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Identification of groundnut genotypes resistant to iron deficiency chlorosis

Groundnut (*Arachis hypogaea* L.) is the second most important oilseed in India, which is mainly grown in states like Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra. More than one-third of the soils in India are calcareous and spread mostly in the low rainfall areas of the western and central parts of the country where groundnut is a major crop. As calcareous soils are deficient in available iron (Fe^{2+}), iron deficiency chlorosis (IDC) is more prevalent in Saurashtra region of Gujarat, Marathwada region of Maharashtra, and parts of Rajasthan, Tamil Nadu and Karnataka causing significant reduction in yield (Singh *et al.*, 2004). Iron deficiency leads to interveinal chlorosis of younger leaves, while under severe deficiency they turn into white and papery and further as brown and necrotic. Genetic variability for resistance to IDC has been reported earlier in groundnut (Samdur *et al.*, 2000; Li and Yan-Xi, 2007). Cultivation of IDC resistant cultivars in calcareous soils is economically feasible and sustainable approach compared to application of iron containing fertilizers through soil or foliar spray.

In the present study, 43 groundnut genotypes were evaluated in a field experiment using randomised complete block design with two replications in calcareous soil deficient in available iron [Soil pH (1:2.5) 8.12; exchangeable calcium 21.10 c mol (P^+) kg/l; $CaCO_3$ 9.5%; DTPA extractable-Fe 3.96 ppm] at the Regional Agricultural Research Station, Vijayapur located in Northern dry zone of Karnataka during rainy season of 2013. Seeds of 43 groundnut genotypes were collected from different institutions *viz.*, ICRISAT-Patancheru (11), BARC-Mumbai (9), UAS-Raichur (2), and UAS-Dharwad (21). Each genotype was planted as one row of 3 m length in each replication with a spacing of 30 x 10 cm. Recommended package of practices were followed with respect to application of fertilizers (except Fe-containing fertilizers), pest management, and other agronomic practices to raise a healthy crop. Genotypes were assessed for IDC resistance related traits like visual chlorotic rating (VCR) and SPAD chlorophyll meter reading (SCMR) at four different stages of crop growth [30, 60, 90 and 120 days after sowing (DAS)]. Field data for VCR were recorded on line-basis using 1 to 5 scale proposed by Singh and Chaudhari (1993). The chlorophyll meter SPAD 502 was used to record SPAD chlorophyll meter reading on standard leaf (third leaf from the top on main stem) as mean of three random plants in each line at four different stages *viz.*, 30, 60, 90 and 120 DAS. Iron content in seeds (mg kg^{-1}) were estimated using atomic absorption spectrophotometer (AAS) at ICRISAT, Patancheru as per the method of Sahrawat *et al.* (2002).

The mean sum of squares for IDC resistance related traits like VCR and SCMR across four different stages *viz.*, 30, 60, 90 and 120 DAS and Fe content in seed (mg kg^{-1}) showed highly significant differences among the genotypes studied (Table 1). Forty-three genotypes exhibited interveinal chlorosis of varying intensities evident from large variability observed for mean VCR (1.1 to 3.8) and SCMR (14.6 to 39.0) across four different stages (Table 2). Overall, majority of genotypes were initially (at 30 DAS) susceptible to IDC, recovered at intermediate stage (at 60 DAS), and further became much more susceptible during later stages (at 90 and 120 DAS) as evident from mean values for VCR (1.69, 1.56, 1.82, 2.06) and SCMR (24.34, 38.33, 34.99, 29.67) across four stages, respectively. This indicates higher requirement of iron for initial growth and also for pod development at later stages. Earlier reports in groundnut suggest attaining of maximum intensity of iron chlorosis at 30-70 days (Singh and Chaudhari, 1993) or 50-65 days after emergence (Li *et al.*, 2009). The observed differences could be due to genotypic differences *per se*.

Significantly lower VCR scores and higher SCMR values across four stages observed among genotypes like ICGV 86031 (1.0, 39.0), ICGV 06146 (1.0, 36.4), A30b (1.0, 37.5), and MG 8 (Dwarf) (1.1, 36.1), indicated them as resistant to IDC throughout their crop growth period. But, released varieties like R 9227 (3.8, 14.6), Mutant III (3.3, 14.9), Dh 2000-1 (3.1, 19.7), R 8808 (3.0, 22.8), JL 24 (2.8, 19.1), and TMV 2 (2.8, 21.4) were found more susceptible as evident from higher mean VCR scores and lower SCMR values across four stages. Visual Chlorotic rating, chlorophyll estimation and SPAD readings have been used earlier to evaluate groundnut genotypes for iron deficiency chlorosis (Samdur *et al.*, 2000; Li and Yan-Xi, 2007). Samdur *et al.* (2000) found significantly negative correlation between VCR and SCMR, while highly significant and positive correlation between SPAD readings and chlorophyll content and suggested chlorophyll meter as an efficient and speedy tool to screen genotypes for tolerance to iron-deficiency chlorosis. SPAD chlorophyll meter reading is simpler, robust and reliable for judging IDC resistance compared to VCR in groundnut as found in this study and could be an ideal indicator for identifying resistance sources and also breeding for IDC resistant groundnut genotypes. Earlier, Li *et al.* (2009) also indicated SPAD value as a feasible screening indicator to select iron-resistant groundnut cultivars.

