

## Variability in Groundnut Genotypes for Tolerance to Drought

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### Abstract

Groundnut (*Arachis hypogaea* L.) is one of the world's most important legumes, both in subsistence and commercial agriculture in arid and semi-arid regions of the world. Global warming, an increasing threat, is expected to increase the water scarcity in the environment, affecting plant growth and metabolism. Groundnut yield in rain-fed areas has been limited by drought stress because pod yield and other growth parameters have been severely affected. Twenty five groundnut genotypes including four local checks (B-4, Rajashri, Baidehi and Jayanti) were composed and an experiment was conducted during 2010 and 2011 at the National Oilseed Research Program (NORP), Nawalpur, Sarlahi, Nepal. The experiment was conducted in a randomized complete block design in three replications. The objective of the study was to determine the genetic variability in different groundnut genotypes to drought tolerance. The analysis of variance indicated highly significant differences for most of the plant characters. Remarkable levels of variability have existed among the groundnut varieties that are essential in groundnut improvement. The genotypes ICGV-99171, ICGV-98089, ICGV-97100, Baidehi, ICGV-00440 and B-4 were observed better for drought tolerance with high pod yield. It is suggested that these genotypes could be grown under regions of limited rainfall and may be used as parents in breeding programmes for developing drought tolerant groundnut cultivars.

**Key words:** groundnut, drought tolerance, root shoot ratio, SLA, SCMR

### Introduction

Groundnut (*Arachis hypogaea* L.) is an important legume crop both in subsistence and commercial agriculture in arid and semi-arid regions of the world (Izge *et al.* 2005). Groundnut yield in rain-fed areas has been limited by drought stress because the pod yield and other growth parameters have been severely affected (Pimratch *et al.* 2008, Nautiyal *et al.* 2002, Reddy *et al.* 2003, Nigam *et al.* 2005). Yield losses have been estimated to be 56-85% (Nageswara Rao *et al.* 1989), depending on crop growth stage when it was exposed to drought (Reddy *et al.* 2003), drought intensity and drought duration (Nautiyal *et al.* 2002, Nigam *et al.* 2005). Even in irrigated areas, groundnut is frequently exposed to drought because water supply is not sufficient. Frequent occurrence of drought is one of the limiting factors adversely affecting groundnut productivity, especially in rain fed areas.

Soil water deficits in the pegging and root zone decreases pod and seed growth rates by approximately 30% and decreases weight per seed from 563 to 428 mg. (Sexton *et al.* 1997). However, a large reduction in pod yield, and the reduction percentage also varies among peanut cultivars (Haris *et al.* 1988, Nageswara Rao *et al.* 1998).

The varieties should be able to provide higher yield under drought. Genetic variability for drought resistance has been reported in groundnut (Upadhyaya 2005, Songsri *et al.* 2009). However, breeding for drought resistance based on pod yield is lacking behind due to significant genotype and environment interactions (Wright *et al.* 1996).

In Nepal, groundnut is used as good quality cooking oil/vegetable ghee, confectionery and snacks and

generally grown in upland during monsoon season in 15000 ha merely on rain fed condition on river basin. Summer rainfall in southern Nepal has historically been very erratic, and long-term records suggest that while the average annual rainfall has remained relatively stable, rainfall during the peanut growing season has declined over the past decade. Four varieties of groundnut B-4, Janak, Jyoti and Jayanti have been released for general cultivation. Their successful production has been drastically affected by a number of problems such as the erratic rainfall as well as long time water stress in mid season (NORP/ NARC 2008).

Tailoring groundnut varieties with tolerance to drought and efficient in water use offers the best long term and cost effective solution to encounter the uncertainty of monsoon and shrinking availability of irrigation water in country. The use of drought-resistant varieties is an important strategy to combat the drought problem. Rapid progress in drought resistance breeding has been achieved based on characters like harvest index (HI), water use efficiency (WUE), specific leaf area (SLA) and SPAD chlorophyll meter reading (SCMR) (Nigam *et al.* 2005). The SLA and SCMR have been found to be highly correlated with WUE (Nageswara Rao *et al.* 2001, Sheshshayee *et al.* 2005) have been used as surrogate traits for WUE (Nigam *et al.* 2005, Lal *et al.* 2006, Sheshshayee *et al.* 2006, Arunyanark *et al.* 2008, Jongrungklang *et al.* 2008, Pimratch *et al.* 2008). Root systems also play a crucial role in determining shoot water status and therefore effective water uptake is an important determinant of drought resistance (Kashiwagi *et al.* 2006). Larger root systems and deep growth of root systems into lower soil profile can take up more water to support plant growth and yield (Ludlow & Muchow 1990, Turner *et al.* 2001). Genetic variations for root characters have been found among groundnut genotypes (Ketring 1984).

