were two folds compared to those due to leaf infection. These losses were three and four folds in case of Reiho and Giza 176.

Keywords: Blast, *Pyricularia grisea,* Losses, Growth stage, Rice cultivar.

INTRODUCTION

The blast fungus, *Pyricularia grisea* (cooke) Sacc. (Synonym *Pyicularia oryzae* Cavara, teleoomorph *Magnaporthe grisea* (Hebert) Barr; Rossman *et al.,* 1990) is an important pathogen of rice growing countries and one of the most serious biotic constraint to rice productivity in Egypt (Aidy *et al*., 1994, Sehly *et al*., 2002). Although many studies have been reported on the epidemiology of this disease, few objective estimate of actual losses due to blast alone, and no quantitative estimates of the loss caused by blast at different crop growth stages, are available for use in formulating disease management strategies (Teng et al., 1991). Rice blast disease expresses itself in two major forms, as leaf blast (LB) infection during the vegetative stage and panicle blast (PB) infection during reproductive stage. The latter form usually has more economic importance since it directly reduces yield and quality (Surek & Beser, 1997). In Egypt, a severe outbreak of rice blast disease was occurred on the cv. Reiho and caused tremendous losses in about 250,000 faddans, (kamel *et al.,* 1985). LB and PB infections were highly significant and positively or negatively correlated with a reduction in yield and its components (Torres and Teng 1993). The degree of loss due to panicle blast infection is strongly influenced by the time of panicle infection, as the greater losses occurred with the earlier infection (Goto, 1965; katsube and koshimizu, 1970; Kamel *et al.*, 1985). Losses in grain yield due to artificial inoculation at both milking and soft dough were higher than those occurred from artificial inoculation at mature stage, inoculation at milking stage induced the highest reduction in grain yield compared with inoculation at flowering, soft dough and mature stages on rice cultivar Giza 159. The loss values were 6.3, 7.9, 7.3 and 4% at flowering, milking, soft dough and mature stages, respectively. However, artificial inoculation of leaves of Giza 159 and protection of its panicles resulted in 13.2% yield loss (Sehly *et al*., 1992). The current study was conducted during 1999 rice season at Sakha and Gemmiza Agricultural Research Station. It aimed to estimate the losses due to blast disease on different growth stages of three rice cultivars, i.e. Giza 171, Giza 176 and Reiho.

MATERIALS AND METHODS

Two experiments were carried out under favorable environmental conditions for blast disease development in 1999 season. The first was at the experimental farm of Rice Research and Training Center (RRTC), Sakha, whereas the second was at the experimental farm of Gemmiza research station. Three rice varieties, namely Giza 176, Giza 171, and Reiho were evaluated in split – plot design with four replications. The varieties were located at the main plots, whereas the treatments (leaf and panicle infection levels) were allocated as sub – plots.

Thirty day – old rice seedlings were transplanted on June 11 at Sakha and June 12 at Gemmiza in plots measured 3 X 3.5 m2 at 20 X 20cm, with three plants/hill. Nitrogen fertilizer was added as urea (46.5% N) at the rate of 60 units/ fed.

Creation of different levels of leaf and panicle blast infection:

1-Protection with fungicide Beam at different growth stages:

In order to obtain different levels of infection, the fungicide Beam 75 % WP (tricyclazole) was sprayed twice, each at a rate of 100 g/fed.. The first spray was applied just at leaf infection appearance, about one month after transplanting, the second one was done at late booting stage (prior to heading) to minimize both leaf and panicle infection, Table (1).

2-Artificial inoculation at different growth stages:

Plots specified for artificial inoculation were inoculated, 30 days after transplanting, by spraying rice plants with spore suspension (5×10^4 spores/ml) at a rate of 50 ml / m2. The suspension contained a mixture of blast isolates of Giza 171, Reiho and Giza176, Table (1).

