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YIELD POTENTIAL OF NOVEL RICE GENOTYPES, AND EFFECT OF *Trichogramma* RELEASE AND BLAST RESISTANCE ON RICE PRODUCTIVITY

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ABSTRACT

Rice is a vital food crop for about one-half of the global population. Unfortunately, it suffers from some biotic and abiotic stresses, which negatively affect the yield potential. Rice plants, in Egypt, are subject to infestation with several insect pests, but the most destructive one is the rice stem borer, *Chilo agamemnon* Bles. In addition, rice blast remains the most serious disease to manage**.** Blast resistance has consistently been one of the most important objectives of rice breeders in Egypt. The current investigation was conducted at the experimental farm of Rice Research and Training Center, Sakha Agricultural Research Station during 2014 and 2015 rice seasons. The objectives were to find out the efficiency of *Trichogramma* release in controlling the rice stem borer compared with insecticide, and to identify some novel resistant and high yielding varieties with high broad spectrum of blast resistance and high level of tolerance to stem borer infestation. Seventeen genotypes were evaluated under both natural and artificial inoculation for blast. Also, yield and yield attributes of these genotypes were estimated. The results revealed that all japonica genotypes were resistant or moderately resistant to the stem borer while indica and indica japonica genotypes were almost susceptible to the stem borer. The release of *Trichogramma* twice, each at a rate of 30,000 individuals /feddan, the first release was ten days before maximum tillering, and the second one was at 20% flowering. The release of this egg-parasitoid reduced the borer infestation, overall the 17 genotypes, by 78-80% white heads, and was relatively more efficient than the application of the recommended insecticide (Furadan at a rate of 6 kg /feddan). Consequently, *Trichogramma,* as eco-friendly application, could be used as an alternative management for stem borer than insecticide. Blast nursery evaluation revealed that all japonica GZ lines were highly resistant, as well as high yielding, such as GZ10364-22-3-1-2 and GZ10365-2-4-1-2. Under artificial inoculation with specific and virulent blast races, all genotypes were resistant to all aggressive races except Sakha 101 that was susceptible Till now, the genotypes, Giza177, Sakha 105, Sakha 106, Giza 178, Giza 182, GZ 6296-12-1-2-1-1 and GZ 6903-1-2-2-1-1 are resistant to the blast, and could be utilized as good sources of resistance in the breeding program. As for agronomic and yield characteristics, the genotypes, GZ GZ10365-2-4-1-2, GZ10356-4-3-2-5 and GZ10365-2-4-1-3 were earlier than the rice varieties Sakha 101and Egyptian yasmine by at least 20 days, thus these varieties can save more irrigation water for other crops. The genotypes, GZ10364-22-3-1-2, GZ10365-2-4-1-2 and Sakha 101 recorded the highest values of milling percentage and grain yield. The superiority of these genotypes in grain yield could be attributed to their higher number of panicles /hill, and to their agronomic efficiency.

Keywords: Rice, blast, stem borer, *Trichogramma*, resistance, genotypes.

INTRODUCTION

Rice production suffers from some constraints that negatively affect the yield potential. Some of these constraints are abiotic factors and some others are biotic factors.

Rice stem borers and rice blast are main biotic factors in the Egyptian rice fields. The rice stem borer, *Chilo agamemnon* Bles. Is a real threat to rice cultivars, which may reflect yield reduction, Sherif *et al* (2008). The growers use insecticides to control the pest earlier than needed when they watch the dead heart symptom, which appears during the vegetative stage. Such insecticide applications are highly hazardous to natural enemies, from which is the egg-parasitoid, *Trichogramma* spp., that represent important biological elements to control stem borers in rice fields (Marub 1993, Asaady and Navai 1995, Sherif *et al* 2008). *atThere* are two ways to enhance the population of *Trichogramma. evanescens* in rice fields. The first way is by conserving the occurring population through avoidance (or minimizing) the use of pesticides. The second one is by mass-rearing of the parasitoid to be released at proper rates and proper times. Sherif *et al* (2008) concluded that the most appropriate rate of *T. evanescens* release is 30,000 individuals / feddan, and to be released twice; 20 and 40 days after transplanting rice plants sown by the first week of May.

Trichogramma chilonis and *Trichogramma dendrolium* have provided better control for the Asian corn borer, *Ostrinia furnacalis* (Guenee) (Feng *et al* 1999, Tan 1999 and Wu *et al* 2001). The Indian meal moth, *Plodia interpunctella* was also controlled in food products located in retail stores by the release of *T. deion*. The bio-intensive program, including releasing *T. chilonis*, for controlling cotton insects gave best seed cotton yields in farmers' fields and the highest net income (Anonymous 1999). *Trichogramma* release for control of the Asian corn borer has become one of the key techniques of integrated pest management of corn pests in China (Wang *et al* 2003). El-Habashy (2009) reported that two releases of *T. evanescens* on 5 July and 20 July or on 20 July and 18 August achieved a satisfactory *C.agamemnon* control, resulting in about 71-74 % reductions in white heads. In addition, on the large scale, he found that the reduction of white heads due to the release of *T. evanescens* was 94.38 % compared to 46.28 % due to insecticide application. Upamanya *et al* (2013) evaluated the performance of *T. japonicum* in comparison to the insecticide, chloropyriphos against rice stem borer, *Scirpophaga incertulas* and *S. innotata* and found no significant difference between the parasite and insecticide in dead hearts, white ears and yield. However, they recorded a significant difference between both of them and the untreated plots. Shawer *et al* (2013) reported that releasing the parasite, *T. evanescens* proved to be effective in controlling the rice stem borer, *Chilo agamemnon* Bles. with no need to use insecticides in the fields sown with the cultivar Giza 178, and the infestation was reduced by 49.30 - 63.36 % dead hearts and by 63.15 - 65.18 % white heads. Wang *et al* (2014) reported that nearly 4 milion hectars of corn are treated with *T. dendrolium, T. chilonis* and *T. ostrinia* annually to control the Asian corn borer, *Ostrinia furnacalis.*

