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Evaluation of recombinant inbred population for *Spodoptera litura* resistance and productivity parameters in groundnut (*Arachis hypogaea* L.)

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Abstract
Spodoptera litura is an important pest affecting the yields of groundnut worldwide and host plant resistance is a key pest management strategy. In the present study, a set of 318 recombinant inbred lines were studied for their resistance *to Spodoptera litura* and productivity parameters during rainy season at hot spot location, Dharwad. Wide variation existed for *Spodoptera litura* damage (7.85 – 35.65 %) and also for various productivity parameters among the recombinant inbred lines. High heritability coupled with high genetic advance for response to *Spodoptera litura*, and for number of pods per plant, hundred seed weight and yield per plant among the productivity parameters indicated relatively higher additive component of genetic variance. Non-significant phenotypic (0.039) and genotypic (0.065) correlation existed between *Spodoptera litura* damage and yield per plant suggesting the scope for selection of high yielding and *Spodoptera* resistant lines. Among the parents, female (TAG 24) was susceptible to *Spodoptera litura* (26.8 % leaf damage) while the male parent (ICGV 86031) was moderately resistant to *Spodoptera litura* (14.1 % leaf damage). Among the 318 recombinant inbred lines, 15 transgressitve segregant lines showed resistance to *Spodoptera litura* with less than 10 % leaf damage. Among them, C3-34 line had higher yield per plant (16.6 g) along with exhibiting tolerance to *Spodoptera litura* and can serve as donor in *Spodoptera* resistance breeding programme in groundnut. Further, this recombinant inbred population could be utilized in development of marker associated with *Spodoptera* resistance.

Keywords: Groundnut, Host plant resistance, *Spodoptera litura*, productivity

Introduction
Groundnut (*Arachis hypogaea* L.), one of the major economic oilseed crops of the world and is cultivated in more than 100 countries in an area of 27.66 million hectares with an annual production of 43.98 million tonnes and productivity of 1590 kg ha^{-1} (FAO, 2016) [7]. In India, groundnut is grown in an area of 5.80 million hectares, with production of 6.85 million tonnes and productivity of 1182 kg ha^{-1} (FAO, 2016) [7]. In India, groundnut productivity is lower which could be ascribed to various biotic and abiotic stresses affecting growth and yield of the crop. Among the various biotic stresses, tobacco cutworm (*Spodoptera litura*), late leaf spot and rust have major role in reducing the groundnut yield levels.

Spodoptera litura (F.) commonly known as “Tobacco caterpillar” is one of the serious pests of groundnut. Due to polyphagous nature of *Spodoptera litura*, it is considered as a pest of national importance. In India, it feeds on 74 species of cultivated crops and some wild plants. Besides groundnut, it also affects tobacco, cotton, pulses and several vegetable crops (Singh and Jalali, 1997) [19]. It has been reported that an infestation level of one larva per plant during the seedling or flowering stage can result in 20 per cent yield loss in groundnut (Dhir *et al.*, 1992) [5]. Severe outbreak of the pest can result in 30-40 per cent loss in pod formation (Joshi and Kumar, 2005). Yield losses are reported to be 13-71 per cent in the states of Karnataka and Andhra Pradesh (Amin, 1983). In India, transitional tract of Karnataka (Dharwad) has been identified as hot spot for *S. litura* during *kharif* season, where yield loss to the extent of 66.6 per cent was reported in groundnut (Kulkarni, 1989) [10]. The damage is done by larvae, which feed gregariously on leaves and fresh growth causing extensive damage (Patil, 2000) [14].

Though many effective chemicals are suggested to control *Spodoptera litura*, but they are not eco-friendly and add to the cost of cultivation. Further, enormous and indiscriminate use of insecticides has adverse effect on non-target organisms like predators and parasitoids, pesticide residue in food, pest resurgence, development of insect resistance, toxic effects on human beings and environmental pollution (Sharma, 2007) [17]. In this context, considerable efforts have been made to develop crop cultivars with enhanced resistance to insect pests

(Sharma *et al*., 2003) [18]. Host plant resistance (HPR) is one of the important and eco-friendly approaches of keeping the pest populations below economic injury levels (EILs). Improving host plant defense to insects will result in reduced losses due to herbivores, less insecticides use, better crop yields and safer environment (Howe and Jander, 2008) [8]. In this regard, breeding for inbuilt resistance occupies importance and is a viable approach which stresses the need to identify potential resistant sources.

