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Assessment of Groundnut (*Arachis hypogaea* L.) Mini Core for Resistance to Multiple Biotic Stresses under Hot Spot Location

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A B S T R A C T

Groundnut is one of the important oilseed crops of India. Several biotic stresses affect in achieving the real potential yields. Cultivation of biotic stress resistant cultivars is an ecologically and economically sound approach. The occurrence of different biotic stresses varies with location and season thus limiting the wide adoption of varieties resistant to one or the other biotic stresses. This necessitates the importance of evolving multiple biotic stress resistant genotypes. In the present study, a set of 184 mini core genotypes along with 12checks were assessed for major foliar diseases late leaf spot and rust and a major defoliator, *Spodoptera litura* in hot spot location. In mini core, *hypogaea* botanical group had higher frequency of resistant genotypes to *Spodoptera litura* (31 %), late leaf spot (33 %) and rust (8 %) when compared to other botanical groups. Among the *Spodoptera litura* resistant genotypes, eight genotypes *viz*., ICG 862, ICG 928, ICG 76, ICG 2777, ICG 5016, ICG 12276, ICG 4412 and ICG 9905 had significantly higher pod yield per plant (> 23.2 g) compared to check JL 24 (18.1 g). Among the 184 genotypes of mini core, five genotypes *viz.*, ICG 2381, ICG 11426, ICG 12625, ICG 12370 and ICG 875 were resistant to late leaf spot (field disease score < 4). ICG 2381 had resistance to late leaf spot, rust and *Spodoptera litura* but had low pod yield per plant and hence can serve as potential multiple stress resistant donor genotype in breeding programmes.

Introduction

Groundnut, an important oil seed crop is cultivated in more than 100 countries in an area of 27.66 mha with an annual production of 43.98 mt and productivity of 1590 kg ha^{-1} (FAO, 2016). In India, groundnut is grown in an area of 5.80 m ha, with production of 6.85 m t and productivity of 1182 kg ha^{-1} (FAO, 2016). Gujarat and Andhra Pradesh rank first and second, respectively both in area and production followed by Karnataka in area and Tamil Nadu in production. Though, India is a leading producer of groundnut, its productivity is low (1182 kg ha^{-1}) compared to USA (4118 kg ha^{-1}), China (3674 kg ha^{-1}) and Argentina (2928 kg ha^{-1}) (FAO, 2016), the reasons being lack of improved high yielding cultivars, cultivation under shallow soils of low fertility, uneven rainfall distribution, continuous cropping without crop rotation, low plant population, incidence of biotic and abiotic stresses. Among the various biotic stresses affecting the groundnut crop, tobacco cutworm (*Spodoptera litura)*, late leaf spot and rust have major role in reducing the yield levels to a considerable extent. *Spodoptera litura* (F.) is considered as a pest of national importance and 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 *Spodoptera litura* during *kharif*season, where yield loss to the extent of 66.6 per cent was reported in groundnut (Kulkarni, 1989).

Among the foliar diseases, late leaf spotand rust were more threatening than other diseases. The pod loss of 50-80 per cent due to rust was reported in an epidemic year (Sandhikar *et al.,* 1989). Late leaf spot can cause a reduction of 10-50 per cent yield (McDonald *et al.,* 1985). In transitional tract of Karnataka, late leaf spot resulted in yield loss up to 50 per cent (Puranik *et al.*, 1973; Astaputre and Kulkarni, 1996). Late leaf spot and rust occur together commonly whenever the groundnut is cultivated, but their incidence and damaging level is different with respect to location and season. Both the diseases have individual capacity to cause economic level of yield loss. In India, late leaf spot and rust occur together and cause yield loss up to 70 per cent (Subrahmanyam *et al.,* 1990).

Though many effective chemicals are suggested to control *Spodoptera litura,* late leaf spot and rust, but are not eco-friendly and add to the cost of cultivation. In this regard, breeding for inbuilt resistance occupies importance and is an amenable approach which necessitates the identification of potential resistant sources. Earlier, mutant 45, NC Ac 343, mutant 28-2 (Prasad and Gowda, 2006), ICGV 91180, NC Ac 343, M 28-2 and M 45 (Naidu *et al.,* 2016) were identified as resistant to *Spodoptera litura* with minimum leaf damage. Dwivedi *et al.,* (2002) reported ICGV 99005, 99003, 99012 and 99015 as rust resistant while, ICGV 99006, 99013, 99004, 99003 and 99001 as resistant to late leaf spot under artificial condition. GPBD 4, B 37c and ICGV 87165 were resistant to both late leaf spot and rust with significantly lower field disease score and AUDPC (Motagi *et al.*, 2014). Sudini *et al.*, (2015) reported that ICGs 11426, 11088, 4389, 6022, 6993, 2857, 4746, 15419, 6402, 6766 were resistant to rust and ICG’s 14127, 5051, 6646, 7153, 12276, 12625, 2925, 9961, 10036 were moderately resistant to late leaf spot and also reported that none were found resistant to both late leaf spot and rust.

