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Screening groundnut (*Arachis hypogaea* L.) genotypes for resistance to early, late leaf spot and rust disease under natural epiphytotic conditions

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Abstract
The present investigation was carried out to study screening of 42 groundnut genotypes for early, late leaf spot and rust disease under natural epipytotic conditions in coastal sandy soils at agricultural college Bapatla college farm. Nine genotypes showed resistance against early leaf spot and six each for late leaf spot and rust disease. 21 genotypes showed moderate resistance to early leaf spot and 15 genotypes showed moderate resistance for late leaf spot and rust. Such resistant genotypes can be used for further resistance breeding programme.

Keywords: Groundnut, leaf spot, rust, crop rotation, genotypes

Introduction
Groundnut is an important food crop of the world. Groundnut (*Arachis hypogaea* L.), is an important annual legume in the world mainly grown for oil seed, food and animal feed. Besides income for farmers, groundnut provides an inexpensive source of high quality dietary protein and edible oil. Groundnut seeds contain high quality edible oil (50%), easily digestible protein (25%), carbohydrates (20%), vitamin E, niacin, folacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium (FAO, 2004).Groundnut oil is used as fuel in diesel engines and lighting and also in the manufacture of peanut butter, margarine, furniture creams, salad oils, soaps and cooking oil and for cooking sardines before packing them in olive oil. The groundnut cake obtained after oil extraction and groundnut haulms are useful animal feeds.It is an important commercial crop of rain fed areas nearly contributes to around 40 *per cent* of the total oilseeds production. In India duly occupy an area of 4.9 M ha with a production 9.25 M t and a productivity of 1893 kg ha^{-1} (Indiastat, 2017-18) [7]. In Andhra Pradesh, groundnut occupies an area of 0.74 M ha producing 1.05 M t with the productivity of 1426 kg ha^{-1} (Indiastat, 2017-18) [7]. It's cultivation is mainly concentrated in the Rayalaseema districts *viz*., Anantapur, Cuddapah, Karnool and Chittoor covering 95 *per cent* of the total area of the state. The Krishna agro-climatic zone of Andhra Pradesh, groundnut is gaining popularity and farmers are growing groundnut in coastal sandy soils throughout the year *viz., Kharif, Rabi and Summer* seasons without any crop rotation and with 300 *per cent* cropping intensity. Farmers are growing groundnut under high input management *i.e* higher seed rate, higher than the Acharya N G Ranga Agricultuaral University recommendation and the yields levels are also higher. Despite higher yields there is still chance of even more profit by minimizing the cost of cultivation by avoiding the fungicidal spray at weekly interval. Farmers are growing groundnut crop in this tract because of assured sub surface irrigation year round. This condition favours the incidence of foliar diseases. The present varieties which are used by farmers are mostly susceptible to foliar diseases and this is the major reason for low yield levels. At the time of harvesting farmers can find only bare stems without leaves. The infected and defoliated leaves fall on the soil and thereby build up the sufficient innoculum load in the soil for succeeding groundnut in the ensuring crop season. Of the foliar fungal diseases, rust and the two leaf spots together popular as "*Tikka*" in India. Both early and late leaf spot are in common occurrence wherever groundnut is grown. However, the incidence and severity of diseases vary between localities and seasons (Mc Donald *et al*., 1985) [6]. The main cause for yield loss is due to the co-occurrence of rust and LLS can go up to 70% in India when fungicides are not applied (Subrahmanyam *et al*., 1984) [10].

Fungicides are the most common tools practiced by most of the Indian formers for controlling disease incidence. In recent years, there has been growing concern in indiscriminate use of fungicides because they are potentially hazardous to environment and chemical residues in the soil adding to the pollution. These factors have led to the search for new approach for plant disease management. Keeping this in mind in order to find the solution for the problem of high use of chemicals to control in the foliar diseases. An experiment is carried to identify the resistant variety for the foliar diseases.

