RESEARCH ARTICLE

PHYSIOLOGICAL PLASTICITY OF 60 CULTIVARS OF *ARACHIS HYPOGAEA* UNDER NATURAL DROUGHT CONDITIONS OF SEMIARID REGION IN INDIA

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Received-02.01.2019, Revised-20.01.2019

Abstract: Physiological plasticity of sixty peanut cultivars, belonging to four botanical groups, were evaluated during *Kharif* season under well-watered (with protective irrigation; P) and natural drought(under rain-fed;RF) conditions and compared for physiological and yield attributes to identifythe promising ones. The days required for 50% flowering varied from 24.5-34.0 days and 26.0-37.7 days with an average of28 and 30 days in P and RF crops, respectively. The natural drought under RF condition delayed crop maturity (112-132 days) as against 113-119 maturity days in P.Interestingly, 30 cultivars matured within 113 days at 2130 ºC degree days under both the condition indicating their adaptability and plasticity to drought. Though themean pod yield of peanut cultivars were 1260 kg ha^{-1}under P and 1130 kg ha^{-1}under RF conditions, cultivars ICGS 5, JGN 23, AK 265, GG 5, GG 11, GG 16, Girnar 1, AK 159, SBXIshowed > 1300 kg ha^{-1} pod yield under both the conditions. The cultivars with early flowering, high SCMR,low SLA, high yield and HI,and early maturity showed the escape mechanism and were considered as most promising for rain-fed cultivation, where there is greater likelihood of drought situation.Our study showed, Spanish bunch (VUL) group was more suitable compared to Virginia bunch (HYP), Virginia runner (HIR) and Valencia (FST) peanut group for desirable traits in rain-fed condition. The cultivars JGN 23, SB XI, and Girnar1 showed most of the desirable characters with high physiological plasticity and hence, can be of immense use for rain-fed conditions.

Keywords: Degree days,Flower initiation, Natural drought, Peanut, Physiological Plasticity

INTRODUCTION

The peanut is a major food legume of tropical and sub-tropical region of the globe and grown in about 110 countries under rain-fed condition mostlywith full of uncertainty of weather conditions (FAO, 2014, Singh *et al*., 2013). The productivity of peanut is less than 1000 kg ha^{-1} in more than 30 % of the peanut growing countries in the world, whereas it is between 1000-2000 kg ha^{-1} in 40-45 % of the countries.Only 25% of the 110 countries possess productivity above 2000 kg ha^{-1} (FAO, 2014). India though has the largest peanut area (5.53 m ha) in the world, but its average productivity is only around 1300 kg ha^{-1}, whichfluctuates between 990 to 1750 kg ha^{-1} mainly due to its cultivation as rain-fed crop without protective irrigation during *kharif* season (Singh 2004, 2011; Singh *et al*., 2013).However with good cultural practices and protective irrigations farmers are harvesting up to 4000 kg ha^{-1}pod yield in certain areas (Singh, 2011). This calls for the attention of researchers to look into the matter and modify the recommendations.

Crop productivity per unit water is important especially for developing water use efficient cultivars(Codon *et al*.,2004). Physiological parameters associated with drought tolerance can be utilized foridentification of drought resistant cultivars which can be used in crop improvement programmes (Nautiyal *et al*., 1999, 2012; Singh *et al*., 2013, 2014a, b). The leaf area and specific leaf area (SLA) are strongly correlated with photosynthesis and transpiration efficiency and thus dehydration tolerance capacity(Nageswara Rao *et al*., 1992; Wright *et al*., 1994). Chlorophyllisthe major photosynthetic pigment and high chlorophyll density under water deficit stress is an indicator of tolerance (Arunyanark *et al*., 2008). The SLA and SPADchlorophyll meter readings (SCMR) are quite useful, among the surrogate non-destructive traits as indirect selection tools for drought tolerance (Upadhyay, 2005; Nigam, 2008).