Estimation of blast infection:

Samples of rice leaves were taken six times at 7- day intervals, starting about three weeks after transplanting. Samples of 100 leaves and 100 panicles were randomly collected from each plot to determine blast infection. Percentage of infected leaves was calculated, while severity of infection was estimated by counting the total number of type-4 blast lesions/100 leaves. Neck rot infection percentage was obtained as the number of infected panicles in each sample. Severity of infection was calculated according to Townsend and Huberger (1943) as follows:

$$S = \frac{\Sigma(n \times v) \times 100}{T \times 10}$$

Where :

S = severity of infection
n = number of panicles within infection category (from 1 with one infected primary branch of the panicle to 10 for the complete infection in the uppermost internode of the panicle which named neck infection.
v = numerical values of infection categories
T = total number of examined panicles
10 = constant (highest numerical value)

Area under disease progress curve (AUDPC):

To compare relative levels of resistance of the considered rice cultivars to blast under field conditions, data of leaf and panicle blast severity were converted to area under disease progress curve (AUDPC). According to the formula described by **Pandy and Merian (1989)**:

AUDPC = $D \frac{1}{2} (Y_1 + Y_K) + Y_2 + Y_3 + \dots\dots\dots Y_{K-1}$

Where Y1, Y2, Y3 ……… YK = scores of blast severity at a constant intervals of D-days.

Grain yield:

Grain yield of each plot was estimated by harvesting all hills in the plot except one outer row from each side. Total weight was recorded for each plot and weight was adjusted to 14 % moisture content, then the yield was calculated as t/ha.

Yield loss %:

Loss % was estimated according to the equation adopted by **Calpuzos *et al.*, (1976)**.

% Reduction in grain yield = 1- Yd/Yh × 100

where:
Yd = yield of infected plots
Yh = yield of healthy or protected plots.
Actual yield loss due to blast infection :
Actual yield loss was calculated according to the following formula :

$$\text{Actual yield loss due to blast infection} = \frac{\text{Yield loss \%} \times R^2}{100}$$

Whereas, R^2 = coefficient of determination

RESULTS AND DISCUSSION

Leaf blast infection :

Results in Table (1) show that leaf blast infection severity of the three tested cultivars were highly significant different between protected and inoculated plots at both Sakha and Gemmiza locations. The highest leaf infection severity was found on Giza 171 (125 and 104 lesions/ 100 leaves) at Sakha and Gemmiza, respectively, which resulted from artificially inoculated plots during vegetative stage, while Giza 176 exhibited the least severity as 107 and 63 lesions/ 100 leaves at both locations under the same infection conditions. Protected plots at only vegetative growth stages or at both vegetative, and heading stages showed the lowest number of lesions on all cvs., with Giza 176 being the least infected cultivar.

Table (1): Leaf blast infection severity of three rice varieties as influenced by infection levels at vegetative and heading stages, 1999 season

No.	Treatments (T)		Location / Variety (V) / Severity of leaf blast					
			Sakha			Gemmiza		
	Vegetative stage	Heading stage	Giza 171	Reiho	Giza 176	Giza 171	Reiho	Giza 176
1	Protection *	Protection	16	9	7	24	9	7
2	Natural infection (N.I.)	Natural infection (N.I.)	100	89	82	89	52	44
3	Artificial Inoculation (A.I.)**	Protection	125	115	107	104	72	63
4	Protection	A.I. (Milking stage)	13	13	11	20	9	10
5	Protection	A.I. (Soft dough)	16	16	14	25	10	7
LSD 5% between : 2 T means at each V			11.2			8.5		
2 V means at each T			12.3			8.2		

*** Protected with Beam at the rate of 100 g/fed.** Spray with spore suspension at 50x10^4 spores/ml**

Also, figures (1,2) show that blast infection development on the three rice cvs. i .e. Giza 171, Reiho and Giza 176 indicated that the maximum infection was recorded 66 days after transplanting, around mid-August at the two tested locations. This result is in line with that of Sehly *et al.,* (1988), who reported that the first peak of the air – borne conidia of blast fungus occured by the end of August when the infection of rice plants had reached its peak, also Badr (1989) and Salem (1990) they found that the peak of leaf blast infection of the susceptible cvs. occurred 49 – 60 days after transplanting.