The iron content in seed differed significantly among the groundnut genotypes and it ranged from 19.0 (R 9227) to

Table 1. Mean squares for iron deficiency chlorosis resistance related traits in groundnut

Trait	Source of variation		
	Replication	Genotypes	Error
df →	1	42	42
VCR at 30 DAS	1.41	1.22**	0.41
VCR at 60 DAS	0.10	0.70**	0.08
VCR at 90 DAS	0.01	1.08**	0.08
VCR at 120 DAS	0.02	1.14**	0.13
SCMR at 30 DAS	1.88	73.27**	3.42
SCMR at 60 DAS	15.07	83.98**	10.91
SCMR at 90 DAS	18.98	155.54**	34.21
SCMR at 120 DAS	0.84	194.69**	8.70
Fe content in seed (mg kg^{-1})	0.82	37.34**	7.70

VCR - Visual chlorotic rating; SCMR– SPAD chlorophyll meter reading; DAS - days after sowing; df - Degrees of freedom,
** Significant at 1% level of probability

Table 2. Mean values for iron deficiency chlorosis resistance related traits in 43 groundnut genotypes

Sl. No.	Genotypes	Visual chlorotic rating 30 DAS	60 DAS	90 DAS	120 DAS	Mean	SPAD chlorophyll meter reading 30 DAS	60 DAS	90 DAS	120 DAS	Mean	Fe in seed (mg kg^{-1})	Response*
1.	TMV 2	3.0	2.0	3.0	3.0	2.8	21.0	28.8	18.8	17.1	21.4	27.95	S
2.	JL 24	3.0	2.0	3.0	3.0	2.8	13.8	31.3	18.4	12.8	19.1	30.45	S
3.	GPBD 4	2.5	2.0	3.0	2.5	2.5	13.7	37.8	20.9	11.6	21.0	24.90	S
4.	GPBD 5	1.0	1.5	2.0	3.0	1.9	25.6	39.1	31.4	13.1	27.3	26.45	MR
5.	G 2-52	2.5	2.0	3.0	2.0	2.4	17.8	37.0	24.4	31.8	27.7	23.15	S
6.	Dh 86	2.5	2.0	2.0	2.0	2.1	17.1	41.5	35.1	33.5	31.8	19.90	S
7.	Dh 40	3.0	2.0	3.0	3.0	2.8	19.6	29.7	18.7	13.6	20.4	23.15	S
8.	Mutant III	3.5	3.5	3.0	3.0	3.3	11.8	13.8	21.8	12.0	14.9	24.60	S
9.	TGLPS 3	2.5	2.0	2.0	3.0	2.4	18.2	27.3	35.9	20.4	30.5	21.55	S
10.	Dh 3-30	3.0	2.0	3.0	3.0	2.8	20.3	29.3	22.9	17.4	22.5	31.40	S
11.	DSG 1	2.0	2.0	3.0	2.0	2.3	20.3	34.3	29.3	27.6	27.9	23.25	S
12.	S 230	2.0	2.5	3.0	3.0	2.6	20.0	40.0	31.8	14.3	26.5	25.25	S
13.	JSP 39	3.0	2.5	3.0	2.5	2.8	23.6	24.3	28.7	21.0	24.4	19.45	S
14.	Dh 8	1.5	2.0	3.0	2.5	2.3	14.0	31.1	18.4	22.0	21.4	31.25	S
15.	Dh 216	1.5	2.0	2.5	3.0	2.3	21.3	30.9	30.8	13.1	24.0	22.20	S
16.	Dh 101	2.5	1.5	2.0	2.0	2.0	25.6	41.4	39.5	30.3	34.2	23.80	MR
17.	Dh 2000-1	3.5	3.0	3.0	3.0	3.1	14.3	27.3	23.9	13.2	19.7	21.50	S
18.	ICGV 06040	2.5	3.0	3.0	3.0	2.9	21.4	25.4	25.1	15.6	21.8	25.24	S
19.	ICGV 06099	2.0	3.0	3.0	3.0	2.8	17.3	26.3	19.2	17.5	20.1	21.85	S
20.	ICGV 06420	2.0	1.0	2.0	3.0	2.0	25.7	40.3	32.7	20.7	29.8	22.90	MR
21.	ICGV 05155	2.5	1.0	1.0	2.0	1.6	24.1	41.4	41.7	34.1	35.3	20.30	MR