Blast is the most widespread and damaging disease of rice worldwide. The disease attacks the crop at all stages of development, prompting frequent fungicide applications, which are expensive and pose an environmental hazard. It is most important to looking for new resistant varieties for blast that can exhibit a broad spectrum of resistance to prevalence races and specific races that result in breakdown of resistant cultivars such as Sakha 101 and Sakha 104 and make yield instability during different seasons. Thus, blast is remains one of the most difficult crop diseases to manage, (Khush and Jena, 2007 and El-Shafey et al, 2015). Blast resistance has consistently been one of the most important objectives of rice breeders in Egypt. Breeding disease resistant varieties is the most cost-effective and reliable method of disease management. Resistance is often lost in few years after release of resistant cultivars due to high race shifting and high levels of variability of the blast fungus. (Bonman *et al*., 1986; Han *et al.,* 2001; Kiyosawa, 1981; Mackill and Bonman, 1992; Yaegashi, 1994).

The strategy of enhancement of host-plant resistance is considered the most important approach to overcome this disease. Pyramiding of two or more effective resistance genes into high yielding cultivars induces the durability and spectrum of resistance. Therefore, identifying superior and highly effective resistance genes can be enormously supportive in increasing the degree of resistance and can be valuable in breeding durable resistance for blast disease (Hittalmani et al., 2000; Liu et al., 2005; Ramkumar et al 2010; Wang *et al*., 1994).

The objectives of the current investigation were to test the efficiency of releasing the egg-parasitoid, *T. evanescens* for reducing the rice stem borer infestation in rice cultivars. Rice genotypes were evaluated for their reaction to rice blast. Identifying some novel resistant genes and high yielding rice cultivars with a wide spectrum of blast resistance is very important to select diverse parents and assist in broadening the germplasm base of future rice breeding programs. Performance of seventeen rice genotypes was a major task of this investigation.

MATERIALS AND METHODS

The present research was carried out at the Farm of Rice Research and Training Center (RRTC), Sakha, Kafr EL-Sheikh, Egypt, during two successive rice seasons; 2014 and 2015.

Agronomic and grain quality characteristics:

Seventeen genotypes were sown on the first May in 2014 and 2015 seasons, and single seedling of each genotype was transplanted 30 days later in the permanent field. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot consisted of five rows, each row was five meters long and contained 25 hills/m^2. All agricultural practices were applied as recommended. The estimated traits were: growth duration, plant height, number of tillers and panicles /plant, filled grains/panicles. Moreover, panicle length, 1000-grain weight, milling % and number of grains /panicle and grain yield t/h were evaluated for all mentioned genotypes. Analysis of variance was used to estimate the genotypic variance and phenotypic variance and percentage of genotypic (GCV%) and percentage of phenotypic (PCV%) coefficient of variability components according to the formula suggested by Burton, 1952. Genetic advance upon selection (Δ g) as and percentage of the mean (Δ g %) was computed according to Johnson et el. 1955.

Rice stem borer and biological control:

The seventeen rice genotypes presented in Table (1) were transplanted in randomized complete block design, with three replicates and each plot measured 10 m^2. Three treatments were considered; release of *Trichogramma*, application of the insecticide, Carbofuran, and the third treatment included the control check. The egg-parasitoid was released at a density of 30,000 individuals per feddan twice; 20 and 40 days after rice transplanting. Carbofuran (Furadan, 10G) was applied as 6 kg per feddan for one time. To evaluate the rice genotype sensitivity to the rice stem borer, *Chilo agamemnon*, 30 hills (10 hills per plot × 3 replicates) from each genotype were cut at the soil surface, three weeks prior to harvest. Total number of tillers was recorded, and number of tillers bearing white heads were counted. Thus, percentage of white heads were computed in the treatments. Reductions in white head percentages due to *Trichogramma* release or due to insecticide application were calculated according Abbott formula on the basis of stem borer infestation in the check.

The collected data were analyzed for analysis of variances according to Gomez and Gomez (1984).