Materials and Methods

An experimental study was carried out at the Agricultural college farm, Bapatla using 42 diverse genotypes obtained from various research stations which were located across Andhrapradesh *viz.*, Agricultural Research Station, Kadiri, RARS Tirupati, RARS jagityal and DGR Junagharh The list of genotypes together with their pedigree and origin is presented in table 1

Table 1: List of Genotypes together with their pedigree and origin

Sl. No	Genotypes	Pedigree	Origin
1	Kadiri 6	JL24 X AH316 S	ARS Kadiri
2	Kadiri 7 Bold	ICGV86522 X ICGVFDRS X ICGV 91172	ARS Kadiri
3	Kadiri 8 Bold	ICGV86522 X ICG 10 X ICGV 91172	ARS Kadiri
4	Kadiri 9	K-4 X Vemana	ARS Kadiri
5	Kadiri Harithandra	91-57-2 X P1-47-6177	ARS Kadiri
6	K 1454 red	Vemana X Tirupati	ARS Kadiri
7	K 1501	K-4 X ICGX 930179 P2	ARS Kadiri
8	K1574	Vemana x JSSP-6-VB	ARS Kadiri
9	K1609	K-8 X JL-24	ARS Kadiri
10	K1621	ICGV99099 X K-4	ARS Kadiri
11	K1715	K-7 X ICGV99099 X K-4	ARS Kadiri
12	K1719	K-7 X TAG 24	ARS Kadiri
13	K1725	K-7 X TAG 24	ARS Kadiri
14	K1735	K-7 X JL 24	ARS Kadiri
15	K1787	ICGX020063-F2-B1-SSD-P23-B2	ARS Kadiri
16	K1789	ICGX020066-F2-B1-SSD-P2-B1	ARS Kadiri
17	K1800	ICGV96176(Floriant X 2597447 XICGV88312)	ARS Kadiri
18	K1805	ICGV020047-F2-SSD-SSD-P18-B1	ARS Kadiri
19	K1811	ICGV020055-F2-SSD-SSD-P18-B1	ARS Kadiri
20	K1812	ICGV020055-F2-SSD-SSD-P20-B1	ARS Kadiri
21	K1813	ICGV020055-F2-SSD-SSD-P25-B1	ARS Kadiri
22	K1847	K-8 X K-4	ARS Kadiri
23	K1924(VGLS)	VG9521 X R 8808	ARS Kadiri
24	K1924(SB)	VG9521 X R 8808	ARS Kadiri
25	K2014	K-9 X 3 X 155-005	ARS Kadiri
26	K2064	K-7 X K-4	ARS Kadiri
27	K2066	K 1468 X K-4	ARS Kadiri
28	K2075	K-7 X TKG 19-A	ARS Kadiri
29	K2077	K-7 X ICGV99073	ARS Kadiri
30	K2104	K-8 X ICGV99073	ARS Kadiri
31	TCGS1416	Germplasm collection	RARS, Tirupati
32	TCGS1426	Germplasm collection	RARS, Tirupati
33	TCGS1073	Germplasm collection	RARS, Tirupati
34	TCGS894	Germplasm collection	RARS, Tirupati
35	TCGS1157	Germplasm collection	RARS, Tirupati
36	Dharani	VRI 2-XTCGP-6	RARS, Tirupati
37	Narayani	JL-24 x Ah316/s	RARS, Tirupati
38	Abhaya	Vemana XTAG-24	RARS, Tirupati
39	TAG 24 (C)	TGS-2 X TGE-1	BARC Trombay, Mumbai
40	JCG-88-2	J 11 x TG (E) 1	RARS,Jagityal
41	Girnar-3	Girnar 1 x ICGS 11	DGR, Junagadh
42	Girnar-2	M 13 x R 33-1	DGR, Junagadh

The experimental field is laid out in randomized block design with three replications during *Kharif* 2017, *rabi* 2018 and *summer* 2019 and data pooled over three seasons was used for study. The experiment had plot size of 5 x 1.5 m^2 of each genotype having 5 rows. Row to row 30 cm and plant to plant 10 cm distance were maintained. At regular intervals weeding was carried out, and Earthing up operation was taken up after gypsum application. All the recommended practices were followed to raise a healthy crop. Data collection on leaf spots (early, late) and rust disease was based on a visual score as follows: 1 = highly resistant, >1 - 3 = resistant, 4– 5= moderate resistance, 6 – 7 = susceptible and 8 – 9 = highly susceptible (Subrahmaniyam *et al.*, 1995) [9]. Disease severity indicates 0%= highly resistant, 1 - 10% = resistant, 11 – 30%= moderate resistance, 31 – 60% = susceptible and 61 – 100% = highly susceptible. Data on leaf spots and rust were collected at 30, 40 and 50 DAS for early leaf spot and 60, 70 and 80 DAS for both late leaf spot and rust disease.