Groundnut mini core was evaluated for late leaf spot and rust resistance (Yugandhar, 2005; Madhura, 2006, Shivaleela, 2012; Rajashekar, 2013; Upadhyaya *et al.*, 2014, Sudhini *et al.*, 2015). But, no study is reported on evaluation for *Spodoptera litura* resistance. Present study is aimed at assessing of resistance to *Spodoptera litura* in addition to major foliar diseases late leaf spot and rust under hot spot location and identification of multiple resistant genotypes in groundnut mini core.

Materials and Methods

The study comprised groundnut mini core having 184 genotypes, a subset of core germplasm and was collected from ICRISAT, Hyderabad. In addition to this, four control genotypes (ICG 11457, ICG 12370, ICG 13099 and ICG 13723), three susceptible (JL 24, TMV 2, TAG 24) and five resistant genotypes (ICGV 86031, ICGV 87157, ICGV 87160, ICG 2271 and ICG 1657) as checks to different biotic stresses were included in the study. The study was conducted at Main Agriculture Research Station (MARS), University of Agriculture Sciences, Dharwad, India (15^o 13’ N, 75^o 07’ E, 678 m above mean sea level, and 800 mm average annual rainfall) during rainy season 2017.

Each genotype was sown in a row of 2-meter length with 2 replications in 4 blocks by following randomized incomplete block design. Spanish and Virginia bunch genotypes were sown in 30×10 cm spacing while, Virginia runner genotypes in 60×10 cm spacing. The susceptible check JL 24 for all the three biotic stresses was planted after every 10 test entries to assure maximum incidence. Normal package of practices were followed to raise the healthy crop avoiding the plant protection measures. These genotypes were evaluated for their reaction to foliar diseases *viz.*, late leaf spot and rust and defoliator pest *Spodoptera litura* under hot spot conditions for all the three biotic stresses at Dharwad (Karnataka). In addition, they were assessed for various morphological and productivity traits.

Evaluation of mini core genotypes for various biotic stresses

Spodoptera litura

Visual observations on per cent leaf damage due to *S. litura* (0-100%) were recorded at 70 days after sowing (coinciding with peak incidence of the insect pest) by following the standard scale (0-9) as shown in plate 1 (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 per cent leaf damage.

Late Leaf Spot (LLS) and rust

The evaluation of genotypes against late leaf spot (LLS) and rust was taken at 80 days after sowing (DAS) which was coinciding with highest incidence as evident by highest field disease score in susceptible genotypes for both LLS and rust. The five plants in each genotype based on highest disease incidence were assessed for damage due to late leaf spot and rust. The observation on per cent leaf area damage by pathogen of rust and late leaf spot was assessed by following the modified 9-point scale (Subrahamanyam *et al.*, 1995).

Statistical analysis

Analysis of variance and correlation was carried out using GenStat regression method, as the experiment contained both spreading and bunch type genotypes which led to unequal number of genotypes in each block.

Results and Discussion

Variability for different biotic stresses

Analysis of variance for reaction to biotic stresses (*Spodoptera litura*, late leaf spot and rust) and productivity parameters (days to initiation of flowering, days to 50 per cent flowering, plant height, number of primary branches per plant, number of pods per plant, shelling per cent, hundred seed weight and pod yield per plant) in the mini core indicated highly significant genotypic differences for these traits (Table 1) which is pre-requisite for genetic improvement through plant breeding.

The difference between the phenotypic and genotypic coefficient of variation was very low for reaction to different biotic stresses and productivity parameters (Table 2) indicating the predominance of genetic component in governing these traits. The extent of genotypic variability was high for response to *Spodoptera litura* and pod yield per plant in mini core genotypes indicating scope for selection of genotypes with resistance to *Spodoptera litura* and also for pod yield per plant in this material.

