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Evaluation of Linseed Genotypes for Resistance to Bud Fly, *Dasyneura lini* Barnes (Diptera; Cecidomyiidae)

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Abstract—*Linseed (Linum usitatissimum L.) is an important ancient oilseed crop grown for its seed oil or fibre or for both purposes (dual purpose flax) across the Asia, Europe and Americas. The productivity of linseed in West Bengal (360 kg/ha) is very low compared to our national productivity of 435 kg/ha as well as than the world average productivity of 986 kg/ha. Various factors responsible for low yield of linseed, out of them insect pests particularly bud fly is highly destructive causing serious damage and are responsible for lowering the yield (upto 88%) of linseed crop. Among several management options, use of resistant variety is the most practical and economical method of pest management. Therefore, the field trial was conducted under natural condition to screen thirty four genotypes of linseed against bud fly in two consecutive years (2014-15 and 2015-16) during rabi season at Pulses and Oilseeds Research Station, Berhampore, West Bengal. From the pooled data over two years, it is evident that among the germplasm lines, bud fly infestation ranged from 6.8 – 36.1%. Entries Ireland (TFlax), NDL-2011-23 and RLC-148 were found resistant with bud fly infestation upto 10%. The results revealed that the entries BAU-833-11, EC-399086, LMS-2010-2-15, LMS-2010-1-27, LMS-2012-112, LW-9828, NDL-2211-20, RLC-133, RLC-138, RLC-143, RLC-145, Silwani, BAUP-101, BAUP-102, LSL-93, NL-287, NDL-2002, RLC-151 and SHA-1 were moderately resistant to bud fly with > 10 – 25% damage. It was also found that the genotypes JLT-84-5-1-1, KYS-7, NDL-8809, RL-906, T-51, UP-1, 21/4K, BAU-13-6, NDL-2011-36, SLS-100 and T-397 were moderately susceptible to bud fly. During the investigation the germplasms recorded as resistant to bud fly had bud size with lesser length (4.0 - 4.5 mm) and width (2.0 - 2.2 mm). These resistant lines may be used as a donar parents in the multiple resistance breeding programme of linseed.*

Keywords*: Linseed, genotypes, screening, bud fly, Dasyneura lini*

1. INTRODUCTION

Oilseeds occupy an important position in agriculture and industrial economy next to food grains in terms of area, production and value. The cultivated oilseeds comprise nine different crops namely groundnut, soybean, rapeseed-mustard, niger, sunflower, safflower and sesamum as edible oilseeds and castor and linseed as industrial oil crops [11]. Linseed (*Linum usitatissimum* L.) is an important ancient oilseed crop grown for its seed oil or fibre or for both purposes (dual purpose flax) across the Asia, Europe and Americas. It is cultivated mainly for its oil in the south west Asia including Turkistan, Afganistan and India. Of late, its value addition has paved the way for its diversified uses in neutraceutical and medicinal purposes [1]. Linseed is highly nutritious and is a source of complete protein (all 8 essential amino acids), high order linolenic acid (source of Omega-3 and Omega-6 fatty acids), complex carbohydrates, vitamins and minerals [12]. Recent researches have profounded that it is the best herbal source of Omega-3 and Omega-6 fatty acids which improves human nervous system. Its fibre is lustrous, coupled with strength thereby durability and blends well with various natural and manmade fibre.

India ranks third in area after Canada and Kazakhstan which is almost equivalent to but in production slides to fourth place after Canada, China and Kazakhstan. Our national production of 1.47 lakh tonnes is realized from an area of 3.38 lakh ha with low productivity of 435 kg/ha in world arena [3]. In West Bengal the area under this crop was 4.315 thousand ha and production 1.554 thousand tones with the productivity of 360 kg/ha during 2014-15 [2]. The productivity is very low compared to the world average productivity of 986 kg/ha and less than the all major linseed growing countries viz. Canada (1728 kg/ha), USA (1659 kg/ha), U.K. (1500 kg/ha), China (1000 kg/ha) and Ethiopia (933 kg/ha) [3]. Among the various factors responsible for low yield of linseed in our country, insect pests particularly bud fly is highly destructive causing serious damage and are responsible for lowering the yield of linseed crop [10].