As majority of the peanut growing area belongs to semi-arid environment, information is required in making strategies for improvement of drought tolerant cultivars with high yield. In India, now there are more than 190 released peanut cultivars, but there are 50-60 cultivars at the most in seed chain. There is hardly any consolidated report of testing all of these cultivars for drought tolerance under rain-fed condition together.Plant’s response to drought are always dynamic in nature with respect to space, time, intensity of stress etc. Change in an organism’s phenotype triggered by such variationsis called phenotypic plasticity (Bradshaw, 1965).Many researchers have tried to assess the plasticity of

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different plant species under challenging environments and found that this inverse relationshipbetween tolerance and plasticity was fit for fitness-related traits but was trait-dependent for underlying traits (Couso and Fernandez, 2012).We tried to measure the plasticity of these genotypes through analysing the performance of 60 peanut cultivars during *kharif*season under both protected and natural drought (rain-fed) condition to find out the physiological parameters responsible for high yield and identification of cultivars with drought escape mechanism.

MATERIALS AND METHODS

Field experiment

A field experiment was conducted at the research farm of ICAR-Directorate of Groundnut Research, Junagadh, India, in a clayey calcareous vertisol soil having medium fertility in semi arid region of south Saurashtra. Sixty released peanut cultivars belonging to four different botanical groups (Table 1), comprising of 34 Spanish bunch (VUL), 16 Virginia bunch (HYP), 9 Virginia runners (HIR) and one Valencia (FST) were sown during *Kharif* season-2012 in a single row plot in screening blocks. The field was prepared and 40 kg N, 50 kg P and 50 kg K was applied in the soil as basal dose (Singh and Basu, 2005). All cultivars were sown in a 5 m row and having 45 x 10 cm spacing in three replications inJuly, 2012 under sufficient moisture conditions. In the control plots (P) protected irrigationwas provided whenever there was short fall in rain during the entire cropping season.On the other hand, in rain-fed plot (RF) crop was raised under natural condition without any irrigation. The crop was harvested at physiological maturity of respective botanical groups.

Drought spell and its intensities during cropping season

In the present study, the cropping season spanned between 28th and 47th standard meteorological weeks in year 2012 during which the mean maximum and minimum temperature were 33.2 $^{\circ}$C and 24.7°C, respectively, while mean relative humidity was 72.1% and total bright sun shine hours was 594 (Table 2). The total rainfall from sowing till harvest was only 229mm as against the total evaporation rate of 594 mm and there were, a total of three drought spells of various intensities observed during the entire cropping season in rain-fed crop. The crop faced the first drought spell of 10 days during 11 to 20 DAS with only 1.2% rainfall against the evaporative demandof 34.9 mm, the second drought spell of 20 days during 21 to 40 DAS with 13% rainfall against the evaporative demandof 58.5 mm and the last drought spell of 40 to 60 day starting from 72 DAS to harvest where the crop has received only 2.0 mm rainfall which was 0.6% of evaporative demand.

Flowering and morphological parameters

The days to flower initiation, 50% flowering, and total flowers produced during first 10 days were recorded in each cultivar under both the conditions. At 70 DAS three plants from each cultivars and treatments were uprooted and plant height, number of leaves on main axis, number of pods and pegs,and dry biomass per plant was recorded. Keeping the base temperature uniformly at10ºC, the cumulative thermal time (CTT) expressed as θ (ºC d, number of degree-days above the base temperature) required for initiation of flowering (θ_{If}), 50% flowering (θ_{f50}) and maturity (θ_m) were calculated by summation of daily mean temp minus 10 (Vasudeva et al 1992).

SCMR, Leaf Area, Specific leaf area (SLA) and yield parameters

The SCMRwere recorded in the third fully expanded leaf facing sun from the top of the peanut plant at 70 DAS using SPAD-502 (Konika-Minolta,Japan)in each cultivar in triplicates. Twenty leaflets from third compound leaves were collected for measurement of leaf area, specific leaf area (SLA) and relative water content (RWC). Crop was harvested at maturity, dried in sun for a week and pod and haulm yields, HI and other post-harvest observation was recorded.

Statistical analysis

All the data were subjected to statistical analysis following Gomez and Gomez (1984). Linear correlation was worked out between various physiological parameters studied under protected and rain-fed conditions. One-way ANOVA was also carried out for both the treatments using DSTAAT software.

RESULTS

The drought caused initial plant death, delayed flowering and reduced leaf area, SLA, plant height, number of flowers and harvest index, but increased SCMR under rain-fed condition. Significant variation among cultivars was observed for various physiological parameters the details of which are discussed below.