The extent of genotypic variability was also high for reaction to late leaf spot and rust in case of mini core genotypes (Table 2). The results of Khedikar (2008), Khote *et al.,* (2009) and Savaliya *et al.,* (2009) also indicated higher variability for late leaf spot and rust. On the contrary, there was less genotypic variability for days to initiation of flowering, days to fifty per cent flowering and shelling per cent in mini core genotypes revealing very less scope for identification of superior genotypes for these traits. Such low genetic variation was reported earlier by Venkataramana *et al.,* (2001), Nadaf and Habib (1987), Sharma and Gupta (2011) for shelling percentage in groundnut.

High heritability coupled with high genetic advance for response to *Spodoptera litura*, late leaf spot and rust and for number of pods per plant, hundred seed weight and yield per plant among the productivity parameters in the mini core genotypes (Table 2) revealed relatively higher additive component of genetic variance and hence genetic improvement for these traits would be possible through simple selection based on phenotype (Painwadee *et al.*, 2009).

Earlier, Nath and Alam (2002), Venkataraman (2001), Apte *et al.*, (2008), Raut *et al.*, (2010) and Rao *et al.,* (2012) also reported higher additive components of genetic variation for late leaf spot, rust, number of pods per plant and yield per plant.

The indirect selection for yield through yield components like number of pods per plant which has high heritability seems to be much more rewarding than direct selection for yield alone. Shelling per cent on the other hand, had low genetic advance over mean in mini core and elite cultivars because of its low level of heritability and variability. Even though days to initiation of flowering and days to fifty per cent flowering exhibited high level of heritability, genetic advance over mean was low because of very low magnitude of genetic variation indicating very less scope of selection for these traits.

Correlation between different biotic stresses and productivity parameters

There was a significant positive association between *Spodoptera litura* damage and late leaf spot incidence in groundnut mini core (Table 3) indicating that the genotypes that were susceptible to *Spodoptera litura* were also susceptible to late leaf spot. Prasad (1997) also reported positive association between *Spodoptera litura* damage and late leaf spot incidence in the groundnut mutants. *Spodoptera litura* damage had significant negative correlation with days to initiation of flowering and days to fifty per cent flowering in mini core genotypes revealing late flowering and maturing nature of biotic stress resistant genotypes. Naidu (2002) reported that majority of interspecific derivatives matured late which were showing resistance to biotic stresses.

Spodoptera litura damage had significant negative correlation with hundred seed weight in mini core indicating that there would be reduction in seed size in the *Spodoptera litura* susceptible genotypes. *Spodoptera litura* damage had non-significant correlation with yield per plant in the mini core germplasm suggesting that *Spodoptera litura* damage does not have major impact on yield which could be occurrence of *Spodoptera* (70 days after sowing) and hence not having too much cost on yield.

Significant negative correlation was observed between late leaf spot and pod yield per plant in mini core germplasm indicating susceptibility to late leaf spot has more cost on yield in groundnut. The results were in conformity with those of Motagi (2001) who has reported negative correlation between late leaf spot and rust resistance with pod yield while studying mutants. Motagi *et al.*, (1997) reported negative association of late leaf spot with yield in Spanish bunch mutants.

Plate.1 Leaf damage for visual scoring of *Spodoptera litura* damage in groundnut

Table.1 Mean sum of squares for various biotic stresses and productivity parameters in mini core germplasm during *kharif* 2017

Phenotypic traits	Source of variation			
	Replication	Blocks within replication	Genotype	Error
df	1	6	193	191
Leaf damage by *Spodoptera litura* (%) at 70 DAS	16.26	342.98**	126.40**	5.76
Late leaf spot at 80 DAS	0.09	31.33**	2.31**	0.33
Rust at 80 DAS	0.82	1.94**	1.25**	0.34
Days to initiation of flowering	0.04	96.16**	4.09**	0.35
Days to 50 % flowering	0.25	91.00**	3.95**	0.52
Plant height (cm)	6.35	801.37**	64.75**	4.27
Number of primary branches per plant	0.16	92.47**	8.16**	0.09
Number of pods per plant	2.83	249.46**	35.04**	0.74
Shelling per cent	2.64	125.25**	31.48**	0.52
Hundred seed weight (g)	3.90	180.59**	62.82**	3.00
Yield per plant (g)	4.75	455.59**	47.90**	2.93