Results and Discussion

Early leaf spot caused by *Cercospora arachidicola*, late leaf spot caused by *Phaeoisariopsis personata* and rust caused by *Puccinia arachidis.* Early leaf spot symptoms were first observed at 30 DAS as pale areas on the upper surface of lower leaves. The spots later turned yellow, and become necrotic from the centre of the lesion, and later the entire spot become necrotic. The large, circular to irregular spots measured 1 to 10 mm in diameter, characterized by a yellow halo of variable width. At maturity, the spots turned reddish brown to Black**.** Late leaf spot symptoms were first observed at 60 DAS. The spots on leaves were circular with bright yellow halo around matured spots, usually darker than early leaf spots. On the under surface of the leaves, the halo was not seen. The spots were deep black in colour. Severely diseased leaves dried up and resulted in heavy defoliation. Rust symptoms appeared as orange coloured pustules, appeared first on the lower surface of the groundnut leaves. Damaged leaves become necrotic and dried up but remained attached to the plant.

Forty one genotypes along with one susceptible check (TAG 24) were evaluated for their reaction to early leaf spot, late leaf spot and rust diseases. The varied level of reaction to the diseases showed by the genotypes is presented in Table.2

Scoring for early leaf spot

Disease scoring as per the modified 9 point scale (Subrahmaniyam *et al.,* 1995) [9] revealed that the 41 genotypes have different type of reaction to early leaf spot ranged from disease score 3 to 9. Out of 41 genotypes, nine genotypes (JCG-88-2, K 1789, K 1805, K 1800, K 1811, K 1812, K 1813, K 1787 and TCGS 1157) were resistant to early leaf spot disease, whereas twenty one genotypes (K 2104, K 2077, K 2075, K 2066, K 2064, K 2014, K 1924(SB), K 1735,K 1725, K 1719, K 1621, K 1574, K 1501, K 1454 red, Girnar-2,Girnar-3, Kadiri 7 bold, Kadiri 8 bold, Kadiri Harithandra, TCGS 1426 and TCGS 1416 were moderately resistant and nine genotypes (K 1847, TCGS 894, Kadiri 9, TCGS 1073, TCGS (VGLS), K 1715, K 1609, Dharani and Abhaya) were susceptible to early leaf spot. The three genotypes Narayani, Kadiri 6 and TAG 24 expressed as highly susceptible reaction to early leaf spot disease. None of the genotypes observed '1' disease score *i.e* immune reaction to Disease. Highest score *i.e.* 9 was observed for the genotypes Kadiri 6, Narayani and TAG 24 followed by Abhaya and Dharani (8 score). The disease severity per centage was highest (81-100%) for Kadiri-6, Narayani and TAG 24 followed by Abhaya and Dharani (61-80%). The least disease severity recorded in JCG-88-2, K 1789, K 1805, K 1800, K 1811, K 1812, K 1813, K 1787, TCGS 1157 (6-10%).

Scoring for Late Leaf Spot and Rust

Disease scoring as per the modified 9 point scale (Subrahmaniyam *et al.*, 1995) [9] revealed that the genotypes exhibited differential reaction to the disease ranged from disease score 3 to 9. Out of 41 genotypes, six genotypes (K 1800, K 1805, K 1811, K 1812,K 1813 and K 1789) were resistant (Table 2), whereas fifteen genotypes (Kadiri 7 bold, kadiri 8 bold, K 2104, K 2077, K 2075, K 2066, K 2064, K 2014, K 1924(SB), K 1847, K 1787, K 1735, K 1725, Girnar - 2 and JCG-88-2) were moderately resistance to late leaf spot and rust. Sixteen genotypes (TCGS 894, TCGS 1426, TCGS 1416, TCGS 1157, TCGS 1073, Kadiri Harithandra, Kadiri 9, K 1924 (VGLS), K 1719, K 1715, K 1621, K 1609, K 1574, K 1501, K 1454 red and Girnar-3) were susceptible to late leaf spot and rust disease. Among the 41 genotypes, five genotypes (Kadiri-6, TAG 24, Narayani, Dharani and Abhaya) expressed as highly susceptible reaction for both late leaf spot and rust disease. Lowest disease score of 3 was observed in K 1800, K 1805, K 1811, K 1812, K 1813 and K 1789 and highest disease score of 9 was observed in genotypes *viz.*, Kadiri-6, TAG 24, highly susceptible. Disease severity (81-100%) was highest in Kadiri-6 and TAG 24 followed by Narayani, Dharani, Abhaya (61-80%). Therefore, it was observed from the present study that six genotypes showed resistance against late leaf spot and rust while nine genotypes showed resistance reaction against early leaf spot. 15 genotypes showed moderate resistance for late leaf spot and rust. Twenty one genotypes recorded moderate resistance against early leaf spot and 16 genotypes registered susceptible reaction for both late leaf spot and rust diseases. For early leaf spot nine genotypes showed susceptible reaction. Five genotypes Kadiri 6, TAG 24, Narayani, Dharani and Abhaya showed highly susceptible reaction to late leaf spot and rust, similarly for early leaf spot three genotypes showed highly susceptible reaction. The genotypes which showed resistance reaction to the diseases can be used for further resistance breeding programme. Khute *et al.* (2018) [3] reported nine genotypes showed resistance reaction and 12 expressed moderate resistance against early leaf spot. Parbat *et al.* (2018a) [8] reported seven entries were resistant, 14 were moderately resistant and four were highly susceptible for early leaf spot infection Sudini *et al.* (2015) [11] reported six accessions as potential source of rust and late leaf spot resistance. Mane, (2012) [5] reported only one genotype showed moderately resistance and remaining 16 genotypes were susceptible to tikka disease. Lukanda *et al.* (2011) [4] found that two genotypes were moderately resistant, three moderately susceptible and four were highly susceptible to both leaf spots. Hossain *et al.* (2007) [2] reported two genotypes found to be moderately resistant to both the leaf spots and rust disease.