Flowering

In peanut cultivars, the initiation of flowering started from19 to 28 DAS under protected condition with an average at 23 DAS, but under RF the average flower initiation time was 26 DAS i.e. delayed by 3 days (Table3). Accordingly, the 50% flowering time was attained in 28 DAS under P and 31 DAS in RF conditions which, corresponded to cumulative thermal time θ_f of 546 and 602 ºC d, respectively. Thus mean 50% flowering was also delayed by 3-4 days in RF condition.We found, 20 cultivars flowered within 26 days at θ_f of 506 ºC d under P conditions,whereas 21cultivars flowered within 30 days at θ_f of 565 ºC d in RF condition. Interestingly 14 cultivars were common under both the situations. The numbers of flowers produced from the day of 50% flowering to next 10 days showed very high variation among cultivars.It ranged from 19 (TPG 41) to 111 (HNG 69) flowers per plant under P and 10 (JAL 286) to 105 (BAU 13) under RF.

RWC, SCMR and SLA

The RWC, SCMR and SLAmeasured at 70 DAS showed significant variation within the cultivar as well as under different treatment conditions (Table 3). The mean RWC value of these cultivars was 95.6 (with a range of 92.3 to 97.1) under P conditions which decreased to 84.9 (with a range of 71.5 to 91.8) under RF condition. Interestingly, there were 35 cultivars showing >85 RWC under RF conditions. The mean SCMR value of these cultivars was 37.5 under P conditions which increased to 39.5 under RF. Seventeen cultivars under P and 24 cultivars in RF showed higher SCMR values of >40 and of these 10 cultivars were common under both the conditions (Table 5). The mean SLA was 185 and 147 cm^2g^{-1}under P and RF conditions, respectively. Among the cultivars highestSLA was observed in VRI 2 (293 cm^2g^{-1}) and lowest in ICGS 37 (135 cm^2g^{-1}) in P, however under RF the SLA was highest in Chico (210 cm^2g^{-1}) and lowest in Kadiri 9(112 cm^2g^{-1}). Twelve cultivars under P showed SLA values less than 160 cm^2g^{-1},while 24 cultivars showed SLA values less than 140 cm^2g^{-1}under RF condition indicating drought adaptive response in these cultivars (Table 5).

Plant height, number of leaves and pods

The morphological characters varied significantly with the treatment conditions (Table 4). Under protected condition mean plant height was 43.6 cm, which decreased to 39.8 cm under rain-fed condition.Similarly, theleaves on main axis was reduced from 16 to 14 under RF conditions (Table 3). Under protected condition the number of cultivars with a greater number of leaves on main axis was higher but, under RF there were equal no. of cultivars showing less and more leaves. On an average the cultivars GG 2, JGN 23, LNG 2, GG 7, GG 14, DRG 12 and TG 51 showed more leaves.

On an average there was 11.6 pods $plant^{-1}$in P and 14 in RF at 70 DAS and out of 60 cultivars, nine showed more number of pods under P condition and only seven under RF condition. The cultivars TPG 41, Gangapuri, DRG 14 and TLG 45 produced more number of pods. Five cultivars which showed more pods under P did not maintain same trend under RF. Interestingly, three cultivars SB IX, JGN 23 and Pratap Mungfali1 showed better response with more number of pods under RF.

Maturity period and observations at harvest

There was a considerable effect of drought on the overall maturity of the crop as a result the cultivars under RF condition took 112-132 days with a CTT of 2114-2420 ºC d to mature as against 113-119 days with 2130-2224 ºC d in protected condition. Interestingly, 33 cultivars matured within 112 days at 2114 ºC d under RF condition and 30 cultivars matured within 113 days at 2130 ºC d under P condition and more so 30 cultivars were common in both the condition indicating their adaptability and plasticity to drought.

There were significant differences in the mean pod yield of peanut under protected (1260 kg ha^{-1}) and RF (1130 kg ha^{-1}) conditions. Seventeen cultivars showed > 1450 kg ha^{-1} pod yield under P, however 16 cultivars showed > 1300 kg ha^{-1} pod yield under RF condition and of these nine were common in both the conditions (Table 5). Due to continuous drought there was death in plant under RF conditions, but no death under protected condition. As a result, the average number of pods $plant^{-1}$increased under RF condition due to thinning of plant population and it was 11.4 under P and 13.2 pods $plant^{-1}$in RF condition.There was drastic reduction in the haulm yield of peanut under RF (2860 kg ha^{-1}) as compared to the one under protected (3330 kg ha^{-1}) conditions. Fifteen cultivars showed >4000 kg ha^{-1}haulm yield under P, however under RF condition only 12 cultivars could produce> 3300 kg ha^{-1}haulm yield.