Linseed bud fly, *Dasyneura lini* Barnes is the key pest and causing 88% losses of grain yield [9].Adult fly is a small orange coloured mosquito-like fly laid eggs on the sepal or other parts of the flower buds and its tiny pinkish maggot feed on the developing buds and produce galls. When full grown, the larvae fall to the ground and pupate in soil. The infested buds become hollow and can be easily identified from the healthy buds by pressing and pulling.

Among various management options, use of resistant variety is the most practical and economical method of pest management. Therefore, the study was conducted on varietal screening to identify the resistant sources against bud fly.

2. MATERIALS AND METHODS

The field trial was conducted under natural condition to screen thirty four genotypes of linseed against bud fly in two consecutive years (2014-15 and 2015-16) during rabi season at Pulses and Oilseeds Research Station, Berhampore, West Bengal. The genotypes (Table-1) were grown in a plot size of 1.5 x 3.0 m with 30 x 10 cm spacing and replicated thrice in RBD design following recommended agronomic practices for raising the crop. No insecticide was sprayed in the plots. To create maximum pressure of bud fly, single line of susceptible variety Neelum was grown as infester row in between the path and round the field. The bud fly infestation was recorded at dough stage from 10 randomly selected plants per entry by counting total number of floral buds as well as infested buds and percent bud infestation were calculated as per the following formulae.

$$\text{Bud fly infestation (\%)} = \frac{\text{Infested buds}}{\text{Total number of buds}} \times 100$$

All the genotypes were categorized into resistant (upto 10% damage), moderately resistant (> 10 - 25% damage), moderately susceptible (> 25 - 50%), susceptible (> 50 - 75%) and highly susceptible (> 75% damage) on the basis of average bud fly infestation as suggested by Malik [8]. The biophysical characteristics of the genotypes were also recorded to find out their relation with the bud fly infestation. From each line five green buds were peeled out randomly to record size (length x width) in mm with the help of digital caliper. Flower colour and shape were also recorded by visual observation after the opening of the flower.

3. RESULTS AND DISCUSSION

The preference of bud fly to different linseed genotypes in terms of percent bud damage during 2014-15 are presented in the table-1. It is revealed from this study that none of the entries was found free from the bud fly infestation. The genotype Ireland (TFlax) registered significantly lowest infestation of bud fly (6.6%) and the seed yield was 10.5 qt/ha. Entries NDL-2011-23 and RLC-148 also exhibited resistant reaction to the bud fly (upto 10% infestation). Highest seed yield (10.7 qt/ha) was recorded in NDL-2011-18 with the bud fly infestation of 13.2%. The entries registered more bud fly damage (> 25 - 50%) were JLT-84-5-1-1, T-51, UP-1, 21/4K, BAU-13-6, SLS-100 and T-397. Other entries recorded under the moderately resistant category (> 10 - 25% bud damage). Among the entries tested for bud fly preference during 2014-15, the entries Ireland (TFlax), NDL-2011-23, RLC-148 and NDL-2011-18 were found promising in terms of low bud fly infestation and more yield.

During 2015-16 crop season, the susceptibility/ resistance of linseed entries against bud fly are presented in the table-2 also revealed that none of the entry was found to be free from the bud fly infestation. In this year lower bud fly infestations were also noticed in the entries Ireland (TFlax), NDL-2011-23 and RLC-148, which were statistically at par. Higher bud fly infestation was recorded in NDL-8809, UP-1, 21/4K, SLS-100, EC-399086, LMS- 2010-2-15 and NDL-2011-36 which were ranked as moderately susceptible. From this study it may be recorded that the entry Ireland (TFlax), NDL-2011-23, RLC-148 and NDL-2011-18 were promising in terms of yield and less preference to bud fly.

From the pooled data over two years (Table-3), it is evident that among the germplasm lines, bud fly infestation ranged from 6.8 – 36.1%. Based on consecutive two years data only three entries viz. Ireland (TFlax), NDL-2011-23 and RLC-148 were found to be least preferred by bud fly as well as they were high yielder in new alluvial zone of West Bengal.

During the investigation the germplasms recorded as resistant to bud fly had bud size with lesser length (4.0 - 4.5 mm) and width (2.0 - 2.2 mm). Entries with larger size bud were susceptible to bud fly may be due to larger bud structure provide more food and space to the maggot of bud fly for development. This observation corroborates the findings of [4-5], and [7].