The progress in breeding for drought resistance in peanut based on pod yield has been slow because of high genetic and environment interactions (Wright *et al.* 1996). The use of surrogate traits related to drought resistance has been suggested by many authors (Nageswara Rao *et al.* 2001, Nigam *et al.* 2005) as the inheritance of these characters must be simpler than pod yield. The information on the heritability and the relationships among the characters is important for plant breeders to formulate appropriate breeding

strategies to achieve breeding goals. The aims of this study were to understand whether heritability estimates for characters under investigation were sufficient for further improvement of these characters and to explore whether physiological characters and other drought related characters could be used as surrogate traits for pod yield under drought condition.

The objective of the study was to determine the genetic variability in different groundnut genotypes to drought tolerance and its component traits so that it would be possible to identify the trait based drought tolerance genotypes for drought prone groundnut area and future groundnut improvement programme.

## Methodology

The experiment was conducted at the experimental farm of the National Oilseed Research Program (NORP), Nawalpur, Sarlahi district, Nepal during rainy season in year 2010 and 2011. The area lies in the central Tarai with high potential for groundnut crop. The area lies between 85° 35' 52" east longitude and 27° 03' 86" north latitude. Average altitude of the district is 144 masl. Average maximum annual temperature ranged from 38 to 40°C and the minimum temperature ranged from 4 to 5°C. Average annual rainfall was about 1200 to 1500 mm. Soil of the experimental plot was sandy loam in texture with pH of 5.5 in the area. The climate was subtropical in average. It was dry with moderate temperature during vegetative and flowering stage and low rain at flowering stage with low temperature at late flowering and maturity stage of the crop. Twenty five genotypes included from NORP and ICRISAT including local check varieties (B-4, Rajashri, Baidehi and Jayanti) were used to study the different genetic variability parameters. The tested genotypes were confectionary type, tolerant to drought lines developed from ICRISAT including some of the recommended early and late varieties of Nepal. The experimental plots were prepared properly and were fertilized @ 20:40:20 Kg NPK ha<sup>-1</sup> basally.

The experiment was laid out in a randomized complete block design (RCBD) in three replications (Fig 3). The plot size was 5.0 X 1.2 m<sup>2</sup> with space of 25 cm. The distance between rows and plants was 30 and 15 cm respectively. On the other hand plot to plot and replication to replication distance was 0.5 and 1.0 m respectively. Seeds of genetic materials were sown on 1<sup>st</sup> week of July, in 2010 and 2<sup>nd</sup> week of July in 2011.

Seeds were sown in furrow at the depth of 4 cm approximately. Two weeding were done at 15 and 28 days after seeding. No irrigation was applied during total period of the experiment. The half part of each plot in every replication was covered with the 300 gauge plastic tunnel of bamboo stick to restrict the rain water completely at 28 to 75 days after seeding (DAS) called as water stress condition. After 80 DAS, plastic tunnel was uncovered to let rain water. The remaining half part of each plot was left to let rain called as normal condition.

SPAD SCMR and SLA were recorded at 8.00-9.00 a.m at 70 days after sowing. The second to third leaves from the top of the main stem of each plant was detached and kept in plastic bags in an ice box. The leaf samples were soon transported to a laboratory and fresh weight was recorded. SCMR was measured immediately by a Minolta handheld portable SCMR meter (SPAD- 502 Minolta, Tokyo, Japan), using four leaflets per sample. In recording the SCMR, care was taken to ensure that the SPAD meter sensor fully covered the leaf lamina and the interference from veins and midribs could be avoided. The same samples were further measured for leaf area, using a leaf area meter (LI 3100C Area meter, LICOR Inc., USA). The SLA was calculated using the following equation (Nageswara Rao *et al.* 2001):

$$\text{Specific leaf area (SLA)} = \frac{\text{Area of the leaves}}{\text{Weight of the leaves}}$$