DISCUSSION

In the present agriculture, for efficient use of water our focus should be to raise water use efficient cultivars both under irrigated as well as rain-fed conditions (Codon *et al* 2004). Though traits conferring capacity of dehydration avoidance and tolerance are available, integrated traits expressing tolerance at organ level are more useful (Singh 2011, Singh et.al.2013). Selection based on genetics, yield and physiology is part of physiological genetic approach (Reddy *et al*., 2003, Singh et al 2010). Flowering in peanut starts at 20 DAS with effective flowering observed at 30 DAS (Singh 2011). But there is diversity in maturing pods due to extended flowering period and pod yield depends upon flower production (Singh,2004, 2011). In this study, significant variation among cultivars was found for most of the studied traits. Under rain-fed condition, there was delay inflowering due to inenough rainfallduring 11-19 DAS however; during 20-31 DAS there was scanty rainfall (~10 mm), which initiated flowering with production of a greater number of flowers $plant^{-1}day^{-1}$ on anaverage.In present study, though 50% flowering was observed at 25-34 DAS under protected (P) and 26-38 DAS under rain-fed (RF) condition, but the effective flowering was observed between 28-38 DAS under P and 31-40 DAS under RF. We identified this as the critical yield determining stage which should not face drought.

Screening based on various physiological and agronomical traits resulted in identification of cultivars possessing desirable traits. In general, the early flowering, high SCMR, pod yield and HI, and low SLA were identified as the desirable traits under both the conditions. The cultivars showing early flowering, high pod yield and high HI, high yield and

SCMR, highSCMR and low SLA and high pod yield and early maturity in both the treatments are listed in Table 6. Further, the cultivars with early flowering, high SCMR,low SLA, and high yield and HI showed the escape mechanism and were considered as highly suitable for rain-fed cultivation under drought situation however, the one showing *vice versa* physiological traits were mostsusceptible.Though several cultivars having desirable traits under both protected and rain-fed conditions were listed in Table 5, the cultivars JGN 23, SB XI, andGirnar 1 showed most of the desirable characters and hence can be of immense use as donor parents for rain-fed conditions.

Reduced SLA provides lesser surface area for harvesting photosynthetic light, a protective mechanism of the photosynthetic pigments under stress condition as plants are not able to utilize all the absorbed photons and the unutilized photons is diverted towards the non-photochemical quenching through heat generation. Also the reduced SLA provide a lesser leaf surface area in direct contact with the ambient air circulation which causes a loss of water from leaves. Wunna*et al* (2009) reported positive association between SLA and HI in drought condition.

In this study, we found SCMR as a highly useful trait in identification of cultivars for drought tolerance. Bootang et al. (2010) reportedthat physiological parameters SCMR and SLW gave higher contribution to biomass under drought than pod yield and the HI and number of mature pods contributed to high pod yield. However, in this study, we found SLA and HI were highly useful traits for identifying cultivars under natural drought events.

Here in this study, the rain-fed crop faced three distinctly different drought spells from 11-20 DAS, 21-40 DAS and 68 DAS to harvest which resulted in delayed flowering, and lesser flowers production in first 10 days and affected yield and yield attributes. Seventeen cultivars showed > 1450 kg ha^{-1} pod yield under P, however 16 cultivars showed > 1300 kg ha^{-1} pod yield under RF condition and of these nine cultivars were common in both the conditions indicating their plasticity to drought stress. Earlier Nautiyal, et al. (2002) reported early stage drought in peanut does not affect yield, biomass productionand nodule dry weight.On the contrary, end season drought, in various peanutcultivars,increased SCMR and SLW,but reduced biomass, pod yield and seed size without affectingthe HI and number of (Bootanget al., 2010).The mean HI in this study under both facing and RF treatment was similar.However, imposition of drought under rain-fed condition increasedSCMR, but decreased RWC, number of flowers and pods and yield. Recently,SCMR has been found a more pertinent trait than SLA in summer peanut under transient water deficit stress condition (Kalariya et al. 2015a).