Panicle blast infection :

Panicle blast infection severity was highly significantly reduced when the plots were protected with Beam at heading stage, on all cvs. tested (Table 2). The highest infection severity was obtained from artificially inoculated plots at milky stage followed by dough stage. The highest infection severity was recorded on cv. Giza 176 (42.5 and 34.3%), then Reiho (38.0 and 32.1 %) and finally Giza 171 (27.6 and 25.0%) at both Sakha and Gemmiza, respectively. However, differences in host resistance were reflected in different degrees of infection for each cultivar. The highest infected cultivar at vegetative stage (leaf infection) was Giza 171 followed by

Reiho and Giza 176, while at heading stage (panicle infection), Giza 176 recorded the highest severity of panicle blast infection followed by Reiho and Giza 171. These results are in line with the findings of Marchetti (1983) and Aidy *et al.,* (1998). They used different cultivars with different levels of resistance and found different levels of infection.

Table (2): Panicle blast infection severity of three rice varieties as influenced by infection levels at vegetative and heading stages, 1999 season

No.	Treatments (T)		Location / Variety (V) / Severity of panicle blast					
			Sakha			Gemmiza		
	Vegetative stage (V)	Heading stage	Giza 171	Reiho	Giza 176	Giza 171	Reiho	Giza 176
1	Protection *	Protection	0.8	1.6	1.8	0.7	1.2	1.4
2	Natural infection (N.I.)	Natural infection (N.I.)	18.0	28.5	30.4	17.6	24.5	26.2
3	Artificial Inoculation (A.I.)**	Protection	0.9	1.6	1.9	0.7	1.3	1.5
4	Protection	A.I. (Milking stage)	27.6	38.0	42.5	25.0	32.1	34.3
5	Protection	A.I. (Soft dough)	24.5	32.2	34.0	21.7	28.6	29.2
LSD 5% between : 2 T means at each V			2.7			2.5		
2 V means at each T			2.5			2.4		

*** Protected with Beam at the rate of 100 g/fed.** Spray with spore suspension at 50x10^4 spores/ml**

Area under disease progress curve (AUDPC):

Date in Table (3) show that the protected plots at vegetative stage had the lowest AUDPC values on all cvs. ranging from 58.8 to 152.8. The highest AUDPC value was found on Giza 171(800, 702 and 538, 535.5) under both artificially and naturally infected plots at Sakha and Gemmiza followed by Reiho and Giza 176, respectively.Highly significant differences were found between artificially inoculated plots and each of the other protected and naturally infected plots. Also, the same significant differences were recorded among different cultivars at both locations..

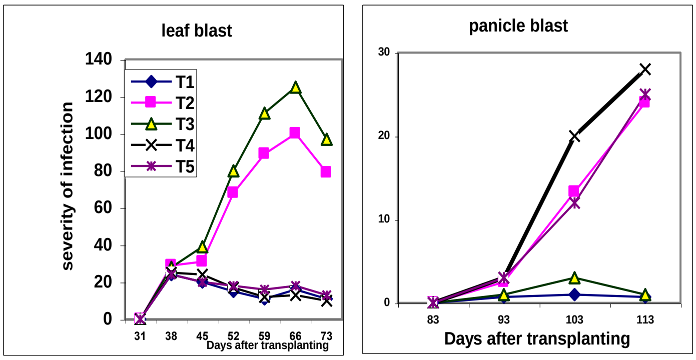
Table (3): Effect of infection levels with *P. grisea* at different rice growth stages of three cvs. on AUDPC of leaf blast infection at two locations in 1999 season

No.	Treatments (T)		Location / Variety (V) / AUDPC of leaf blast					
			Sakha			Gemmiza		
	Vegetative stage (V)	Heading stage	Giza 171	Reiho	Giza 176	Giza 171	Reiho	Giza 176
1	Protection *	Protection	124.0	80.3	61.8	161.0	77.5	58.8
2	Natural infection (N.I.)	Natural infection (N.I.)	538.0	377.8	294.8	535.5	333.3	227.8
3	Artificial Inoculation (A.I.)**	Protection	800.0	528.3	441.5	702.0	466.3	330.0
4	Protection	A.I. (Milking stage)	132.8	83.3	60.3	152.8	81.3	61.3
5	Protection	A.I. (Soft dough)	152.0	79.3	65.8	156.0	78.5	61.8
LSD 5% between : 2 T means at each V			51.3			43.8		
2 V means at each T			50.8			53.2		