The length of the root from surface to root tips and length of the shoot were measured. Then it was calculated in ratio as formula given below:

$$\text{Roots} = \frac{\text{Length of the root}}{\text{Length of the shoot}}$$

**Table 1. Analysis of variance (ANOVA) showing mean squares for yield components and drought related traits in groundnut genotypes during water stress conditions.**

Source of variation	Replication df=2	Treatments df=24	Error df=48	F value
Pod per plant (No)	376.17	45.11**	36.06	1.37
100 kernel wt.(g)	57.95	162.78*	48.43	5.17
Shelling %	42.05	103.45**	59.22	0.66
Pod yield (kg/ha)	149867.50	160014.77*	183820.40	1.11
Haulm yield (t/ha)	18.00	97.00**	23.47	0.07
Root shoot ratio	0.11	0.024**	0.020	1.18
SLA	1253.70	1855.84**	903.83	1.82
SCMR	57.91	26.03**	20.73	1.03
Drought score	98361655.32	14259898.88**	9167924.50	1.43

\* and \*\*= Significant at 5% probability level and highly significant at 1% probability level respectively.

Drought scoring was recorded by following the scoring system: Normal leaf-1, Some of the plant leaves turn back-2, Total plant leaves turn back-3, Whole leaves of the plot turn back-4 and Total plant destroyed-5.

The shelling percentage was calculated by using the following formula:

$$\text{Shelling \%} = \frac{\text{Net kernel weight (pod weight-shell weight)}}{\text{Total pod weight}} \times 100$$

The 100 kernel weights were calculated by randomly selected 100 kernels from each plot.

The data were subjected to analysis of variance (ANOVA) using SPSS software and the means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of probability according to Duncan (1955). The coefficient of variability were calculated by a formula suggested by Burton (1952).

## Results and Discussion

Characters taken for the study are major indicators of pod yield and kernel yield of groundnut. The ANOVA indicating the sources of variation and mean squares for the yield and yield component traits among the groundnut genotypes are presented in Table 1. The result indicated highly significant variation among the genotypes for the traits; pod per plant, shelling%, haulm yield, root and shoot ratio, SLA, SCMR and drought score, and significant difference was observed for 100 kernel weight and pod yield ha<sup>-1</sup>. These results indicated that the genotypes varied for the traits. The findings are similar to some of the early workers Branch & Kvien 1992, Hamidou *et al.* 2012).

**Table 2 (a). Performance of different traits under water stress and normal rain fed condition during 2010-2011 in 25 groundnut genotypes**