Earlier, the genotypes, ICGV 86031 (41 %), 87264 (50 %), 87807 (49.33 %), 93021 (46.16%), M 28-2 (36.33 %), M 45 (34.33 %) and M 110 (45 %) were identified as resistant to *Spodoptera litura* (Naidu, 2002) [12]. The mutant 45 (34 %), NC Ac 343 (36 %) and mutant 28-2 (36 %) had minimum damage indicating their resistance to *Spodoptera litura* (Prasad and Gowda, 2006). Naidu *et al.* (2016) [13] reported that ICGV 91180 (34.33%), NC Ac 343 (35.67 %), M 28-2 (36.33 %) and M 45 (34.33 %) as resistant to *Spodoptera litura*. Though these many genotypes were identified as resistant to *Spodoptera litura*, they were not studied for other productivity parameters. In the present study an effort was made to evaluate a large recombinant inbred line population for *Spodoptera litura* resistance along with other productivity parameters under hot spot location.

Materials and methods

The research material consisted of 318 recombinant inbred lines (RILs) derived from the cross TAG 24 × ICGV 86031. The female parent TAG 24 is a high yielding popular cultivar but susceptible to late leaf spot, rust and *Spodoptera litura*, while the male parent ICGV 86031 is a multiple stress resistant genotype including resistance to *Spodoptera litura*. These recombinant inbred lines along with two parents were sown in 4 blocks with 2 replications in randomized complete block designat Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka (15º 13’ N, 75º 07’ E, 678 m above mean sea level, and 800 mm average annual rainfall) during *kharif* 2017. Each genotype was sown in a row length of 2 m with 30 x 10 cm spacing. The recommended package of practices was followed to raise the healthy crop avoiding the plant protection measures.

Visual observations were made on per cent leaf damage due to *S. litura* (0-100 %) at 70 days after sowing (peak incidence period) by following the standard scale (0-9) (Anon., 2015). The observation on per cent leaf damage was assessed by leaf damage at top, middle and bottom leaves from 5 plants showing maximum incidence of insect in each genotype and expressed as mean per cent leaf damage**.** At/after harvest of the crop, productivity parameters like height of the plant, number of primary branches per plant, number of pods per plant, pod yield per plant, shelling per cent and hundred seed weight were taken.

Statistical analysis

Analysis of variance and different components of genetic variation (PCV, GCV, H and GA) of recombinant inbred lines was performed by balanced design using Gen Stat regression method by using Gen Stat 64-bit (version 17.7) software. Genotypic and phenotypic correlation coefficients were calculated to determine the direction and magnitude of association between resistance to *Spodoptera litura* and other productivity parameters and tested against table ‘t’ values at (n-2) degree of freedom both at 0.05 and 0.01 probability levels for their significance.

Results and discussion

Recombinant inbred lines exhibited significant genotypic variability (Table 1) for all the characters studied including *Spodoptera litura* indicating the scope for selection of resistant genotypes. Predominance genetic component was evident due to narrow difference between the phenotypic and genotypic co-efficient of variation for all the traits (Table 2). High heritability coupled with high genetic advance for response to *Spodoptera litura*, shelling per cent revealed higher additive component of genetic variance and hence genetic improvement for these traits would be possible through simple selection based on phenotype.

Correlation studies indicated that there was non-significant correlation between *Spodoptera litura* damage and pod yield per plant indicating the scope for selection of *Spodoptera* resistant lines combining high pod yield. This was evident with the four recombinant inbred lines (C3-34) with less damage due to *Spodoptera litura* (10.0 %) and on par pod yield per plant (16.6 g) with resistant parent (Table 4). *Spodoptera litura* damage had significant negative correlation with days to initiation of flowering and days to fifty per cent flowering revealing that majority of the resistant genotypes were late in flowering and maturity. Earlier reports show that majority of interspecific derivates matured late which were showing resistance to biotic stresses (Naidu, 2002) [12]. Iroume and Knauft (1987) [9] also reported negative association between response to biotic stresses and pod yield in case of advanced breeding lines. This suggests the necessity to break negative associations by intensive hybridization or induced mutations followed by selection. Yield per plant had significant positive correlation with number of pods per plant (Table 3). This indicates that number of pods per plant is an important yield contributing trait. Earlier, Meta and Monpara (2010) [11], Raut *et al.* (2010) [16], Vekariya *et al.* (2010) [20] and Babariya and Daboriya (2012) [4] have reported that pods per plant and hundred seed weight contribute to yield per plant. This may be due to linkage of favorable genes for these traits under consideration and extent of co-heritability (Babariya and Daboriya, 2012) [4]. As pods per plant and hundred seed weight are interrelated and also had strong genotypic association with pod yield per plant, the improvement in one component will automatically result in improvement of another component and finally the pod yield.