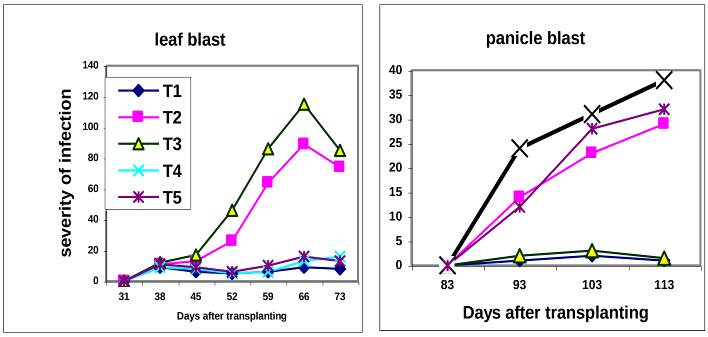
*** Protected with Beam at the rate of 100 g/fed.**

**** Spray with spore suspension at 50x10^4 spores/ml**

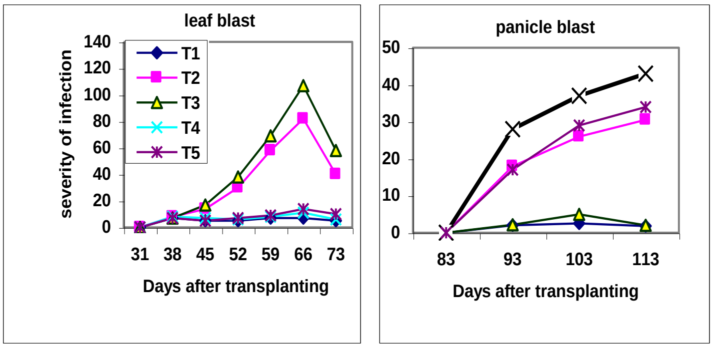
Giza 171



Reiho

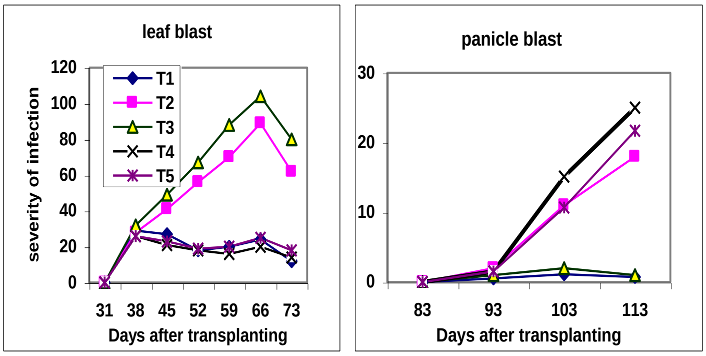


Giza 176

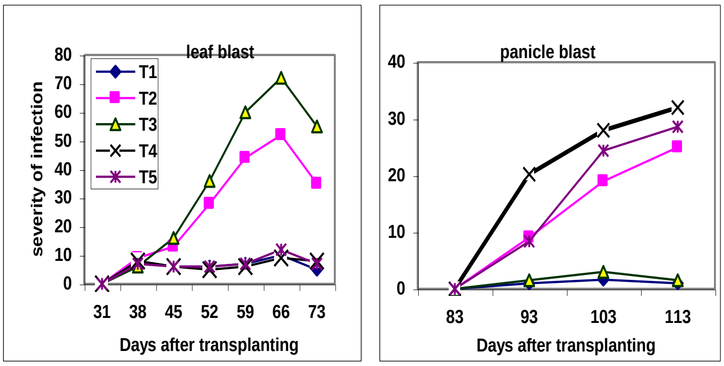


FIG(1): Blast disease progress curve on both leaf & panicle infection on three rice cultivars representing different treaetments at sakha , in 1999 season.
T1,protected leaves & panicles. T2, check(naturally infected leaves & panicles)
T3, artificially inoculated leaves & protected panicles.T4, protected leaves & inoculated milky panicles. T5, protected leaves & ioculated soft dough panicles.