Table 1: Pedigree, type and year of release of the studied seventeen rice genotypes

No.	Entry	Pedigree	Type	Year of Release
1	Giza 177	Giza171/Yomji No.1//Pi No.4	J	1995
2	Sakha 101	Giza176/Milyang79	J	1997
3	Sakha 105	GZ5581× GZ 24316	J	2007
4	Sakha 106	Giza177× Hexi 30	J	2007
5	Giza 181	IR28× IR22	I	1988
6	Giza 182	Giza181/IR39422/Giza181	I	1999
7	Egyptian yasmin	IR262×KDML105	I	
8	GZ10355-9-1-1-4	GZ7456 ×BY-GC 30	J	
9	GZ10355-9-1-1-5	GZ7456 ×BY-GC 30	J	
10	GZ10356-4-2-1-4	GZ8130 × CT6163	J	
11	GZ10356-4-3-2-5	GZ8130 × CT6163	J	
12	GZ10364-22-3-1-2	BY-GC 30 × Milyang 95	J	
13	GZ10365-2-3-2-3	BY-GC 30 × SKC 23822	J	
14	GZ10365-2-4-1-2	BY-GC 30 × SKC 23822	J	
15	GZ10365-2-4-1-3	BY-GC 30 × SKC 23822	J	
16	GZ6296-12-1-2-1-1	Ac 1225 × Hua Lien you 202	IJ	
17	GZ6903-1-2-2-1-1	Sakha 101 × Suweon 313	J	

J: Japonica Type, I: Indica Type and IJ: Indica japonica Type

Stem borer infestation assessment:

All genotypes were evaluated for rice stem borer infestation. The reaction of evaluated genotypes was classified into five categories according to standard evaluation of Rice Research and Training Center (RRTC), Sakha, Egypt, (2006) as follows: Resistant (R): 0 – 3 % white head (WH), Moderately resistant (MR): > 3 – 6 % WH, Moderately susceptible (MS): > 6 – 9 % WH, Susceptible (S): > 9 – 12 % WH, and Highly susceptible (HS) > 12 % WH.

Plant materials:

Seventeen Egyptian rice genotypes were used in this study. A detailed description of the materials used in the present investigation is shown in Table 1.

Blast nursery test:

Blast reaction was determined under field conditions at two locations i.e. Sakha and Gemmiza. Seventeen Egyptian rice genotypes were grown and their major resistance genes were exposed to natural infection with mixed blast races in blast nursery condition. At seedling stage, seedbeds were prepared during the first week of July in each season and fertilized with nitrogen in the form of urea (46.5%N) at the rate of 60 Kg nitrogen per feddan and manured (8 m3 farm-yard manure /fed) and prepared for seeding the varieties. Five rows of Sakha 101 (susceptible variety) were sown, then five of the considered varieties, and again one row of the spreader Giza 159, with 15 cm apart. Another five varieties were sown, followed by one row of the resistant check (Giza 181). The susceptible and resistant checks were sown alternatively, surrounding five of the considered varieties. About forty-days from sowing, the typical blast lesions were scored, according to the standard evaluation system using 0-9 scale (IRRI 1996) as follows:

1-2 = resistant (R)
3 = moderately resistant (MR)
4-6 = susceptible (S)
7-9 = highly susceptible (HS)

Artificial inoculation:

Seventeen Egyptian varieties were seeded in plastic trays (30 x 20 x15 cm.). Each tray comprised 20 rows representing twenty varieties in four replications. The trays were kept in the greenhouse at 25-30ºC, and fertilized with Urea 46.5%N (5 gm/tray). The plants were inoculated for blast evaluation under greenhouse conditions with six specific races of blast. Seedlings were ready for inoculation at 3-4-leaf stage, about 3-4 weeks after sowing.

Twenty-day old seedlings, in the trays, were inoculated by spraying with water suspension of isolates. Spore suspension(100 ml) was prepared and adjusted to 5 x 10^4 spores/ml. Gelatin was added to the spore suspension at a concentration of 2.5 g/L (El-Shafey et al, 2015) to enhance the adhesion of spores on leaf surfaces and sprayed using electrical spray gun. The inoculated seedlings were held in a moist chamber with at least 90% R.H. at 25-28 oC for 24 hr, and then moved to the greenhouse. Ten days after inoculation, severe symptoms appeared on different rice cultivars. Blast infection was scored, according to the Standard Evaluation System of IRRI, 1996.

RESULTS AND DISCUSSION

Mean performance:

Mean performance of all agronomic traits is presented in Table (2). The data revealed highly significant mean squares for all studied traits, suggesting the presence of genetic variations among the rice genotypes for all studied traits. Data in Tables (2 & 3) showed that all genotypes were more affected by environment conditions from year to year. For duration, most of genotypes were early maturing except Sakha 101 and Egyptian yasmine that had most than 140 days. As for plant height, the short stature are most preferred at 90 cm such as Sakha 101 but the plant height more than 100 cm is an undesirable trait such as Egyptian yasmine.

Table 2:Mean performances of rice genotypes for duration , plant height, tillers and panicles per plant and filled grains/ panicle traits.