Genotype	Pod/plant(no)		100 kernel weight(g)		Shelling (%)		Pod yield (kg/ha)	
	Water stress	Normal	Water stress	Normal	Water stress	Normal	Water stress	Normal
ICGV-99171	18.9	23.8	38.9	40.2	54.9	72.2	1293.9	2614.4
ICGV-97100	18.8	21.8	31.1	35.9	62.5	77.6	1030.0	2681.1
Rajashri	15.6	20.8	37.5	41.5	65.8	68.0	995.0	2200.5
ICGV-98088	18.9	22.7	35.8	39.6	64.4	66.9	877.8	1669.4
B-4	14.5	16.7	35.1	39.2	69.4	73.9	610.0	1610.5
ICGV-97098	15.8	23.6	35.0	33.7	55.2	77.2	718.3	1572.2
ICGV-97093	15.0	17.6	32.7	40.9	77.2	65.0	521.7	1696.1
ICGV-980100	16.8	19.3	33.9	37.1	61.3	66.5	553.3	1930.6
ICGV-91104	15.2	18.3	46.9	58.1	60.2	69.7	786.7	2172.8
ICGV-86124	15.4	17.1	42.5	44.2	71.2	70.6	1032.2	1899.4
ICGV-91058	17.7	16.5	38.0	51.4	70.7	71.6	894.4	2364.4
ICGV-91114	16.1	21.9	40.4	38.6	70.3	74.4	864.4	2010.0
Jyanti	20.8	20.1	34.8	38.7	67.4	73.0	867.2	2261.7
ICGV-98089	18.4	22.8	34.3	36.8	63.4	70.9	1023.3	2106.1
ICGV-92173	22.3	25.4	33.7	36.1	67.2	66.7	756.1	2603.3
ICGV-88473	18.3	18.9	43.1	56.4	60.8	73.0	968.3	2311.1
ICGV-97087	19.6	23.7	29.7	39.1	63.7	64.0	670.0	1278.3
ICGV-86339	16.4	19.4	34.3	36.0	71.1	76.6	1031.7	1979.4
Baidehi	14.9	18.2	39.1	38.6	77.2	75.9	1050.6	2241.1
ICGV-91074	14.5	20.7	43.4	54.2	63.4	68.8	896.1	2498.9
ICGV-97243	15.9	21.0	27.6	35.9	68.9	69.2	499.4	1320.0
ICGV-00350	14.7	23.9	30.8	35.3	65.5	72.7	1076.1	2630.6
ICGV-95017	23.1	28.2	31.0	33.0	68.9	69.1	640.0	1780.6
ICGV-95005	21.4	29.2	29.1	31.9	63.7	73.0	443.3	1601.1
ICGV-00440	15.8	21.2	47.9	60.2	61.7	72.3	952.8	2605.5
$\bar{X}$	17.38	21.25	36.27	41.31	65.39	71.14	842.41	987.86
CV%	31.77	32.7	18.83	15.96	11.75	11.0	38.03	30.02

The results are in agreement with the results obtained by Nath and Alam (2002), who found highly significant variation among the genotypes for the characters, pods plant<sup>-1</sup>, 100 seed weight, shelling % and pod yield plot<sup>-1</sup>. The similar results were found by Upadhyaya *et al.* (2011) for SCMR and SLA and Thakur *et al.* (2011) for root and shoot ratio, SLA and SCMR. Vadez *et al.* (2011) also found significant difference for the root and shoot ratio.

The mean performance values for the groundnut genotypes in all the characters studied in year 2010 and 2011 under water stress and normal conditions are presented in Table 2 (a & b). The results indicated that ICGV-95017, ICGV-92173 and ICGV-95005 recorded highest pods per plant (23.1, 22.3 and 21.4), respectively in water stress condition. However, the lowest pods were observed in B-4, ICGV-91074, ICGV-00350 and Baidehi with 14.5, 14.5, 14.7 and 14.9 respectively. ICGV-95005 and ICGV-92173 had also the highest pods per plant under normal condition.

**Table 2 (b). Performance of different traits under water stress and normal rain fed condition during 2010-2011 in 25 groundnut genotypes**