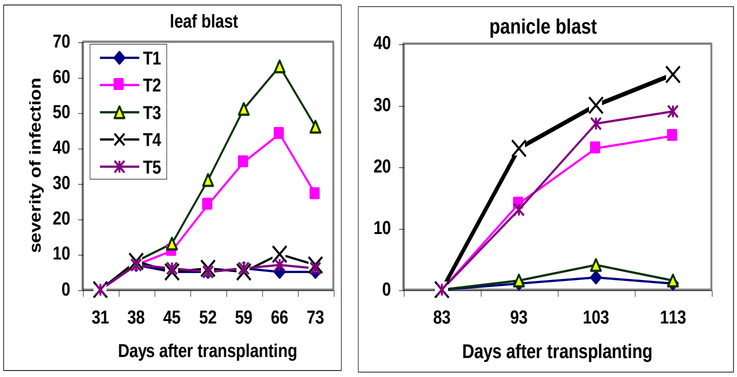
Giza 171



Reiho



Giza 176



FIG(2): Blast disease progress curve on both leaf & panicle infection on three rice cultivars representing different treatments at EL-Gemmiza, in 1999 season.
T1,protected leaves & panicles. T2, check(naturally infected leaves & panicles)
T3, artificially inoculated leaves & protected panicles.T4, protected leaves & inoculated milky panicles. T5, protected leaves & ioculated soft dough panicles.

The use of AUDPC as a criterion for blast infection, reflecting disease severity in time is easier than using individual scores for the evaluation of disease development. So, results revealed that all protected cultivars showed lower AUDPC values than those artificially inoculated. Giza 171 showed the highest AUDPC value, while Giza 176 showed the lowest one. However, in case of panicle blast infection, Giza 176 was the most infected cultivar exhibiting the highest severity of infection followed by Rehio and Giza 171. This may indicate that different genes controlling leaf and panicle blast infection of those cultivars. These results are in agreement with those of Zheng *et al.,* (1998) who reported that the genetic analysis indicated that the resistance to neck blast was controlled by two genes while the resistance to leaf blast was controlled by one gene more .

Effect of blast infection on yield and its components:

Yield :

Data in Tables (4,5) show that the cvs. Giza 171, Rehio and Giza 176 had different levels of leaf and panicle blast infection. However, losses in grain yield differed from one cultivar to another, the highest actual loss % in grain yield for all cvs. was obtained from protected plots at vegetative stage but artificially inoculated at milking stage. The highest yield loss at sakha was that of Giza 176 followed by Rehio and Giza 171. Values of actual losses were 24.7, 24.5 and 20.4% for the three cvs., respectively. Losses were least in plots protected at vegetative stage and artificially inoculated at soft dough stage for the three cvs. (6.1 , 7.4 and 8.8% for Giza 171, Reiho and Giza 176, respectively) (Table 4). Results also indicated that natural infection at both vegetative and heading stage showed considerable actual loss (17.1, 18.3 and 15.4% for Giza 171, Reiho and Giza 176, respectively).

However, high level of leaf blast infection (artificial inoculation(A.I.) at vegatative stage) but protected at heading stage showed low actual loss in grain as 9.2, 9.6 and 5.5% for the three cvs., respectively. The same trend was found at Gemmiza (Table 5).

1000- grain weight:

Data in Table (4) show that the highest actual loss % in 1000- grain weight for all cvs. was obtained from plots protected at vegetative stage but artificially inoculated at milking stage with highest loss on Giza 176 followed by Rehio and Giza 171. Values of actul losses were 31, 24.5 and 21.1% for all the three cvs., respectively.