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

Table.2 Genetic components of variation for various biotic stresses and productivity parameters in mini core germplasm

Phenotypic traits / Components	Minimum	Maximum	Mean	PCV (%)	GCV (%)	h^2_{bs}	GA	GAM
Leaf damage by *Spodoptera litura* (%) at 70 DAS	4.5	45.0	19.1	44.0	42.0	91.1	15.7	82.6
Late leaf spot at 80 DAS	2.5	8.0	6.5	20.5	18.2	79.3	2.1	33.5
Rust at 80 DAS	2.0	7.0	6.23	15.8	14.2	80.2	1.6	26.3
Days to initiation of flowering	26	34.5	29.8	6.4	6.0	89.9	3.5	11.9
Days to fifty per cent flowering	27.5	36.0	31.6	6.0	5.5	85.2	3.3	10.5
Plant height (cm)	14.3	55.5	30.9	22.0	21.0	90.6	12.7	41.2
Number of primary branches per plant	4.1	14	6.7	35.5	34.8	95.9	4.7	70.2
Number of pods per plant	8.3	33.0	16.6	28.4	26.5	87.2	8.5	51.2
Shelling per cent	54.4	76.7	69.2	6.0	5.0	70.4	6.0	8.7
Hundred seed weight (g)	24.6	55.2	38.6	15.3	14.6	90.1	11.0	28.5
Yield per plant (g)	4.8	33.4	14.7	39.3	35.7	80.8	9.6	65.5

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 various biotic stresses and productivity parameters in mini core germplasm

Traits	*Spodoptera litura* damage	Late leaf spot	Rust	Days to initiation of flowering	Days to fifty per cent flowering	Plant height	Number of primary branches per plant	Number of pods per plant	Shelling per cent	Hundred seed weight	Yield per plant
Spodoptera litura damage	1	0.462**	0.162**	-0.434**	-0.439**	0.179**	-0.352**	-0.028	-0.010	-0.198**	-0.067
Late leaf spot	0.543**	1	0.201**	-0.636**	-0.595**	0.306**	-0.476**	-0.185**	-0.025	-0.050	-0.223**
Rust	0.207**	0.280**	1	-0.067	0.055	-0.055	-0.044	-0.020	0.095	-0.050	0.071
Days to initiation of flowering	-0.476**	-0.727**	-0.087	1	0.960**	-0.377**	0.555**	0.220**	-0.067	0.231**	0.220**
Days to fifty per cent flowering	-0.485**	-0.703**	-0.081	0.991**	1	-0.370**	0.554**	0.227**	-0.063	0.232**	0.215**
Plant height	0.192**	0.348**	-0.083	-0.418**	-0.425**	1	-0.323**	-0.293**	0.032	0.098	-0.205**
Number of primary branches per plant	0.457**	-0.544**	-0.061	0.593**	0.614**	-0.336**	1	0.421**	-0.089	0.198**	0.195**
Number of pods per plant	-0.032	-0.241**	-0.065	0.264**	0.273**-	0.329**	0.457**	1	0.053	0.041	0.219**
Shelling per cent	-0.036	-0.024	0.093	-0.099	-0.097	0.056	-0.056	0.086	1	0.106*	0.051
Hundred seed weight	-0.224**	-0.316**	-0.134**	0.260**	0.278**	0.115*	0.215**	0.042	0.148**	1	0.152**
Yield per plant	-0.063	-0.258**	0.094	0.263**	0.274**	-0.219**	0.199**	0.246**	0.063	0.194**	1

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

Table.4 Mean performance of mini core genotypes showing ≤ 10 per cent *Spodoptera litura* damage (at 70 DAS)