No.	Genotype	Duration (day)		Plant height (cm		Tillers/ plant		panicles/ plant		Filled grains/ panicle	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
1	Giza 177	125	124	103.00	99.00	21.00	21.00	20.33	19.00	146.00	121.67
2	Sakha 101	144	144	90.00	91.00	23.00	25.00	22.33	23.00	168.67	149.00
3	Sakha 105	125	125	101.67	101.00	22.00	19.00	21.00	20.33	128.67	128.33
4	Sakha 106	126	123	106.00	107.00	18.33	17.00	18.00	21.00	133.67	124.67
5	Giza 181	144	140	95.33	97.67	19.00	23.00	18.33	23.67	155.33	155.00
6	Giza 182	126	129	95.33	95.00	16.67	23.00	16.67	27.00	139.33	136.00
7	Egyptian yasmin	145	136	116.00	111.67	26.00	28.00	25.00	21.67	167.00	170.33
8	GZ10355-9-1-1-4	125	124	94.00	92.00	18.00	18.00	16.67	23.00	128.00	125.00
9	GZ10355-9-1-1-5	125	125	99.67	97.00	24.00	23.00	22.33	22.00	135.00	131.67
10	GZ10356-4-2-1-4	126	126	95.33	95.00	20.33	20.00	18.33	23.00	143.00	136.33
11	GZ10356-4-3-2-5	125	122	96.33	93.67	21.67	22.00	18.67	22.00	136.33	132.33
12	GZ10364-22-3-1-2	126	125	106.00	102.33	23.00	23.00	21.00	22.00	158.00	145.00
13	GZ10365-2-3-2-3	126	124	95.00	94.00	21.67	24.00	19.33	20.67	135.00	134.67
14	GZ10365-2-4-1-2	124	121	97.00	94.00	24.67	25.67	22.00	18.00	137.00	128.33
15	GZ10365-2-4-1-3	125	124	101.67	98.67	21.33	21.00	19.67	21.00	168.00	162.00
16	GZ6296-12-1-2-1-1	126	125	95.67	94.00	25.00	26.33	24.00	22.67	173.67	171.67
17	GZ6903-1-2-2-1-1	133	133	99.00	99.00	24.67	24.00	24.00	21.00	145.33	133.00
	LSD 5 %	1.645	0.995	0.995	0.828	1.340	0.324	1.025	0.507	9.455	7.558

Regarding to number of tillers and panicles/plant, the rice lines, Egyptian Yasmin, Sakha 101, GZ10365-2-4-1-2 GZ6296-12-1-2-1-1 and GZ6903-1-2-2-1-1 recorded the highest values of number of tillers and panicles/plant.

For number of filled grains/panicle, the rice genotypes; GZ6296-12-1-2-1-1, Sakha 101, GZ10365-2-4-1-3 and Egyptian Yasmine were best.

For panicle length, rice genotypes; Giza 182, Egyptian Yasmine, Sakha 101 and GZ10356-4-3-2-5 gave the highest values of panicle length as compared with the other rice genotypes

As for 1000-grain weight, Sakha 101, GZ10365-2-4-1-2 and GZ10364-22-3-1-2 recorded the heaviest 1000-grain weight , Giza 181 and Egyptian yasmine gave the lowest 1000-grain weight. These differences among the genotypes may be due to the differences in their genetic background. These results are in close agreement with those obtained by Hammoud *et al.*, (2006).

The longest growth duration was that of Sakha 101 rice variety. By the way, it could be concluded that GZ10364-22-3-1-2 and GZ10365-2-4-1-2 new rice entries could be replace Sakha 101 rice variety as it has become blast susceptible variety. Similar data have been reported by Chandrasekhar *et al*. (2001), Singh (2002) and Hammoud, (2011).

The rice genotypes, GZ10364-22-3-1-2, GZ10365-2-4-1-2, and Sakha 101, recorded the highest values of milling % and grain yield (t/ha). The superiority of these varieties in grain yield might be due to their higher number of panicles/plant and their agronomic efficiency. These results were previously obtained by Hassan, *et al*. (2012), Abd El-Hadi, *et al*. (2012), Sedeek, et al. (2012) and Hammoud, *et al.* (2013).

Table 3: Mean performances of rice genotypes for panicle length, 1000-grain weight, milling % and grain yield traits.

No.	Genotype	Panicle length (cm)		1000- grain weight (g)		Milling %		Grain yield (t/fed)	
		2014	2015	2014	2015	2014	2015	2014	2015
1	Giza 177	19.57	19.00	27.50	27.77	72.19	70.54	3.67	4.07
2	Sakha 101	23.00	23.00	28.80	28.87	73.55	71.72	4.34	4.51
3	Sakha 105	23.83	20.33	27.80	28.33	70.34	73.11	3.85	4.19
4	Sakha 106	22.97	21.00	27.70	27.83	68.70	70.17	3.85	4.25
5	Giza 181	23.60	23.67	25.63	24.17	66.32	63.18	3.42	3.32
6	Giza 182	22.00	27.00	25.60	25.67	65.27	66.87	3.78	4.19
7	Egyptian yasmin	25.40	21.67	24.33	24.33	67.14	63.41	3.52	3.55
8	GZ10355-9-1-1-4	22.80	23.00	27.77	28.13	70.44	69.09	4.10	4.16
9	GZ10355-9-1-1-5	23.53	22.00	27.53	27.67	71.33	70.23	4.49	4.46
10	GZ10356-4-2-1-4	22.83	23.00	26.93	26.53	70.23	69.13	4.15	4.23
11	GZ10356-4-3-2-5	24.30	22.00	27.37	27.37	69.14	69.34	4.23	4.08
12	GZ10364-22-3-1-2	22.77	22.00	27.90	28.70	71.28	70.69	4.75	4.50
13	GZ10365-2-3-2-3	21.93	20.67	27.23	27.50	70.68	70.00	4.33	4.11
14	GZ10365-2-4-1-2	19.63	18.00	28.17	28.27	72.20	70.54	4.46	4.48
15	GZ10365-2-4-1-3	21.50	21.00	27.43	27.37	70.32	71.82	4.35	4.19
16	GZ6296-12-1-2-1-1	22.60	22.67	25.37	25.50	66.22	66.08	4.55	4.19
17	GZ6903-1-2-2-1-1	22.37	21.00	26.50	27.07	70.22	69.34	3.82	3.35
	LSD 5 %	0.910	0.507	0.331	0.712	1.716	1.878	0.152	0.205

Phenotypic, genotypic variability, heritability and genetic advance:

Estimate of phenotypic genotypic coefficient variability and genetic advance are presented in Table (4). The results showed that the most traits under studies had wide range of variability. Thus wide range was reflected in the variation among tested cultivars, where all cultivars mean squares for all traits were highly significant under two years. Thus, selection for given traits among these cultivars would be effective in all cases. Similar results were obtained by Aidy, *et a*l (1992), El-Hity and El-Keredy (1992) and Hammoud, *et al* (2014). The phenotypic coefficient of variability PCV % was higher than genotypic coefficient GCV % in all genotypes for all indicated that the most portion of PCV % was more contributed by environmental condition and culture practices, Metwally *et al* (2014).