Table 1. List of selected 60 peanut cultivars used in this study

S.N.	Cultivars	Habit group	Year of release	Area of adoption	Special characters
1	AK-159	VUL	2002	Maharashtra and Madhya pradesh (MP)	High oil content
2	Chico	VUL	--	--	Early maturity
3	DRG 12	VUL	1994	Andhra Pradesh(AP), Tamil Nadu(TN), Maharashtra,Karnataka	High yielding
4	DRG 1	VUL	--	--	--
5	GG 2	VUL	1983	Gujarat	Water use efficient
6	GG 20	HYB	1992	Gujarat	Large seeded with low aflatoxin contamination
7	GG 5	VUL	1999	Gujarat	Drought tolerant; leaflets stay green at maturity
8	GG 6	VUL	2003	Gujarat	Early maturity
9	GG 4	VUL	1993	Gujarat	High yielding and early maturity
10	GG 7	VUL	2001	Gujarat & southern Rajasthan	Early maturity
11	GG 8	VUL	2006	Northern Maharashtra and Madhya Pradesh	---
12	Girnar 1	VUL	1988	Western Maharashtra, T.N. and A.P.	Multiple diseasesresistant,early maturity
13	Girnar 3	VUL	2010	West Bengal (WB), Orissa, Manipur	---
14	GPBD 4	VUL	2004	Maharashtra, Karnataka, AP & TN	---
15	ICGS 37	VUL	1990	Gujarat, northern Maharashtra and MP	Tolerant to end-of-season drought; photo-period insensitive
16	ICGS44	VUL	1988	Gujarat, northern Maharashtra & MP	High seed protein (25%) content
17	ICGV 86590	VUL	1991	Peninsular India	Multiple diseases resistant
18	ICGV 91114	VUL	2007	AP	Early maturity
19	JAL 42	VUL	--	--	Early maturity
20	JGN 23	VUL	2009	Madhya Pradesh	Drought tolerant
21	JL 24	VUL	1978	Maharashtra	Early maturity

22	JL 286	VUL	2004	Maharashtra	Early maturity
23	Kadiri5	VUL	2005	AP	Drought tolerant
24	Kadiri9	VUL	2009	AP	Tolerant to early and late season drought
25	PratapMungfali1	VUL	2005	Rajasthan	Early
26	SB XI	VUL	1965	Maharashtra	Tolerant to *Aspergilusflavus* colonization
27	SG 99	VUL	2004	Punjab	---
28	TAG 24	VUL	1991	Maharashtra	Early maturity
29	TG 37A	VUL	2004	Gujarat, Rajasthan, Uttar Pradesh (UP), Orissa, W.B. Bihar and Assam	Possesses fresh seed dormancy (up to 15 days)
30	TG 51	VUL	2008	W.B., Orissa, Jharkhand and Assam	---
31	TLG 45	VUL	2004	Maharashtra	Large seeded
32	TMV 2	VUL	1940	Tamil Nadu, A.P. and Karnataka	Widely adapted
33	TPG-41	VUL	2004	All India	Large seeds, high O/L ratio, 25 day fresh seed dormancy
34	VRI 2	VUL	1989	Tamil Nadu	Tolerant to ELS, LLS & rust
35	CSMG 84-1	HYR	1992	Uttar Pradesh Rajasthan and Haryana	Variegated kernel colour
36	CSMG 9510	HYR	2005	U.P., Punjab, & northern Rajasthan	40-45 day fresh seed dormancy
37	DSG 1	HYR	1997	Karnataka	--
38	GG 11	HYR	1984	Gujarat	Resistant to rust
39	GG 16	HYR	2006	TN, AP, Kerala & southern Maharashtra	---
40	ICGV 88448*	HYR	--	--	Extra bold
41	M 13	HYR	1972	Punjab	Tolerant to leaf spots
42	M 335	HYR	1986	Punjab	Large seeded,Tolerant to ELS and LLS,
43	Somnath	HYR	1990	Gujarat and Rajasthan	Large seeded, early maturity,
44	AK 265	HYB	2007	Southern Maharashtra, Karnataka,AP, and TN	Drought tolerant
45	B 95	HYB	1993	Southern Maharashtra.	Large seeded, high yielding
46	BAU 13	HYB	1993	Bihar	Large seeded
47	CSMG 884	HYB	1999	UP, Punjab and Rajasthan	Large seeded, early maturity
48	DRG 17	HYB	1994	Rajasthan, Punjab, UP & Haryana	Tolerant to moisture stress
49	GG 14	HYB	2003	Northern Rajasthan, Punjab, Haryana & UP	
50	Girnar 2	HYB	2008	UP, Punjab, northern Rajasthan	Large seeded, stay green leaves at harvest
51	HNG 10	HYB	1998	Uttar Pradesh, Punjab, Rajasthan and Haryana	High yielding
52	HNG 69	HYB	2010	UP, Punjab and northern Rajasthan	High yielding
53	ICGS 5	HYB	1992	UP Rajasthan and Haryana	Drought tolerant
54	ICGS 76	HYB	1989	Southern Maharashtra and Karnataka	Resistant to ELS and LLS
55	ICGV 86031	HYB	--	--	Tolerant of iron chlorosis
56	ICGV 86325	HYB	1994	Southern Maharashtra,AP,Karnataka,Kerala, TN	High yielding
57	Kadiri 3	HYB	1978	AP	Clustered bearing
58	LGN 2	HYB	2001	Gujarat & southern Rajasthan	High yielding
59	TKG 19A	VUL	1995	Konkan region of Maharashtra	Bold and HPS grade kernels
60	Gangapuri	FST	1971	Madhya Pradesh	Moderately resistant to foliar disease