Sl. No.	Genotypes	Botanical variety	*Spodoptera* damage (%)	Late leaf spot	Rust	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	ICG 862	*hypogaea*	4.5	4.5	6.5	32.5	33.5	20.8	8.4**	13.1*	72.6**	33.9	23.2*
2	ICG 928	*hypogaea*	5.0	4.5	7.0	32.5	34.5	26.7	8.5**	18.6**	71.9*	42.7	28.2**
3	ICG 5051	*hypogaea*	5.4	7.0	7.0	28.0*	30.0*	20.0	4.8	10.2	73.4**	36.7	14.4
4	ICG 2925	*hypogaea*	6.7	6.5	6.5	32.0	34.0	18.0	9.0**	20.9**	67.5	32.6	11.4
5	ICG 14523	*hypogaea*	6.8	5.5	5.5	32.0	33.5	29.7	9.4**	15.4**	70.9*	40.7	15.3
6	ICG 76	*hypogaea*	6.8	5.0	6.5	33.5	34.5	29.3	7.7**	13.5**	72.9**	51.5**	25.2**
7	ICG 10890	*fastigiata*	7.5	5.5	6.5	28.5	30.0*	30.1	5.0	12.3*	62.1	25.1	14.8
8	ICG 14705	*hypogaea*	7.5	6.5	6.5	28.5	31.5	27.6	6.2	13.7**	72.6	35.0	9.3
9	ICG 2777	*hypogaea*	7.7	5.0	6.5	33.5	35.5	21.4	8.6**	29.3**	70.1	33.4	35.2**
10	ICG 14466	*hypogaea*	7.8	6.0	5.5	30.0	32.0	28.1	8.1**	13.6**	69.6	37.3	9.6
11	ICG 13787	*hypogaea*	7.8	6.0	7.0	32.0	33.5	27.0	9.3**	17.2**	67.9	45.3**	14.3
12	ICG 9777	*hypogaea*	8.1	7.0	6.5	32.5	34.5	31.8	5.8	11.7	70.9*	43.0	12.7
13	ICG 5016	*hypogaea*	8.2	4.5	5.5	32.0	34.0	25.7	10.6**	16.8**	71.8*	42.0	25.2**
14	ICG 1668	*hypogaea*	8.3	5.5	5.5	31.5	33.5	32.0	11.4**	13.9**	54.5	46.9**	12.5
15	ICG 5662	*hypogaea*	8.3	6.5	5.5	31.5	33.5	28.0	7.8**	17.6**	67.1	40.9	12.0
16	ICG 14482	*hypogaea*	8.3	5.5	6.5	31.5	33.5	38.1	8.2**	13.3*	70.0	47.6**	12.6
17	ICG 12276	*hypogaea*	8.4	5.0	5.5	29.0	31.5	32.9	8.2**	17.0**	73.4	43.4	26.3**
18	ICG 2381	*hypogaea*	8.8	2.5	2.5	31.5	33.0	29.6	9.4**	23.9**	69.0	47.6**	9.3

Contd……

Sl. No.	Genotypes	Botanical variety	*Spodoptera* damage (%)	Late leaf spot	Rust	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)
19	ICG 4412	*hypogaea*	9.0	4.5	5.5	32.5	34.5	23.5	13.1**	33.1**	69.5	48.1**	26.2**
20	ICG 4538	*hypogaea*	9.3	6.5	6.0	31.5	32.5	31.3	14.9**	28.6**	68.1	44.3**	13.3
21	ICG 9905	*hypogaea*	9.3	4.5	6.5	32.5	34.0	31.0	9.5**	14.9**	67.4	39.8	27.0**
22	ICG 11855	*hypogaea*	9.5	6.5	6.5	30.5	32.0	31.6	13.9**	23.5**	65.6	51.7**	20.9
23	ICG 2511	*hypogaea*	9.5	6.5	6.5	32.5	34.5	23.3	8.8**	21.6**	67.7	32.6	21.6
24	ICG 513	*hypogaea*	9.6	6.0	5.5	28.5*	30.0*	36.1	4.7	11.8	63.0	54.4**	7.3
25	ICG 6913	*hypogaea*	9.7	5.5	6.5	31.5	33.5	26.9	8.7**	15.9**	69.9	46.6**	9.2
26	ICG 15419	*hirsuta*	9.7	4.5	5.5	32.0	33.5	26.7	8.1**	12.6*	73.6**	43.1*	16.8
27	ICG 4746	*hypogaea*	9.8	7.0	6.0	30.5	32.0	25.1	7.7**	17.1**	64.0	33.6	9.7
28	ICG 7000	*hypogaea*	9.8	6.5	6.5	30.5	32.0	39.1	4.9	12.3	65.1	45.1**	11.9
29	ICG 721	*hypogaea*	9.9	5.5	6.0	31.5	32.5	44.2	8.9**	14.8**	66.3	39.2	6.0
	Checks												
30	JL 24	*fastigiata*	43.4	7.5	6.5	29.0	30.5*	34.5	5.4	9.0	66.5	40.0	18.1
31	ICG 2271	*hypogaea*	7.8	3.5	2.0	31.5	33.0	28.0	9.3**	12.3	63.7	33.1	13.2
32	ICGV 86031	*vulgaris*	16.6	6.5	5.5	28.5	30.0*	31.2	7.4**	22.3**	69.9	40.8	12.7
	Mean		19.10	6.52	6.22	29.84	31.63	30.90	6.77	16.68	69.22	38.63	14.74
	C.D. (5%)		4.92	1.19	0.86	1.19	1.43	4.10	0.95	3.34	4.42	3.69	5
	C.D. (1%)		6.49	1.57	1.14	1.58	1.89	5.4	1.26	4.41	5.84	4.87	6.6
	C.V. (%)		12.58	8.82	7.03	1.99	2.29	6.69	7.14	9.94	3.24	4.49	17.19