Generally, minimum losses were obtained from plots protected at vegetative growth stage and artificially inoculated at soft dough stage for the three cvs. (10.0, 7.3 and 16% for Giza 171, rehio and Giza 176, respectively). Also, results indicated that natural infection at both vegetative and heading stages showed considerable actual loss as 16.3, 11.4 and 25.9% for Giza 171, Rehio and Giza 176, respectively. However, artificial inoculation at vegetative stage but protection at heading stage showed low actual loss in 1000 – grain weight as 12.0, 7.7 and 12.3% for the three cvs., repecively, Table (4). The same rend was observed at Gemmiza, Table (5), these results are in agreement with those of Sehly *et al.,* (1992).

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Correlation analysis:

Correlation coefficients among yield loss, Some disease parameters and yield components for Giza 171 presented in Table (6). Data indicated that severity of leaf blast infection (SLB) was significant and highly significant and positively correlated with yield loss (0.587**), severity of panicle blast (SPB) (0.486*), AUDPC (0.880**) and % of unfilled grains (UFG) (0.685**), while it was highly significant and negatively correlated with no. of panicles/m2 (-0.835**), panicle weight (-0.807**) and 1000 – grain weight (-0.772**). SPB was significant highly significant and positively correlated with yield loss (0.819**), AUDPC (0.514*) and % UFG (0.733**), while it was significant and negatively correlated with panicle weight (-0.859**) and 1000-grain weight (-0.818**). AUDPC was highly significant and positively correlated with yield loss (0.793**) and % UFG (0.753**), while it was highly significant and negatively correlated with no. of panicles/m2 (-0.755**), panicle weight (-0.776**) and 1000- grain weight (-0.686**). These results are in agreement with Torres and Teng (1993).

Table (6). Correlation coefficients computed among some disease parameters, yield components and yield loss of Giza 171 at Sakha and Gemmiza in 1999 season

No.	Characters	SLB	SPB	AUDPC	No. P/m^2	% UFG	PW	1000-GW	YL
1	Severity of leaf blast **(SLB)**	-	0.486*	0.880**	-0.835**	0.685**	-0.807**	-0.772**	0.587**
2	Severity of panicle blast **(SPB)**		-	0.514*	-0.062	0.733**	-0.859**	-0.818**	0.819**
3	**AUDPC**			-	-0.755**	0.753**	-0.776**	-0.686**	0.793**
4	No. of panicles/m^2 **(No. P/m^2)**				-	-0.512*	0.227	0.205	-0.441*
5	% of unfilled grains **(% UFG)**					-	-0.876**	-0.850**	0.795**
6	Panicle weight **(PW)**						-	0.884**	-0.785**
7	1000-grain weight **(1000-GW)**							-	-0.736**
8	Yield loss **(YL)**								-

*** Significant at 5%** **** Highly significant at 1%**

Regression analysis :

The SLB and SPB were used as the independent variables (x1) and (x2), while yield loss (y) was used as the dependent variable for the three rice cvs. Results in Tables (7 , 8) indicated that the values of coefficient of determination (R2) for the three cvs. were 0.83 and 0.75% of the losses in yield for the cv. Giza 171, 0.94 and 0.86 for Reiho and 0.90 and 0.89 for Giza 176 at Sakha and Gemmiza, respectively. In other words 90 and 89% of yield losses, in case of Giza 176 as an example, are due to the combined effect of leaf and panicle infections at Sakha and Gemmiza, respectively.

Table (7). Regression equation of three rice cultivars under different categories of leaf and panicle blast severity at Sakha - 1999

Variety	Regression equation	R^2	Standard error of estimates (S.E)	F
Giza 171	**Y**= 1.8430 + 0.3947 SLB + 0.6456 SPB	0.83	9.175	81.59**
Reiho	**Y**= 3.3231 + 0.2432 SLB + 0.7031 SPB	0.94	8.473	107.32**
Giza 176	**Y**= 2.6770 + 0.2018 SLB + 0.7541 SPB	0.90	9.563	89.61**