***** The cultivars marked with are promising genotypes

Table 2. Weather parameters at various peanut crop growth stages at Junagadh, Gujarat India during the cropping season *Kharif* 2012

		Temperature (^{0}C)							
Growth Period	Crop growth stages	Max	Min	mean	RH(%)	BSS (h)	Evap (mm)	Rainfall (mm)	SMC at the end of the period
1-10 DAS (11-20 July)	Cracking, establishment and early vegetative growth	33.1	25.9	29.5	76.4	5.8	34.9	24.3 (69.6)	9.6%
11-20 DAS (21-30 July)	Vegetative growth	33.8	26.6	30.2	71.4	0.6	58.5	0.7 (1.2)	8.5%
21-40 DAS (31 July to 19 Aug)	Vegetative growth, flower initiation and peg initiation	32.7	25.8	29.2	76.5	1.8	76.3	9.9 (13.0)	7.5%
41 TO 67 DAS (20 Aug to16 Sept)	Flowering, Peg initiation to beginning seed	31.1	24.7	27.9	85.5	21.1	62.2	262.4 (422)	7.5%

68 TO 133 DAS (17 Sept to 20 Nov)	Beginning seed to full maturity and harvest	35.4	20.4	27.9	50.7	565.2	361.6	2.0 (0.6)	6.5%
Mean		33.2	24.7	28.9	72.1				
Total						595	594	299 (50)	

Where, RH is Relative humidity, BSS is Bright sun shine hours during the period and the figures in parenthesis indicate percent rainfall of evaporative demand.

Table 3. Mean, minimum and maximum and standard deviation (SD) values of various parameters studies in 60 peanut cultivars

	Days for flowering Initiation		Days to 50% flowering		Total flowers produced in first 10 days		RWC at 70DAS		SCMR at 70DAS		SLA at 70DAS	
	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF
Mean	23.2	26.3	27.7	31.2	61.7	57.3	95.6	84.9	37.5	39.5	185	147
Min	19.3	23	24.5	26	19	10	92.3	71.5	25.3	27.9	135	112
Max	28	32.5	34	37.7	111	105	97.1	91.8	44.4	50.4	293	210
SD	2.27	2.21	2.18	3	24.5	26	0.86	4.43	4.02	4.27	34	16
	Number of leaves on main axis		Plant height (cm)		Number of pods/plant		Pod yield kg ha^{-1}		Fodder yield (kg ha^{-1})		HI	
	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF
Mean	15.5	14.0	43.6	39.8	11.4	13.2	1260	1130	3330	2860	0.29	0.29
Min	13.0	11.0	30.8	28.1	7.9	7.4	530	390	930	1260	0.11	0.17
Max	18.7	17.2	56.4	55.3	18.4	18.1	2110	1700	6440	4520	0.41	0.42
SD	1.35	1.23	6.39	5.30	2.18	2.26	530	390	930	1260	0.11	0.17