The male parent, ICGV 86031, had moderate resistance to *Spodoptera litura* with 14.1 per cent leaf damage, while the female parent TAG 24 was susceptible to *Spodoptera litura* with 26.8 per cent leaf damage (Table 3). Earlier, ICGV 86031 was registered as multiple stress resistant including resistance to *Spodoptera litura* (Dwivedi *et al.*, 1993) [6] and was reported to be having less damage due to *Spodoptera litura* under field screening (Naidu 2002). Among the 318 recombinant inbred lines of TAG 24 × ICGV 86031, fifteen lines showed resistance to *Spodoptera litura* with less than 10 % damage due to *Spodoptera* compared to its resistant parent, ICGV 86031 (Table 3). This could be due to transgressive segregation with respect to *Spodoptera litura* resistance in the recombinant inbred population. Among the 15 resistant lines, only one line C3-34 had higher yield per plant (16.6 g) along with exhibiting resistance to *Spodoptera litura* damage (10.0). This line could be used as potential donor for incorporation of resistance to *Spodoptera* after confirming its resistance under artificial screening. Further, this recombinant inbred population showing so much variation for *Spodoptera* resistance could be ideal for genotyping and thus help in identification of marker associated with *Spodoptera* resistance.

Table 1: Mean sum of squares for *Spodoptera litura* damage and productivity parameters in recombinant inbred lines (RILs) during *kharif* 2017

Phenotypic traits	Source of variation			
	Replication	Blocks within replication	Genotype	Error
DF	1	6	316	316
Leaf damage by *Spodoptera litura* at 70 DAS	0.17	90.32**	54.00**	4.01
Days to initiation of flowering	1.02	2.52**	1.73**	0.41
Days to 50 % flowering	3.75	2.38**	1.66**	0.59
Plant height (cm)	7.53	68.27**	26.78**	3.92
Number of primary branches per plant	0.72	1.17**	1.68**	0.08
Number of pods per plant	0.84	44.02**	17.07**	2.81
Shelling per cent	4.02	76.81**	115.12**	7.73
Hundred seed weight (g)	3.72	80.52**	45.73**	4.63
Yield per plant (g)	4.56	81.17**	28.21**	2.98

*& **- Significant at 5 and 1 per cent level of probability, respectively

Table 2: Genetic components of variation for *Spodoptera litura* damage and productivity parameters in recombinant inbred lines (RILs) of groundnut during *kharif* 2017

Components	Minimum	Maximum	Mean	PCV (%)	GCV (%)	h^2_{bs}	GA	GAM
Leaf damage by *Spodoptera litura* at 70 DAS	7.85	35.65	18	30.20	28.00	86.20	9.60	53.60
Days to initiation of flowering	27.50	32.50	29.6	3.40	2.92	73.30	1.50	5.20
Days to 50 % flowering	29.00	34.00	31.2	3.30	2.60	64.50	1.40	4.40
Plant height (cm)	15.10	34.30	24.4	16.30	13.80	72.10	5.90	24.20
Number of primary branches per plant	3.80	11.60	5	18.80	17.90	90.70	1.70	35.20
Number of pods per plant	7.30	26.30	12.8	24.90	20.40	67.20	4.40	34.50
Shelling per cent (%)	39.80	80.00	66.4	11.60	10.80	86.90	13.80	20.80
Hundred seed weight (g)	24.80	54.80	39.6	12.80	11.30	78.50	8.20	20.70
Yield per plant (g)	3.20	34.00	11.9	34.00	30.20	78.90	6.50	55.30

PCV- Phenotypic co-efficient of variation (%) GCV- Genotypic co-efficient of variation (%)
GA- Genetic advance GAM- Genetic advance as per cent of mean
h^2_{bs}- Heritability (Broad sense)

Table 3: Phenotypic and genotypic correlation among *Spodoptera litura* damage and various productivity parameters in recombinant inbred lines (RILs) of groundnut