Among the germplasm studied, Ireland (TFlax), NDL-2011-23 and RLC-148 registered minimum days to 50% flowering and these were found resistant to bud fly, while, 21/4K had maximum days (87 days) was recorded as moderately susceptible with 36.1% bud infestation (Table 4 & 5). These findings are in conformity with that of [13], and [6].

The different genotypes of linseed were grouped into five categories viz. resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible based on percent bud fly infestation are presented in the table-6. Entries Ireland (TFlax), NDL-2011-23 and RLC-148 were found resistant with bud fly infestation upto 10%. The results revealed that the entries BAU-833-11, EC-399086, LMS-2010-2-15, LMS-2010-1-27, LMS-2012-112, LW-9828, NDL-2211-20, RLC-133, RLC-138, RLC-143, RLC-145, Silwani, BAUP-101, BAUP-102, LSL-93, NL-287, NDL-2002, RLC-151 and SHA-1 were moderately resistant to bud fly with > 10 – 25% damage. It was also found that the genotypes JLT-84-5-1-1, KYS-7, NDL-8809, RL-906, T-51, UP-1, 21/4K, BAU-13-6, NDL-2011-36, SLS-100 and T-397 were moderately susceptible to bud fly. Anonymous [1] also reported Ireland (TFlax), NDL-2011-23 and RLC-148 as resistant to bud fly infestation from Kanpur, Kaul, Sabour, Raipur and Raichur in the AICRP trial during 2014-15.

4. CONCLUSION

The result of studies on the screening of linseed genotypes against bud fly revealed that the genotypes Ireland (TFlax), NDL-2011-23, RLC-148 and NDL-2011-18 were comparatively more resistant to the infestation of bud fly and high seed yielder. Therefore, these lines may be used as a donar parents in the multiple resistance breeding programme of linseed.

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Table 1: Screening of linseed entries against bud fly during 2014-15

Sl. No.	Entries	% bud infested		Yield (qt./ha)	
1	BAU-833-11	23.9	(4.9)*	6.2	(2.5)*
2	EC-399086	17.2	(4.1)	5.3	(2.3)
3	Ireland (TFlax)	6.6	(2.6)	10.5	(3.2)
4	JLT-84-5-1-1	32.0	(5.7)	5.4	(2.3)
5	KYS-7	26.3	(5.1)	4.9	(2.2)
6	LMS-2010-2-15	16.2	(4.0)	8.1	(2.8)
7	LMS-2010-1-27	18.4	(4.3)	5.7	(2.4)
8	LMS-2012-112	22.1	(4.7)	6.6	(2.6)
9	LW-9828	11.1	(3.3)	5.0	(2.2)
10	NDL-8809	34.8	(5.9)	4.0	(2.0)
11	NDL-2211-20	12.1	(3.5)	7.2	(2.7)
12	NDL-2011-23	8.1	(2.8)	10.4	(3.2)
13	RL-906	26.2	(5.1)	6.1	(2.5)
14	RLC-133	15.9	(4.0)	5.4	(2.3)
15	RLC-138	22.4	(4.7)	6.2	(2.5)
16	RLC-143	10.4	(3.2)	8.2	(2.9)
17	RLC-145	12.0	(3.5)	6.2	(2.5)
18	Silwani	24.1	(4.9)	9.7	(3.1)
19	T-51	35.6	(6.0)	4.4	(2.1)
20	UP-1	34.2	(5.9)	6.2	(2.5)
21	21/4K	36.2	(6.0)	5.1	(2.3)
22	BAU-13-6	32.2	(5.7)	4.0	(2.0)
23	BAUP-101	13.3	(3.6)	9.0	(3.0)
24	BAUP-102	12.1	(3.5)	7.1	(2.7)
25	LSL-93	18.3	(4.3)	4.4	(2.1)
26	NL-287	24.2	(4.9)	5.2	(2.3)
27	NDL-2011-36	27.2	(5.2)	5.4	(2.3)
28	NDL-2002	11.2	(3.3)	3.7	(1.9)
29	RLC-148	8.9	(3.0)	10.5	(3.2)
30	RLC-151	12.3	(3.5)	7.0	(2.6)
31	SLS-100	31.1	(5.6)	3.4	(1.8)
32	SHA-1	11.6	(3.4)	7.5	(2.7)
33	T-397	29.3	(5.4)	4.2	(2.1)
34	NDL-2011-18	13.2	(3.6)	10.7	(3.3)
SEm (±)		1.17	0.08	0.31	0.06
CD (5%)		1.63	0.20	0.63	0.13

*Figures in the parenthesis are square root transformed values.