Table 4. Analysis of variance among various physiological traits (Mean Sum Square values)

Effects	DF	Initiation of flowering (days)	50% flowering (days)	Total flowers	RWC (%)	SCMR	SLA
Treatment	1	872.7**	1123.6**	1690**	10223.9**	358.2**	130267**
Variety	59	26.2**	34.5**	3343.3**	29.9**	74.2**	3112**
Treatment x Variety	59	3.9**	6.8**	487.4**	31.4**	28.9**	1221**
Residual	240	2.3	3.6	0.6	3	9.6	78
Total	359						
Effects	**DF**	**No.of leaves on main axis**	**Plant Height**	**No. of pods/plant**	**Pod wt/plant**	**Foddrwt/plant**	**HI**
Treatment	1	210.8**	1336.9**	285.2	32.3*	162**	5.53391
Variety	59	7.6**	193.3**	21.9	21.8**	197.3**	0.01652**
Treatment x Variety	59	2.4**	13.5	7.7	5.7	23.1	0.00283*
Residual	240	1.5	12.2	7.1	5.5	19.3	0.00202
Total	359						

* and ** indicates significance at 0.05 and 0.01 level (P value<0.05, 0.01)

Table 5. Peanut cultivarswithdesirable physiological traits under rain-fed and protected conditions during *Kharif*2012

	Protected	**Rainfed**
Traits	**Desirable cultivars**	**Desirable cultivars**
Pod yield	ICGS 5, JGN 23, AK 265, GG 5, GG 11, GG 16, GG 20, Girnar 1, AK 159, ICGV 86325, CSMG 9510, HNG 10, M 13, BAU 13, JAL 42, SB XI, DSG 1 (>1450 kg ha^{-1})	ICGS 5, JGN 23, AK 265, GG 5, GG 6, GG 7, GG 11, GG 16, Girnar 1, Gangapuri, AK 159, SBXI, TMV 2, DRG 1, DRG 12, JL 286 (>1300 kg ha^{-1})
HI	TG 51, JAL 42, JGN 23, Girnar 1, SB XI, ICGS 44, GG 2, TAG 24, JL 286, JL 24, TG 37A, ICGS 5, DRG 1, HNG 10,	TG 51, JAL 42,JGN 23,Girnar 1,SB XI,ICGS 44, GG 2, TAG 24,JL 286,GG 5,GG 7, DRG 12,TLG 45,ICGS 37,