Table (8). Regression equation of three rice cultivars under different categories of leaf and panicle blast severity at El-Gemmiza - 1999

Variety	Regression equation	R^2	Standard error of estimates (S.E)	F
Giza 171	Y= 2.7164 + 0.3487 SLB + 0.5854 SPB	0.75	9.846	64.846 **
Reiho	Y= 2.6324 + 0.2643 SLB + 0.6556 SPB	0.86	8.321	69.326**
Giza 176	Y= 3.5188 + 0.2136 SLB + 0.7499 SPB	0.89	7.961	80.621**

Y = Yield loss SLB = Severity of leaf blast SPB = Severity of panicle blast
**** = Significant at 0.01**

Concerning the partial regression coefficient, it was found that the values of partial regression coefficient for SLB (b1) were 0.3947 and 0.347 with Giza 171, while the values for SPB (b2) were 0.6456 and 0.5854 at Sakha and Gemmiza. For Reiho; the values with SLB were 0.2432 and 0.2643, while it were 0.7031 and 0.6556 for SPB. For Giza 176 it were 0.2018 and 0.2136 for SLB and with SPB the values were 0.7541 and 0.7499 at Sakha and Gemmiza.

These results indicated that loss due to panicle blast infection was two folds of that resulted from leaf blast on Giza 171 at both locations, while on Reiho, panicle blast infection caused three folds of losses compared with leaf blast infection. The highest losses due to panicle blast infection was found on Giza 176, about four folds of losses compared with the values of leaf blast infection at both locations. losses in grain yield due to either leaf or panicle blast infection varied from one cultivar to the another. These results reflect the higher sensitivity of Giza 176 at heading stage to blast infection than at vegetative stage.

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الخسارة التي يسببها مرض اللفحة لمحصول بعض أصناف الأرز خلال مراحل النمو المختلفة

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أقيمت تجربتان لتقدير الخسائر الناتجة عن مرض اللفحة في الأرز في أطوار نموه المختلفة في مركز البحوث والتدريب في الأرز بسخا ومحطة بحوث الجميزة خلال موسم 1999 . في تصميم قطع منشقة وضعت الاصناف في القطع الرئيسية والمعاملات في القطع الفرعية. كانت المعاملات هي: الوقاية بمبيد البيم بتركيز 100 جم / فدان والعدوي بمعلق جراثيم بيركيولاريا جريزيا المسبب لمرض اللفحة بتركيزه 5×10^4 جرثومة / ملي لكل من الطور الخضري ومرحلة طرد السنابل في أوقات مختلفة وهي الطور اللبني والنضج الكامل في القطع الفرعية في أربع مكررات علي الاصناف جيزة 171 وريهو وجيزة 176 وسجلت أعلي شدة إصابة والمساحة تحت منحني المرض لاصابة الاوراق من العدوي في الطور الخضري وأيضا أعلي شدة إصابة للسنابل سجلت مع العدوي في الطور اللبني . وكان الصنف جيزة 171 أشد الاصناف حساسية للاصابة في مرحلة النمو الخضري بينما كان الصنف جيزة 171 أشد الاصناف حساسية للاصابة في مرحلة النمو الخضري بينما كان الصنف جيزة 176 أشد حساسية خلال مرحلة طرد السنابل .وأوضحت النتائج أن إصابة السنابل تسبب خسائر كبيرة مقارنة بإصابة الاوراق حيث أن الخسائر الناتجة عن إصابة السنابل تمثل ضعفي الخسائر الناتجة عن إصابة الأوراق علي الصنف جيزة 171 بينما تمثل ثلاثة أضعاف للريهو وأربعة أضعاف للصنف جيزة 176 .