Heritability :

Heritability % was estimated as a ratio between genotypic variance and the total phenotypic variance and the latter was reduced by the small components of the genetic × environment (G × E) interaction which was most significant for all studied traits indicated that the genetic advance (additive and non-additive) play an important role in inheritance for all traits Table (4). Similar results previously obtained by Karim *et al* (2007), Babar *et a*l (2007), Hammoud et al (2009) and Hammoud (2014).

Genetic advance:

Genetic advance (GA%) under selection which gain from selection as percent increase in the value of genetic advance from generation to generation when the selected most desirable 5% from plants. Genetic advance under selection was estimated under two years 2014 and 2015. For duration, genetic advance gave the highest value 55.04% over the two years compared with orther traits, followed by filled grains/ panicle 43.72%. The lowest value were found in tiller /plant (4.49%). These results indicated that the improved of duration was earlier compared with other traits. Dixit, (1970**)** stated that high heritability is not always associated with high genetic gain but in order to make efficient selection high heritability should be associated with high genetic gain. In present investigation, high genetic gain was found to be associated with high heritability estimated for duration and filled grains /panicle. Consequently, selection for these traits under two years should be effective and satisfactory for successful breeding purposes. Similar results were previously obtained by Hammoud, (2004 and 2005) and Sedeek *et al.,* 2007).

Data presented in Table (5) and Fig. (1) show the natural infestation by the rice stem borer, *Chilo agamemnon* Bles. to 17 rice genotypes. Also, the effect of treating these genotypes with the egg-parasitoid, *Trichogramma evaescens* as compared with the insecticide, carbofuran (Furadan 10 G) on the borer infestation is presented.

Table 4: Phenotypic, genotypic coefficient of variation, and genetic advance of the rice genotypes for some agronomic traits.

	Duration (day)	Plant height (cm)	Tillers/ plant	panicles/ plant	Panicle length (cm)	Filled grains/ panicle	1000- grain weight (g)	Grain yield (t/ha)	Milling %
Genotypes Var.	150.45**	100.24**	24.02**	16.08**	9.18**	722.55**	5.09**	0.43**	19.51**
M.S error	15.97	0.30	0.19	0.41	0.20	26.49	0.11	0.01	1.17
Mean	129.18	99.24	21.78	20.45	22.63	146.94	27.03	4.10	69.74
σ^2 ph	55.47	33.51	8.07	5.50	3.13	249.68	1.73	0.15	6.89
σ^2 G	39.50	33.21	7.88	5.09	2.93	223.19	1.62	0.13	5.72
PCV %	31.55	6.00	2.21	11.96	2.17	22.46	4.87	3.67	3.72
GCV %	26.72	5.98	2.18	11.48	2.10	21.22	4.71	3.52	3.39
H. bs	86.00	99.55	98.70	95.92	95.99	94.48	97.03	95.82	90.99
Δg	12.93	11.85	5.77	4.61	3.48	30.76	2.61	0.75	4.91
Δg%	55.04	12.31	4.49	23.66	4.32	43.72	9.71	7.25	6.98

Table (5): Susceptibility of rice genotypes to rice stem borer, *Chilo agamemnon*, and insect infestation reduction due to *Trichogramma* release and insecticide application

No.	Variety	Untreated check		*Trichogramma*		Reduction % in infestation with Trichogramma		Insecticide		Reduction % in infestation with Insecticide	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
1	Giza 177	6.2	6.80	1.32	1.12	78.71	83.35	1.42	1.90	77.10	72.06
2	Sakha 101	2.44	2.90	0.97	0.54	60.25	81.38	0.58	0.82	76.23	71.72
3	Sakha 105	7.46	9.22	1.11	2.03	85.12	77.98	0.93	2.01	87.53	78.20
4	Sakha 106	6.50	7.33	1.01	1.78	84.46	75.72	1.82	1.81	72.00	75.31
5	Giza 181	12.42	14.66	2.44	3.19	80.35	78.24	2.00	3.92	83.90	73.26
6	Giza 182	11.48	13.95	1.88	3.06	83.62	78.06	1.73	3.65	84.93	73.84
7	Egyptian yasmin	14.69	18.48	2.13	3.42	85.50	81.49	3.60	4.01	75.49	78.30
8	GZ10355-9-1-1-4	4.40	5.10	0.66	0.87	85.00	82.94	1.02	0.92	76.82	81.96
9	GZ10355-9-1-1-5	4.86	5.42	1.07	1.12	77.98	79.34	1.82	0.83	62.55	84.69
10	GZ10356-4-2-1-4	6.56	6.82	1.33	1.63	79.73	76.10	0.98	1.07	85.06	84.31
11	GZ10356-4-3-2-5	6.24	5.70	0.98	1.18	84.29	79.30	1.06	0.74	83.01	87.02
12	GZ10364-22-3-1-2	5.33	7.95	0.74	2.01	86.12	74.72	1.00	1.93	81.24	75.72
13	GZ10365-2-3-2-3	4.66	5.18	0.82	0.93	82.40	82.05	0.85	1.00	81.76	8069
14	GZ10365-2-4-1-2	6.34	7.76	1.19	1.98	81.23	74.48	1.20	1.88	81.07	75.77
15	GZ10365-2-4-1-3	7.80	7.10	1.79	1.54	77.05	78.31	2.01	1.95	74.23	72.54
16	GZ6296-12-1-2-1-1	11.66	12.69	2.12	2.97	81.82	76.60	2.93	2.87	74.87	77.38
17	GZ6903-1-2-2-1-1	7.77	6.50	1.15	1.50	85.20	76.92	1.09	1.20	85.97	81.54
	LSD 5 %	1.198	0.763	0.291	0.389			0.276	0.234		
	Average	7.46	8.44	1.34	1.82	81.12	78.65	1.53	1.91	74.04	77.90