22.	ICGV 02266	3.0	2.5	2.0	2.5	2.5	16.6	33.0	27.9	30.8	27.0	19.70	S
23.	ICGV 06146	1.0	1.0	1.0	1.0	1.0	23.1	41.5	41.6	39.4	36.4	29.95	R
24.	ICGV 91114	2.5	2.0	3.0	3.0	2.6	16.9	32.5	20.9	20.7	22.7	29.85	S
25.	ICGV 00350	2.5	2.0	2.0	3.0	2.4	20.2	42.1	33.5	19.1	28.7	24.70	S
26.	ICGV 87846	1.0	2.0	1.5	1.0	1.4	13.9	41.4	38.4	41.2	33.7	28.05	MR
27.	ICGV 93468	2.5	2.0	2.0	2.0	2.1	18.8	41.4	35.5	34.3	32.5	20.55	S
28.	ICGV 86031	1.0	1.0	1.0	1.0	1.0	33.5	39.4	41.3	41.8	39.0	25.82	R
29.	TAG 24	2.5	2.0	2.0	2.5	2.3	18.6	40.6	31.4	34.9	31.3	22.86	S
30.	TG 26	1.5	2.0	2..0	2.5	2.0	30.8	39.0	30.1	21.5	30.3	33.39	MR
31.	TG 37A	2.5	2.0	3.0	3.0	2.6	27.3	37.4	29.5	17.5	27.9	26.03	S
32.	TG 38	1.0	2.0	2.5	3.0	2.1	21.8	38.1	28.3	17.0	26.3	22.80	S
33.	TG 51	2.5	2.0	2.5	4.0	2.8	24.9	35.1	32.6	13.0	26.4	19.55	S
34.	TG 67	1.5	2.0	2.0	3.0	2.1	31.0	30.1	32.0	17.4	27.6	32.95	S
35.	TG 68	2.0	2.0	2.5	3.0	2.4	26.2	33.7	28.3	19.8	27.0	31.55	S
36.	TG 69	2.0	1.5	2.0	2.0	1.9	28.8	41.2	35.7	30.8	34.1	21.20	MR
37.	TG 72	2.0	1.0	1.5	2.0	1.6	32.1	39.8	41.3	36.8	37.5	25.85	MR
38.	A30b	1.0	1.0	1.0	1.0	1.0	35.1	32.3	41.4	41.2	37.5	34.40	R
39.	JG (Thin shell)	3.0	2.0	3.0	3.0	2.8	16.4	40.3	21.7	14.6	23.2	23.15	S
40.	MG 8 (Dwarf)	1.5	1.0	1.0	1.0	1.1	23.2	40.3	40.9	39.9	36.1	33.55	R
41.	GBFDS 272	3.0	2.0	3.0	2.0	2.5	12.2	33.0	22.1	33.0	25.0	26.80	S
42.	R 8808	3.5	2.0	3.0	3.5	3.0	17.5	36.3	20.1	17.3	22.8	27.00	S
43.	R 9227	4.0	3.0	4.0	4.0	3.8	11.7	22.9	13.3	10.8	14.6	19.00	S
	C.D. (5%)	0.72	0.47	0.47	0.60	0.33	3.05	5.44	4.13	4.86	2.95	4.58	-
	C.V. (%)	18.8	14.5	11.9	14.2	8.8	8.8	9.5	8.6	12.6	6.6	11.0	-

DAS - days after sowing, *Response to iron deficiency chlorosis: R– Resistant, MR- Moderately resistant, S - Susceptible

34.4 ppm (A30b). Significantly higher iron content in seed was observed in many of the IDC resistant/moderately resistant genotypes like A30b, MG 8 (Dwarf), TG 26, TG 67, TG 68, ICGV 06146, except ICGV 86031 which recorded lesser Fe, it may be due to the poor translocation of absorbed ferrous iron into the seed. Significantly lower iron content in seed was observed in IDC susceptible genotypes like R 9227, JSP 39, TG 51, ICGV 02266, Dh 86, and TMV 2. Similarly in soybean, efficient genotypes were found to have higher seed Fe content compared to inefficient genotypes (Vasconcelos and Grusak, 2013).

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