Table 2: Screening of linseed entries against bud fly during 2015-16

Sl. No.	Entries	% bud infested		Yield (qt./ha)	
1	BAU-833-11	23.6	(4.9)*	5.4	(2.3)*
2	EC-399086	26.7	(5.2)	4.8	(2.2)
3	Ireland (TFlax)	7.1	(2.6)	10.1	(3.2)
4	JLT-84-5-1-1	22.4	(4.7)	5.4	(2.3)
5	KYS-7	25.0	(5.0)	5.1	(2.3)
6	LMS-2010-2-15	27.2	(5.2)	4.9	(2.2)
7	LMS-2010-1-27	18.2	(4.3)	5.8	(2.4)
8	LMS-2012-112	22.4	(4.7)	6.5	(2.5)
9	LW-9828	15.3	(3.9)	4.9	(2.2)
10	NDL-8809	35.4	(5.9)	3.9	(2.0)
11	NDL-2211-20	14.6	(3.8)	6.3	(2.5)
12	NDL-2011-23	7.9	(2.8)	10.4	(3.2)
13	RL-906	25.2	(5.0)	5.4	(2.3)
14	RLC-133	14.5	(3.8)	5.0	(2.2)
15	RLC-138	22.1	(4.7)	5.6	(2.4)
16	RLC-143	11.6	(3.4)	6.1	(2.5)
17	RLC-145	13.7	(3.7)	5.5	(2.3)
18	Silwani	15.1	(3.9)	7.7	(2.8)
19	T-51	18.3	(4.3)	4.3	(2.1)
20	UP-1	33.3	(5.8)	5.1	(2.2)
21	21/4K	36.0	(6.0)	5.5	(2.4)
22	BAU-13-6	23.9	(4.9)	4.6	(2.1)
23	BAUP-101	14.1	(3.7)	7.6	(2.7)
24	BAUP-102	13.8	(3.7)	6.1	(2.4)
25	LSL-93	17.9	(4.2)	4.1	(2.0)
26	NL-287	23.0	(4.8)	5.1	(2.2)
27	NDL-2011-36	27.6	(5.3)	4.8	(2.2)
28	NDL-2002	12.1	(3.5)	3.8	(2.0)
29	RLC-148	8.7	(2.9)	10.7	(3.3)
30	RLC-151	14.1	(3.7)	4.3	(2.1)
31	SLS-100	29.6	(5.4)	4.0	(2.0)
32	SHA-1	12.3	(3.5)	5.4	(2.3)
33	T-397	23.7	(4.8)	4.2	(2.1)
34	NDL-2011-18	13.6	(3.7)	9.9	(3.1)
SEm (±)		1.88	0.22	0.61	0.13
CD (5%)		3.73	0.43	1.22	0.26

*Figures in the parenthesis are square root transformed values.

Table 3: Screening of linseed genotypes for resistance against bud fly (Pooled over 2 years)

Sl. No.	Entries	% bud infested	Yield (qt./ha)		
1	BAU-833-11	23.7	5.8		
2	EC-399086	22.0	5.1		
3	Ireland (TFlax)	6.8	10.3		
4	JLT-84-5-1-1	27.2	5.4		
5	KYS-7	25.6	5.0		
6	LMS-2010-2-15	21.7	6.5		
7	LMS-2010-1-27	18.3	5.8		
8	LMS-2012-112	22.3	6.6		
9	LW-9828	13.2	4.9		
10	NDL-8809	35.1	3.9		
11	NDL-2211-20	13.3	6.7		
12	NDL-2011-23	8.0	10.4		
13	RL-906	25.7	5.8		
14	RLC-133	15.2	5.2		
15	RLC-138	22.2	5.9		
16	RLC-143	11.0	7.2		
17	RLC-145	12.9	5.8		
18	Silwani	19.6	8.7		
19	T-51	26.9	4.4		
20	UP-1	33.8	5.6		
21	21/4K	36.1	5.3		
22	BAU-13-6	28.1	4.3		
23	BAUP-101	13.7	8.3		
24	BAUP-102	13.0	6.6		
25	LSL-93	18.1	4.2		
26	NL-287	23.6	5.1		
27	NDL-2011-36	27.4	5.1		
28	NDL-2002	11.7	3.8		
29	RLC-148	8.8	10.6		
30	RLC-151	13.2	5.7		
31	SLS-100	30.3	3.7		
32	SHA-1	12.0	6.5		
33	T-397	26.5	4.2		
34	NDL-2011-18	13.4	10.3		