In 2014 rice season, the rice genotypes had white head percentages ranging from 2.44 (Sakha 101 to 14.69 % (Egyptian Yasmin), with an average over the genotypes of 7.46 %. The infestation was relatively higher in the second rice season (2015), with white head percentages ranging from 2.90 % (Sakha 101) to 18.48 % (Egyptian Yasmin). The overall average was 8.44 % white heads. In such respect, it is important to indicate that the rice genotypes with white head, less than 7 % are considered tolerant to the rice stem borer infestation (RRTC Report 2011). Thus, *C. agamemnon*, and the borer infestation can negatively affect the yield.

However, the chemical control is common among the rice growers whatever the insect infestation level. Accordingly, in the current investigation the egg parasitoid, *Trichogramma evaescens* was released twice in plots of rice genotypes. In 2014 season, (Tabl5 and Fig. 2), the borer infestation was greatly reduced in all genotypes to negligible values; 0.74 - 2.44 % with an overall average of 1.34 %. Almost, the same results were obtained in 2015 season, (range of 0.54 - 3.42 %, average of 1.82 % white heads). Reductions in stem borer infestation due to *Trichogramma* release were calculated as 81.12 and 78.65 % in the first and second seasons, respectively.

However, the insecticide carbofuran (Furadan 10 G), as commonly applied by the rice growers, was applied to be compared to *Trichogramma*. Almost, the same results were obtained. The stem borer infestation (Table 1 and Fig. 2) ranged 0.58 - 3.60 %, with an average of 1.53 % white heads in 2014 season, and ranged 0.74 - 4.01 %, with an average of 1.91 % white heads in 2015 season. Thus, it was calculated that the insecticidal application reduced rice stem borer infestation by 74.04 and 77.90 % in the first and second season, respectively.

Several authors recommended using *Trichogramma* for controlling stem borers either in rice or corn fields; e.g. Wu *et al*, 2001; Sherif et al, 2008 and Shawer *et al* 2013. The appropriate time to release *T. evanescens* in rice fields was recommended as 20 and 40 days after transplanting (Sherif *et al* 2008). Even in cotton fields, the bio-intensive program included releasing *T. chilonis* for controlling lepidopterous insects, which gave best seed cotton yields in farmer's fields and the highest net income (Anonymous 1999).

The current results showed that release of *T. evanescens* was almost equivalent to the insecticide application in controlling C. Agamemnon. Similar results were obtained by Upamanya *et al* (2013) and Zhen *et al*. (2014). Also, Shawer *et al* (2013) obtained 49 - 63 % reduction in dead hearts, and 63 - 65 % reductions of white heads resulting from C. Agamemnon due to the release of *T. evanescens*.

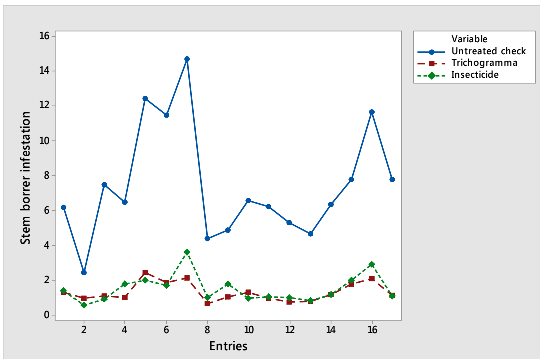

Fig. 1: Stem borer infestation under application of insecticide and *Trichogramma* compared with natural infestation for all tested varieties.

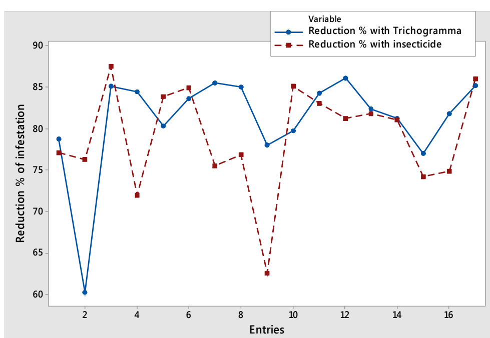

Fig. 2: Reduction % in stem borer infestation under application of insecticide and *Trichogramma*.