	(> 0.33)	DRG 1, Gangapuri,TMV 2 (> 0.33)
SCMR	GG 20, DRG 17, ICGV 86031, ICGS 37, ICGS 44, CSMG 9510, GG8, B 95, SG 99,Somnath, HNG 69,Kadiri 9, TMV 2, TLG 45, CSMG 884, BAU 13, Kadiri3 (>40)	TPG 41, SG 99, DRG 12, Kadiri 9, GG 7, ICGV 86325, LGN 2, ICGS 44, ICGV 86031, GG 11, DRG 17, ICGV 86590, JL 24, ICGS 5, ICGS 37, M 335, TG 37A, Kadiri 5, TKG 19A, GG 8, B 95, Somnath, CSMG 9510, GG 20 (>40)
SLA	ICGS 37, ICGV 86031, ICGV 86590, ICGV 88448, CSMG 884, Somnath, GG 11, M 13, ICGS 44,B 95, TPG41, ICGV 91114 (<160 cm^2g^{-1})	ICGS 37, ICGV 86031, ICGV 86590, ICGV 88448, CSMG 884, Somnath, GG 11, M 13, ICGS 44,TKG 19A, Girnar 2, Kadiri 9, DRG 12, CSMG 9510, DSG 1, TAG 24, DRG 17, SG 99, Girnar 3, HNG 10, M 335, GG 14, ICGV 86325, Pratapmungfali 1 (<141 cm^2g^{-1})
Early Flowering	JGN 23, GG 2, GG 4, GG 7, GG 8, Girnar 1, JL 24, JL 286, Kadiri 5, JAL 42, SB XI, AK 159, Gangapuri, TMV 2, Chico, DRG 1, TAG 24, ICGS 37, ICGV 91114, TKG 19A, (within 26 days at 506 C°D)	JGN 23, GG 2, GG 6, GG 7, GG 8, Girnar 1, JL 24, JL 286, Kadiri 5, JAL 42, SB XI, AK 159, Gangapuri, TMV 2, Chico, Pratapmungfali 1, GPBD 4, ICGS 5, TG 51, TLG 45, SG 99 (within 30 days at 565 C°D)
Early maturity	Chico,JGN23, GG 2, GG 4, GG 5, GG 6, GG7, GG8,Girnar 1, JL 24, JL 286, Gangapuri , TMV2, SB XI, AK 159, Pratapmungfali1, , ICGS 5, ICGS 37, ICGS 44, ICGV 91114, ICGV 86031,JAL 42, DRG 1, TAG 24, TG 37A, TPG41, TLG 45, TG51, VRI 2, Kadiri5, (within 113 days at 2130 C°D)	Chico, JGN23,GG 2, GG 4, GG 5, GG 6, GG7,GG8, Girnar 1, JL 24, JL 286,Gangapuri, TMV2, SB XI, AK 159, Pratapmungfali1, ICGS 5, ICGS 37, ICGS 44, ICGV 91114, ICGV 86031, JAL 42,DRG 1,TAG 24, TG 37A, TPG41,TLG 45, TG51, VRI 2, Kadiri5, GPBD 4, SG 99, (within 112 days at 2114 C°D)

Table 6. Yield trait wise classification of cultivars for drought tolerance

Trait and trait combinations	Treatment conditions	List of cultivars
High yield and HI and early flowering,	P	JGN23, Girnar 1, JAL 42, SB XI
	RF	JGN 23, GG 7, Girnar 1, SB XI, JL 286, GG 11, Gangapuri, TMV 2
High yield and SCMR	P	GG 20, CSMG 9510, BAU13
	RF	ICGS 5
High SCMR and Low SLA	P	ICGV 86031, ICGS 37, ICGS 44, CSMG 884 B 95, Somnath
	RF	Kadiri 9, SG 99, ICGV 86031, ICGV 86325, ICGV 86590, Somnath, GG 11, M 335, TKG 19A, ICGS 37, CSMG 9510
High yield and early Maturity	P	ICGS 5, JGN 23, GG 5, AK 159, JAL 42, SB XI, Girnar 1,
	RF	ICGS 5, JGN 23,GG 5, GG 6,GG 7, Girnar 1, Gangapuri,AK 159,SBXI,TMV 2,DRG 1,JL 286
High yield and HI, and early flowering and maturity	P	JGN23, Girnar 1, JAL 42, SB XI
	RF	JGN23, Girnar 1, SB XI

*****P and RF are protected and Natural drought (rainfed) treatments, respectively.

CONCLUSION

Among the four botanical groups, Spanish bunch group was found best with desirable traits for rain-fed drought-prone condition. The cultivars likeICGS 5, JGN 23, AK 265, GG 5, GG 11, GG 16, Girnar 1, AK 159, SBXI showed > 1300 kg ha^{-1} pod yield under both the conditions and found suitable for rain-fed cultivation. Combination of high SCMR with low SLA, high HI and low SLA, high yield and HI and early flowering behaviour are required for high physiological plasticity for drought tolerance and hence are ideal for both protected and rain-fed cultivation. Cultivars screened for natural drought are of immense use in the areas where drought is occurs often in semi-arid regions of the world. The study concludes that the cultivars with early flowering, high SCMR,low SLA, high pod yield and HI along with early maturity traitpossess drought tolerance mechanism and were considered as highly suitable for rain-fed cultivation.Among different habit groups, Spanish bunchgroup was found more suitable.The cultivars *viz*. JGN 23, SB XI, and Girnar 1 showed most of the desirable characters indicating high physiological plasticity and hence can be of immense use for rain-fed cultivation.

ACKNOWLEDGMENT

The authors are grateful to the Indian Council of Agricultural Research and the Directorate ofGroundnut Research for funding the research work.

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