Conclusion

None of the genotypes were found to be immune to any of the three diseases studied. Only Six genotypes have showed resistance against late leaf spot and rust while nine genotypes have shown resistance reaction against early leaf spot. 15 genotypes showed moderate resistance for late leaf spot and rust. Twenty one genotypes recorded moderate resistance against early leaf spot and 16 genotypes registered susceptible reaction for both late leaf spot and rust diseases. For early leaf spot nine genotypes showed susceptible reaction. Five genotypes Kadiri 6, TAG 24, Narayani, Dharani and Abhaya showed highly susceptible reaction to late leaf spot and rust, similarly for early leaf spot three genotypes showed highly susceptible reaction. Resistant and moderately resistant genotypes can be used in resistance breeding.

Table 2: Disease reaction and Classification of genotypes into different disease reaction groups to early and late leaf spot and rust in Groundnut

Criteria	Disease scale	Disease severity (%)	Disease reaction		
			Early leaf spot	Late leaf spot	Rust
Resistant	1	0	-	-	-
	2	1-5	-	-	-
	3	6-10	JCG-88-2,K 1789,K 1805, K 1800, K 1811, K 1812,K 1813,K 1787, TCGS 1157	K 1800,K 1805,K 1811, K 1812,K 1813, K 1789	K 1800,K 1805,K 1811, K 1812,K 1813, K 1789
Moderately Resistant	4	11-20	K 2104,K 2077,K 2075,K 2066, K 2064,K 2014,K 1924(SB), K 1735,K 1725,K 1719, K 1621,K 1574, K 1501	K 1924(SB), K 1847, K 1787, K 1735, K 1725, Girnar - 2, JCG-88-2	K 1924(SB), K 1847, K 1787, K 1735, K 1725, Girnar - 2,JCG-88-2
	5	21-30	K 1454 red,Girnar-2,Girnar-3,Kadiri 7 bold, Kadiri 8 bold,TCGS 1426, TCGS 1416,TCGS 1157	Kadiri 7 bold, kadiri 8 bold, K 2104, K 2077, K 2075, K 2066, K 2064, K 2014	Kadiri 7 bold, kadiri 8 bold, K 2104, K 2077, K 2075, K 2066, K 2064, K 2014
Susceptible	6	31-40	K 1847,TCGS 894,Kadiri -9, TCGS 1073, K 1924(VGLS), K 1715, K 1609	K 1924(VGLS), K 1719,K 1715, K 1621, K 1609,K 1574, K 1501, K 1454 red, Girnar-3	K 1924(VGLS), K 1719,K 1715, K 1621, K 1609,K 1574, K 1501, K 1454 red, Girnar-3
	7	41-60	Dharani, Abhaya	TCGS 894,TCGS 1426, TCGS 1416,TCGS 1157, TCGS 1073, Kadiri Harithandra, Kadiri 9	TCGS 894,TCGS 1426, TCGS 1416,TCGS 1157, TCGS 1073, Kadiri Harithandra, Kadiri 9
Highly susceptible	8	61-80	Narayani	Narayani, Dharani, bhaya	Narayani, Dharani, Abhaya
	9	81-100	Kadiri-6,TAG 24	Kadiri-6,TAG 24	Kadiri-6,TAG 24

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