*&** indicates genotype's significance of superiority for yield and other parameters compared to susceptible check at 5 per cent and 1 per cent level of probability, respectively

Table.5 Mean performance of mini core genotypes showing ≤ 4 score for late leaf spot and rust at 80 DAS

Sl. No.	Genotypes	Botanical variety	Late leaf spot	Rust	*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)
Late leaf spot resistant genotypes													
1	ICG 2381	*hypogaea*	2.5	2.5	8.8	31.5	33.0**	29.6	9.4**	23.9**	69.0	47.6**	9.3
2	ICG 11426	*hypogaea*	2.5	4.5	12.7	31.5	33.0**	24.3	4.6	21.2**	74.7**	42.9	14.7
3	ICG 12625	*aequatoriana*	2.5	6.0	16.5	30.5	31.5	30.3	4.4	14.0**	69.3	46.2**	22.2
4	ICG 12370	*hypogaea*	3.5	6.5	23.5	32.5	34.0**	25.5	8.3**	14.5**	71.1*	45.5**	18.3
5	ICG 875	*hypogaea*	4.0	6.5	15.3	34.0	35.0**	23.5	7.1**	22.1**	73.5**	45.4**	30.6**
Rust resistant genotypes													
6	ICG 2381	*hypogaea*	2.5	2.5	8.8	31.5	33.0	29.6	9.4**	23.9**	69.0	47.6**	9.3
7	ICG 13723	*hypogaea*	3.5	4.5	17.7	32.5	34.0	29.3	7.6**	12.3	70.5	55.2**	16.0
	Checks												
8	JL 24	*fastigiata*	7.5	6.5	43.4	29.0	30.5	34.5	5.4	9.0	66.5	40.0	18.1
9	GPBD 4	*fastigiata*	4.0	3.0	25.7	28.0	29.5	45.0	7.8	17.9	76.3	37.3	16.4
	Mean		6.52	6.22	19.10	29.84	31.63	30.90	6.77	16.68	69.22	38.63	14.74
	C.D. (5%)		1.19	0.86	4.92	1.19	1.43	4.10	0.95	3.34	4.42	3.69	5
	C.D. (1%)		1.57	1.14	6.49	1.58	1.89	5.4	0.48	4.41	5.84	4.87	6.6
	C.V. (%)		8.82	7.03	12.58	1.99	2.29	6.69	7.14	9.94	3.24	4.49	17.19

*&** indicates genotypes are superior to yield and other parameters than susceptible check.

Iroume and Knauft (1987) 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 (Naidu, 2002).

There was significant positive association between late leaf spot and rust in mini core genotypes which could be due to similar host pathogen interactions for late leaf spot and rust pathogens. Earlier, significant positive correlation was reported between late leaf spot and rust in studying diverse groundnut germplasm (Naidu, 2002) and mutants (Motagi, 2001). Late leaf spot incidence had significant negative correlation with days to initiation and fifty per cent flowering in mini core genotypes revealing the late maturing nature of most of the late leaf spot resistant lines. Earlier, Naidu *et al.*, (2016) also reported late maturing nature of multiple stress resistant lines in case of interspecific derivatives of groundnut.

Performance of mini core genotypes

Among the 184 genotypes in the mini core, only 29 (15 %) genotypes showed resistance to *Spodoptera litura*, 31 (16 %) genotypes showed resistance to late leaf spot and 15 (8 %) genotypes showed resistance to rust. Among all the botanical varieties, *hypogaea* had more number of genotypes for resistance to *Spodoptera litura* (27), late leaf spot (29) and rust (7).