Table (4). Actual loss in yield t/ha and 1000-grain weight due to leaf and panicle blast infection at Sakha in 1999 season

Variety (V)	Treat. No.	Treatments (T)		Severity of leaf blast	Severity of panicle blast	Yield T/ha	Actual yield loss due to blast	1000-grain weight	Actual loss in 1000-grain weight due to blast
		Vegetative stage	Heading stage						
Giza 171	1	Protection	Protection	16	0.8	7.945	-	25.0	-
	2	Natural Infection(N.I.)	Natural Infection (N.I.)	100	18.0	6.438	17.1*	20.3	16.3*
	3	Artificial Inoculation (A.I.)	Protection	125	0.9	7.126	9.2	21.3	12.0
	4	Protection	A.I. (Milking stage)	13	27.6	6.036	20.4	18.5	21.1
	5	Protection	A.I. (Soft Dough)	16	24.5	7.301	6.1	21.8	10.0
Reiho	1	Protection	Protection	9	1.6	8.840	-	25.5	-
	2	Natural Infection(N.I.)	Natural Infection (N.I.)	89	28.5	7.023	18.3	22.3	11.4
	3	Artificial Inoculation (A.I.)	Protection	115	1.6	7.724	9.6	23.3	7.7
	4	Protection	A.I. (Milking stage)	13	38.0	6.388	24.5	19.0	24.5
	5	Protection	A.I. (Soft Dough)	16	32.2	8.000	7.4	23.3	7.3
Giza 176	1	Protection	Protection	7	1.8	10.136	-	27.3	-
	2	Natural Infection(N.I.)	Natural Infection (N.I.)	82	30.4	8.821	15.4	20.0	25.9
	3	Artificial Inoculation (A.I.)	Protection	107	1.9	9.361	5.5	23.0	12.3
	4	Protection	A.I. (Milking stage)	11	42.5	7.435	24.7	18.0	31.0
	5	Protection	A.I. (Soft Dough)	14	34.0	9.143	8.8	22.3	16.0
L.S.D. 5% between :									
2 T means at each V				11.2	2.7	0.311	-	2.1	-
2 V means at each T				12.3	2.5	0.606	-	2.0	-

*** Actual loss was accounted according to R^2 .**

Table (5). Actual loss in yield t/ha and 1000-grain weight due to leaf and panicle blast infection at Gemmiza in 1999 season

Variety	Treat. No.	Treatments (T)		Severity of leaf blast	Severity of panicle blast	Yield T/ha	Actual yield loss due to blast	1000-grain weight	Actual loss in 1000-grain weight due to blast
		Vegetative stage	Heading stage						
Giza 171	1	Protection	Protection	24	0.7	8.165	-	25.5	-
	2	Natural Infection(N.I.)	Natural Infection (N.I.)	89	17.6	6.858	13.4	21.0	14.2
	3	Artificial Inoculation (A.I.)	Protection	104	0.7	7.298	8.4	22.5	10.5
	4	Protection	A.I. (Milking stage)	20	25.0	6.400	16.8	19.3	19.0
	5	Protection	A.I. (Soft Dough)	25	21.7	7.403	6.2	22.8	6.1
Reiho	1	Protection	Protection	9	1.2	9.231	-	26.3	-
	2	Natural Infection(N.I.)	Natural Infection (N.I.)	52	24.5	7.980	13.2	22.5	13.0
	3	Artificial Inoculation (A.I.)	Protection	72	1.3	8.570	5.5	24.3	8.0
	4	Protection	A.I. (Milking stage)	9	32.1	7.175	17.8	20.3	19.6
	5	Protection	A.I. (Soft Dough)	10	28.6	8.578	6.0	24.5	5.0

Giza 176	1	Protection	Protection	7	1.4	10.185	-	27.5	-
	2	Natural Infection(N.I.)	Natural Infection (N.I.)	44	26.2	8.621	13.9	21.3	20.5
	3	Artificial Inoculation (A.I.)	Protection	63	1.5	9.420	5.3	23.8	7.9
	4	Protection	A.I. (Milking stage)	10	34.3	8.083	18.7	19.3	27.3
	5	Protection	A.I. (Soft Dough)	7	29.2	9.448	5.2	23.3	14.0
L.S.D. 5% between :									
2 T means at each V				**8.5**	**2.5**	**0.379**	**-**	**2.4**	**-**
2 V means at each T				**8.2**	**2.4**	**0.417**	**-**	**2.5**	**-**