Fitting curve:

For fitting curve results (Fig. 3), the application of *Trichogramma* showed the same behavior compared to insecticide and the efficiency was more close to each other. Consequently, *Trichogramma* as eco-friendly application, it can be used as alternative management for stem borer than insecticide, to keep the rice ecosystem clean without pollution and the hazardous effect of insecticides. Similar results were obtained by Upamanya *et al* (2013) and Zhen *et a*l. (2014).

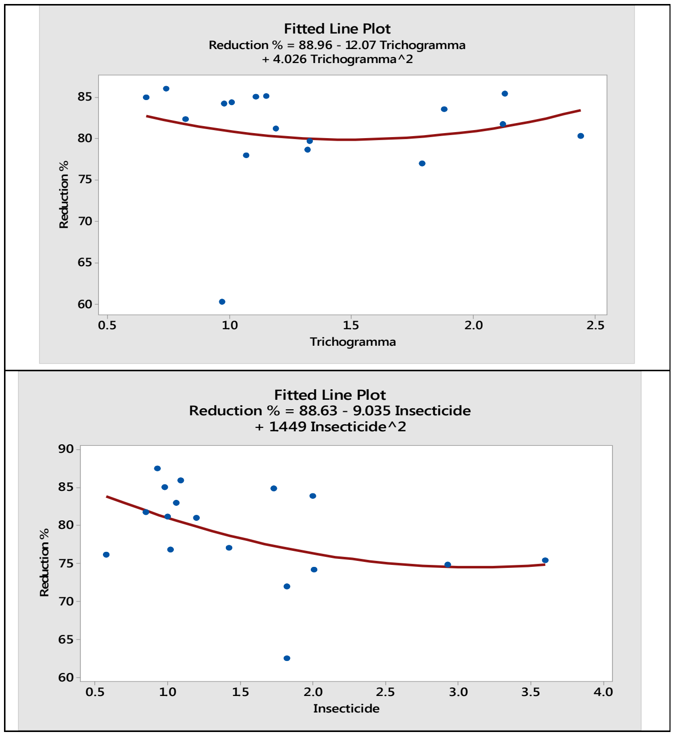

Fig. 3: Fitting curve under application of both *Trichogramma* and insecticide.

Blast disease:

For blast disease assessment as shown in Table 6, blast nursery reaction, for indica and indica japonica rices, all tested varieties were resistant to highly resistant. Consequently, they could be used as donors for blast resistance in breeding program, specially GZ 6296. On the other hand, for japonica, all tested rice varieties were resistant, except Sakha 101 which exhibited susceptible and highly susceptible reaction to blast in both locations; sakha and Gemmiza in two years. All japonica GZ lines were highly resistant and some combined high yielding and blast resistant traits such as

GZ10364-22-3-1-2 and GZ10365-2-4-1-2. These promising lines could be cultivated on large scale to achieve high yield production and blast resistance.

For blast reaction under artificial inoculation (Table 4), all tested rice varieties were resistant to all aggressive blast races, except Sakha 101, which was susceptible to all races.

From the reaction of rice varieties to blast, these varieties exhibited a broad spectrum of resistance, thus, they can be considered as resistant sources for transferring the resistance genes from such varieties. All these results are in agreement with those of El-Refaee *et al* (2011), Hammoud, *et a*l (2013) and El-shafey *et a*l (2015) determined some resistant varieties as a source for blast resistance such Giza 177, Sakha 103 and Sakha 105.

Table 6: Blast reaction of different rice varieties under artificial inoculation

No.	variety	Blast nursery 2014-2015		Blast reaction under artificial inoculation					
		Gemmiza	sakha	IB-45	IC-1	IB-13	ID-1	IC-5	IG-1
1	Giza 177	R	R	1	1	2	2	2	1
2	Sakha 101	S	S	5	6	5	5	6	4
3	Sakha 105	R	R	1	1	1	1	2	1
4	Sakha 106	R	R	1	1	1	1	1	2
5	Giza 181	R	R	2	3	2	1	1	1
6	Giza 182	R	R	1	3	1	1	1	1
7	Egyptian yasmin	R	R	1	3	1	1	1	1
8	GZ10355-9-1-1-4	R	R	1	1	2	1	1	1
9	GZ10355-9-1-1-5	R	R	1	2	1	1	2	1
10	GZ10356-4-2-1-4	R	R	1	1	1	1	1	1
11	GZ10356-4-3-2-5	R	R	1	1	1	1	1	1
12	GZ10364-22-3-1-2	R	R	1	1	1	1	1	1
13	GZ10365-2-3-2-3	R	R	1	1	1	1	1	1
14	GZ10365-2-4-1-2	R	R	1	1	1	1	1	1
15	GZ10365-2-4-1-3	R	R	1	1	2	1	1	1
16	GZ6296-12-1-2-1-1	R	R	2	2	1	1	1	1
17	GZ6903-1-2-2-1-1	R	R	2	1	1	2	1	1

According to blast and stem borer reaction, all genotypes were clustered into two main groups in major clusters, Group I is comprised of indica varieties and consisted 4 genotypes, which are further subdivided into two clusters. The Egyptian aromatic indica variety (Egyptian Yasmin) came separately alone in the cluster-I as highly susceptible to stem borer and highly resistant to blast. Cluster-II containing three genotypes (Giza181, Giza182 and GZ6296), occupied the second susceptible rank to stem borer.