Traits	*Spodoptera* damage	Days to initiation of flowering	Days to 50 % flowering	Plant height	No. of primary branches per plant	No. of pods per plant	Shelling per cent	Hundred seed weight	Yield per plant
Leaf damage by *Spodoptera litura* at 70 DAS	1	0.002	-0.0019	0.109**	-0.115**	-0.084*	-0.045	-0.064	0.039
Days to initiation of flowering	-0.006	1	0.851**	-0.064	0.175**	0.087*	-0.113*	0.044	0.029
Days to 50 % flowering	-0.046	0.050	1	-0.066	0.176**	0.066	0.091*	0.060	0.0038
Plant height	0.121**	-0.057	-0.039	1	0.033	0.039	0.012	.126**	0.126**
No. of primary branches per plant	-0.130**	0.205	0.244**	0.038	1	0.338**	-0.086*	0.045	0.156**
No. of pods per plant	-0.124**	0.120**	0.1442**	0.077	0.426**	1	0.039	0.006	0.237**
Shelling per cent	-0.060	-0.137**	-0.126**	0.021	-0.078	0.049	1	0.086	-0.008
Hundred seed weight	-0.086*	0.097*	0.149**	0.165**	0.041	-0.035	0.098*	1	0.021
Yield per plant	0.065	0.022	0.046	0.193**	0.166**	0.276**	0.004	0.030	1

*& **- Significant at 5 and 1 per cent level of probability, respectively Values above the diagonal represent phenotypic correlation co-efficient while values below diagonal represents genotypic correlation co-efficient.

Table 4: Mean performance of recombinant inbred lines showing ≤ 10 per cent *Spodoptera litura* damage

S. No.	Genotypes	*Spodoptera* damage (%)	Days to initiation of flowering	Days to 50 % flowering	Plant height (cm)	No. of primary branches per plant	No. of pods per plant	Shelling per cent	Hundred seed weight (g)	Yield per plant (g)
1	C3-168	7.8	30.0	32.0	21.6	4.8	9.5	69.4	43.8	8.4
2	C3-96	8.5	30.0	31.5	22.1	5.6	13.2	72.2	45.7*	9.6
3	C3-72	8.5	31.5	33.0	26.8*	5.4	10.7	52.8	24.9	9.9
4	C3-172	8.7	28.0**	30.0*	20.6	4.7	10.5	77.6	40.0	6.9
5	C3-201	8.8	29.5	31.5	15.6	4.4	10.2	76.0	44.1	8.9
6	C3-236	9.0	29.0*	31.0	23.6	5.3	13.1	77.1	42.4	9.6
7	C3-241	9.1	29.0**	30.5	15.9	4.4	10.4	56.5	44.2	11.9
8	C3-99	9.1	30.0	31.5	28.4**	4.5	12.6	74.0	47.6**	10.4
9	C3-186	9.2	31.5	32.5	22.8	7.8**	19.8	43.4	37.4	6.5
10	C3-121	9.2	29.5	31.0	18.6	4.4	10.7	76.3	36.4	8.1
11	C3-308	9.3	28.5	29.5*	22.0	4.8	11.7	71.4	32.2	14.5
12	C3-124	9.5	29.5	31.5	22.3	4.3	11.5	61.3	35.0	8.3
13	C3-34	10.0	30.5	32.0	23.2	7.6**	13.8	66.9	36.4	16.6
14	C3-183	10.0	29.5	30.5	28.9**	5.1	14.6	63.7	43.7	12.1
15	C3-229	10.0	29.5	31.5	26.9**	4.4	11.4	65.4	51.5**	7.8
16	ICGV86031	14.1	29.5	31.0	20.7	5.1	13.4	73.8	40.6	14.3
17	TAG24	26.8	30.5	32	32.6	5.4	14.7	67.0	37.3	11.7
	CD (5%)	3.97	1.02	1.20	4.57	0.56	3.6	5.47	4.62	3.65
	CD (1%)	5.23	1.35	1.58	6.02	0.74	4.75	7.21	6.08	4.81
	CV (%)	11.14	1.75	1.96	8.11	5.67	13.08	4.19	5.44	14.52

*& ** indicates the superiority of the character in respective genotype over resistant check at 5 per cent and 1 per cent level of probability, respectively

Conclusion

The male parent of the recombinant inbred population ICGV 86031 was moderately resistant to *Spodoptera litura* while, the female parent TAG 24 was high yielding variety but susceptible to many biotic stresses including *Spodoptera litura*. Among the 318 lines, only fifteen (4.7 %) lines showed resistance to *Spodoptera litura* with less than 10 % leaf damage due to *Spodoptera*. Among these only one recombinant inbred line C3-34 had higher pod yield on par with resistant parent plant. These selected resistant lines need to be confirmed for their resistance under artificial conditions before employing them as sources of *Spodoptera litura* resistance in breeding programme in groundnut. Further, the extensive phenotyping of this recombinant inbred population could help in identification of marker associated with *Spodoptera* resistance.

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