Table 4: Bio-physical characteristics of the linseed germplasms

Entries	Days to flowering	Bud length (mm)	Bud length (mm)	Shape of flower	Colour of flower
BAU-833-11	81	7.2	3.5	U	W
EC-399086	81	7.0	3.1	U	TB
Ireland (TFlax)	67	4.0	2.0	U	VB
JLT-84-5-1-1	81	6.2	3.2	D	VB
KYS-7	79	6.0	3.0	D	VB
LMS-2010-2-15	70	5.5	2.5	D	TB
LMS-2010-1-27	79	6	2.4	U	W
LMS-2012-112	79	5.1	2.5	D	VB
LW-9828	71	4.5	3.2	D	VB
NDL-8809	81	6	3.5	D	VB

NDL-2211-20	69	6.2	3	D	VB
NDL-2011-23	60	4.5	2.2	U	W
RL-906	79	6	2.5	U	W
RLC-133	81	5.5	3	D	VB
RLC-138	80	6	2.8	D	VB
RLC-143	79	5	2.5	D	VB
RLC-145	72	5.8	3	D	W
Silwani	83	6	3.5	U	VB
T-51	83	5	2.8	U	VB
UP-1	84	6.5	3	D	VB
21/4K	87	6	2	D	B
BAU-13-6	72	5	2.8	U	VB
BAUP-101	79	5	2	F	VB
BAUP-102	70	4.5	2	D	W
LSL-93	65	5	3	F	W
NL-287	80	6	3	D	VB
NDL-2011-36	82	4.5	2.5	U	VB
NDL-2002	81	4.5	3.5	D	TB
RLC-148	61	4.2	2.0	U	TB
RLC-151	69	5.7	2.8	U	W
SLS-100	79	6.2	3.4	U	VB
SHA-1	79	7	2.5	D	TB
T-397	81	5.5	3.5	D	W
NDL-2011-18	70	6	3.0	U	VB
F= Funnel; U= Umbrella ; D= Dome shaped flower					
TB= Tinge blue; VB= Violet blue; W= White; B= Blue colour flower					

Table 5: Categorization of linseed genotypes for resistance against bud fly

Category of resistance	Scale (% damaged buds)	Genotypes
Resistant (R)	Upto 10%	Ireland (TFlax) (6.8), NDL-2011-23 (8.0) and RLC-148 (8.8)
Moderately Resistant (MR)	>10 – 25%	BAU-833-11 (23.7), EC-399086 (22.0), LMS-2010-2-15 (21.7), LMS-2010-1-27 (18.3), LMS-2012-112 (22.3), LW-9828 (13.2), NDL-2211-20 (13.3), RLC-133 (15.2), RLC-138 (22.2), RLC-143 (11.0), RLC-145 (12.9), Silwani (19.6), BAUP-101 (13.7), BAUP-102 (13.0), LSL-93 (18.1), NL-287 (23.6), NDL-2002 (11.7), RLC-151 (13.2), SHA-1 (12.0) and NDL-2011-18 (13.4)
Moderately Susceptible (MS)	>25 – 50%	JLT-84-5-1-1 (27.2), KYS-7 (25.6), NDL-8809 (35.1), RL-906 (25.7), T-51 (26.9), UP-1 (33.8), 21/4K (36.1), BAU-13-6 (28.1), NDL-2011-36 (27.4), SLS-100 (30.3) and T-397 (26.5)
Susceptible (S)	>50 – 75%	-
Highly Susceptible (HS)	>75%	-