The second major cluster involved Group II that comprised japonica varieties and consisted 13 genotypes, which were further subdivided into two clusters; the first sub cluster-I containing Sakha 101 the Egyptian Japonica genotype that is highly susceptible to blast but highly tolerant to stem borer. Sub cluster-II was further divided into three sub-sub clusters. The first sub-sub cluster containing two GZ lines, comprised the highest yielder genotype GZ10364-22-3-1-2 that performed 4.75 t/ fed., and also highly resistant to blast and tolerant to stem borer. Sub-sub cluster-II contained the rest of Egyptian japonica GZ lines and cultivars Giza 177, Sakha 105 and Sakha 106 that are resistant to blast and highly tolerant to stem borer. These results are in agreement with those of El-Refaee *et a*l. 2011 who classified the Egyptian cultivars into two main clusters, the first one comprised indica and indica japonica varieties that are highly resistant to blast and the second one contained the japonica cultivars which are resistant and sub cluster have highly susceptible and old rice cultivars.

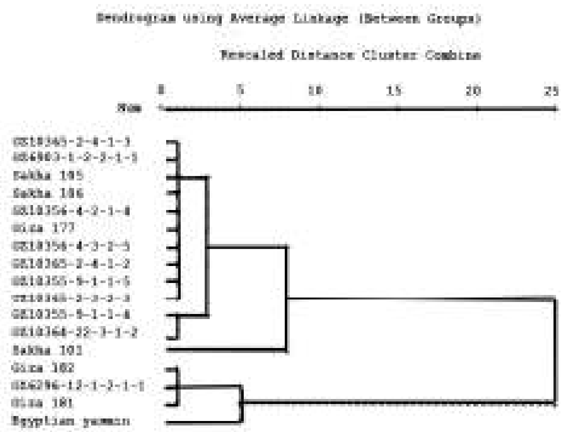

Fig. 4: Dendrogram of different Egyptian rice varieties according to stem borer infestation and blast reaction

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القدرة المحصولية لسلالات الأرز الحديثة وتأثير طفيل التريكوجراما، والمقاومة لمرض اللفحة علي زيادة الانتاجية

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مركز البحوث والتدريب في الأرز - معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

الأرز محصول غذائي حيوي لحوالي نصف سكان الكرة الأرضية، ولكنه لسوء الحظ يتعرض لظروف قاسية سواء حيوية او بيئية. أجري هذا البحث في المزرعة البحثية لمركز بحوث الأرز (محطة البحوث الزراعية بسخا) خلال عامي ٢٠١٤ ، ٢٠١٥ لدراسة كفاءة إطلاق طفيل الترايكوجراما لمكافحة ثاقبة الأرز مقارنة بالمبيدات وتحديد سلالات جديده ذات نطاق واسع من المقاومة لمرض اللفحة وتتحمل الإصابة بثاقبه ساق الأرز وعالية المحصول. أوضحت النتائج أن كل السلالات ذات الطراز الياباني كانت مقاومة أو متوسطة المقاومة لثاقبة ساق الأرز، بينما كانت السلالات ذات الطراز الهندي أو الهندي الياباني حساسة للإصابة بالحشرة. أطلق طفيل التريكوجراما مرتين بمعدل ٣٠,٠٠٠ طفيل / فدان في كل مرة، الأولي عند وصول النباتات لمرحلة التفريع القصوى، والثانية عند تزهير النباتات بمعدل ٢٠ % تقريبا. أدي إطلاق الطفيل الي خفض الإصابة بالحشرة (كمتوسط عام للسلالات المختبرة) بمقدار ٧٨-٨٠ % ، وذلك بالمقارنة بالمبيد (الفيورادان بمعدل ٦ كجم / فدان) الذي أدي إلي خفض الإصابة بمعدل ٧٤ -٧٧ %. كما أوضحت نتائج تقييم الإصابة بمرض اللفحة في حقل اللفحة أن كل السلالات المبشرة المختبرة كانت عالية المقاومة للمرض علاوة علي ارتفاع المحصول، وعلي سبيل المثال السلالة GZ10364-22-3-1-2 ، GZ10365-2-4-1-2. وبخصوص العدوي الصناعية بسلالات لفحة ممرضة ومتخصصة وجد أن كل السلالات السبعة عشرة المختبرة مقاومة للسلالات الممرضة ماعدا سخا ١٠١ الحساس لكل السلالات. ومازالت الأصناف جيزة ١٧٧ ، سخا ١٠٥ ، سخا ١٠٦ ، جيزه ١٧٨ ، جيزه ١٨٢ والسلالات GZ 6903-1-1-2-2-1 و GZ 6296-12-1-2-1-1 مقاومة للمرض حتي الأن وتعتبر مصدراً جيداً للمقاومة لإمداد المربي وبرنامج التربية بمواد مقاومة لمرض اللفحة. كما أظهرت نتائج تقييم المحصول وخصائصه أن السلالات GZ10365-2-4-1-2 ، GZ10356-4-3-2-5 ، GZ10365-2-4-1-3 ، كانت أكثر تبكيرا بحوالي ٢٠ يوما من كل من سخا ١٠١ ، والياسمين المصري. كما نتج أعلي معدل تصافي تبيض من السلالات GZ10364-22-3-1-2 ، GZ10365-2-4-1-2 ، علاوة علي أنها كانت الأعلى محصولا. ويمكن أن ينسب تفوق هذه السلالات في محصول الحبوب إلى تفوقها في عدد السنابل في الجورة، علاوة على كفاءتها العالية في صفاتها المحصولية.