This could be due to the fact that *hypogaea* had the indeterminate growth habit and also has more growing period. Mini core comprises 10 per cent of the core germplasm and has the desirable diversity for reaction to these major biotic stresses studied due to their diverse genetic and geographic origin (Upadhayaya *et al.*, 2014).

Among the 29 genotypes showing less than 10 per cent leaf damage by *Spodoptera litura*, eight genotypes *viz*., ICG 862, ICG 928, ICG 76, ICG 2777, ICG 5016, ICG 12276, ICG 4412 and ICG 9905 recorded significantly higher pod yield per plant compared to high yielding check JL 24 (18.1 g) (Table 4). Among these resistant genotypes, ICG 2777 had high yield per plant (35.1 g) compared to other resistant genotypes. Their high pod yield per plant was mainly due to higher pod number per plant (Table 4). The genotype ICG 2381 was resistant to both late leaf spot and rust diseases in addition to resistance to *Spodoptera litura.* However, this genotype had low pod yield per plant (9.3 g). The low yield observed in this multiple biotic stress resistant genotype could be due to diversion of resources towards multiple biotic stress resistance mechanisms. Many reports suggest a strong negative association between resistance and desirable agronomic features (Arulsekar, 1972; Hammons, 1981; Williams *et al.*, 1984; Shew *et al.*, 1995; Gowda *et al.*, 1996). Hence, ICG 2381 can be used as a potential donor for incorporation of multiple stress resistance. Naidu (2002) reported that ICGV 93021, an advanced breeding line had multiple stress resistance with superior number of pods. In mini core collection, Upadhyaya *et al.*, (2014) reported that ICG 12697 (resistant to late leaf spot, rust and *A. flavus*) and ICG 12625 (resistant to late leaf spot, *A. flavus* and bacterial wilt) had multiple biotic stress resistance along with good yield potential (> 1850 kg/ha).

Among the 184 genotypes of mini core, only five genotypes *viz.*, ICG 2381, ICG 11426, ICG 12625, ICG 12370 and ICG 875 were resistant to late leaf spot (field disease score < 4) (Table 5). Earlier, the genotype ICG 11426 (Upadhyaya *et al.,* 2014; Shivaleela 2012; Sudini *et al.,* 2015) and ICG 12625 (Sujay *et al.,* 2008) were reported as resistant to late leaf spot disease among the mini core genotypes. Sudini *et al.*, (2015) reported ICG 875 and ICG 12625 as moderately resistant to late leaf spot disease. Among these late leaf spot resistant genotypes, ICG 875 that belong to Virginia runner group had moderate resistance to *Spodoptera litura* with 15.3 per cent leaf damage and it recorded significantly higher pod yield per plant (30.6 g) compared to the susceptible check JL 24. This genotype could serve as potential donor to incorporate the resistance to late leaf spot into Virginia runner genotypes.

Among 184 genotypes, only 2 genotypes showed resistance to rust (Field disease score < 4). Both genotypes (ICG 2381 and ICG 13723) had significantly higher hundred seed weight *i.e.*, 47.6 g and 55.2 g, respectively compared to susceptible check JL 24 (40 g) and hence can be potential donor genotype for rust resistance under bold seeded groundnut genotypes.

Multiple biotic stress resistance

Among the 184 genotypes of mini core genotypes, one germplasm accession, ICG 2381 belonging to botanical variety, *hypogea* under Virginia runner growth habit had resistance to all the three biotic stresses *viz.*, *Spodoptera litura*, late leaf spot and rust. Earlier, Upadhayaya *et al.*, (2014) reported that ICG 2381 as resistant to rust and *A. flavus* with good oil quality. Multiple stress resistant genotype, ICG 2381 is a landrace collected from Brazil. It has a purple seeded kernel and also reported to be high oleic type (Ganapati, 2011). Since, this germplasm line had low pod yield and hence can serve as potential donor for multiple biotic stress resistance breeding programme.

In groundnut mini core (184 genotypes), 29 genotypes had less than 10 per cent leaf damage by *Spodoptera litura*, five genotypes had resistance to late leaf spot and two genotypes had resistance to rust. One germplasm ICG 2381 had resistance to late leaf spot, rust and *Spodoptera litura* and can be utilised in the resistance backcross breeding programme to develop superior multiple biotic stress resistant genotypes with desirable productivity traits. These biotic resistant genotypes need to be assessed for their resistance reaction under artificial conditions and evaluated over locations and seasons for their consistent performance besides studying their pod features and other quality parameters.

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