Genotype	Haulm wt (t/ha)		Root shoot ratio		SLA		SCMR		Drought score (1-5 scale)
	Water stress	Normal	Water stress	Normal	Water stress	Normal	Water stress	Normal	
ICGV-99171	7.4	13.9	0.54	0.66	96.9	95.3	38.1	39.3	2.0
ICGV-97100	8.9	11.1	0.37	0.62	77.3	80.8	34.1	39.1	2.7
Rajashri	12.7	13.0	0.46	0.58	94.8	81.3	35.2	43.0	2.0
ICGV-98088	12.9	11.3	0.38	0.53	139.6	152.7	38.0	40.1	2.3
B-4	11.7	15.3	0.42	0.59	89.5	90.1	36.7	39.7	2.3
ICGV-97098	11.6	9.5	0.41	0.54	105.5	111.9	37.7	37.1	3.0
ICGV-97093	9.6	13.3	0.38	0.56	132.2	122.5	33.1	37.7	2.3
ICGV-980100	9.2	11.9	0.54	0.64	111.2	97.5	40.3	40.8	2.3
ICGV-91104	13.1	16.7	0.33	0.51	122.7	115.6	35.3	35.9	2.0
ICGV-86124	7.9	9.9	0.37	0.51	125.1	111.6	36.3	37.6	2.3
ICGV-91058	13.4	14.9	0.42	0.49	125.9	132.0	33.8	36.4	1.7
ICGV-91114	9.7	12.1	0.40	0.48	140.7	133.4	35.2	32.3	2.7
Jyanti	8.4	8.8	0.45	0.57	156.8	108.5	33.2	38.9	2.7
ICGV-98089	11.8	14.0	0.51	0.63	96.9	88.3	38.4	42.9	1.7
ICGV-92173	8.4	16.0	0.71	0.51	108.1	92.1	37.9	40.0	2.3
ICGV-88473	11.0	14.3	0.42	0.54	112.2	99.6	38.0	36.4	1.7
ICGV-97087	9.6	12.0	0.34	0.60	131.1	119.3	37.6	37.9	2.3
ICGV-86339	11.2	9.6	0.34	0.52	117.6	167.1	37.0	38.7	2.0
Baidehi	6.4	10.5	0.56	0.58	141.2	137.2	36.6	37.3	2.3
ICGV-91074	9.0	14.7	0.60	0.52	118.0	117.6	34.6	39.3	2.0
ICGV-97243	10.0	12.7	0.40	0.45	131.9	138.3	35.2	37.8	2.0
ICGV-00350	12.7	11.5	0.42	0.49	125.3	127.8	33.6	36.9	2.3
ICGV-95017	9.0	9.9	0.43	0.66	157.6	131.8	38.0	41.1	2.3
ICGV-95005	11.3	10.8	0.38	0.53	113.9	134.6	36.4	39.6	2.7
ICGV-00440	8.6	13.4	0.55	0.65	114.4	98.5	41.5	39.5	2.0
̄X	10.2	12.4	0.433	0.56	120.46	115.4	36.47	38.62	2.2
CV%	32.46	24.3	32.47	27.9	25.39	26.68	12.37	11.0	22.0

The genotypes, ICGV-00440, ICGV-91104, ICGV-91074 and ICGV-88473 recorded the highest 100 kernel weight of 47.9, 46.9, 43.4 and 43.1 g respectively, while the genotypes ICGV-97243, had the lowest 100 kernel

weight of 27.6 g under water stress condition. Genotypes ICGV-00440 and ICGV-91104 had the highest 100 kernel weight of 60.2 and 58 g under normal condition. The differences in variation in water stress

and normal condition in 100 kernel weight could be due to the high phosphorelation, corboxilation and photosynthesis in normal or having water. Under water stress, pegging and seed set responses of various peanut cultivars varied substantially as reported by Haris *et al.* (1988), Nageswara Rao *et al.* (1998).

The results also showed that significant differences were observed among groundnut varieties in shelling %. ICGV-97093, Baidehi and ICGV-86124 showed the highest shelling % of 77.2, 77.2 and 71.2 % respectively. The lowest shelling % was observed in ICGV-99171(54.9%) under water stress. The genotype ICGV-97100 and Baidehi had the highest shelling % with 77.6 and 75.9% under normal condition. This is also due to similar reason of high water use efficiency and photosynthesis.

The highest haulm yield was produced by ICGV-91058 and ICGV-91104 with 13.4 and 13.1 t ha<sup>-1</sup> respectively. The lowest haulm weight of 6.4mt/ha was produced by Baidehi under water stress condition. Similarly, the highest haulm yield of 16.7, 16.1 and 15.3 t ha<sup>-1</sup> was observed in ICGV-91104 and ICGV-92173 and B-4 respectively (Fig 1).

The highest pod yield per hectare was observed in genotypes ICGV-99171, ICGV-00350, Baidehi, ICGV-00350, ICGV-86124 and ICGV-97100 with 1293.9, 1076.1, 1050.6, 1032.2 and 1030.0 kg ha<sup>-1</sup> respectively. The lowest pod yield per hectare was shown in genotypes ICGV-95005 with 443.3kg/ha under water stress. Under normal condition the highest pod yield was observed in ICGV-97100(2681.1), ICGV-00350(2630.6) and ICGV-99171(2614.4).

The drought tolerance parameter, root to shoot ratio was significantly different among the investigated genotypes. The highest root to shoot ratio was recorded in ICGV-92173 with 0.70 and followed by ICGV-91074 (0.59), Baidehi (0.55), ICGV-00440 (0.55), ICGV-99171 (0.54) and ICGV-980100 (0.53) in water stress. The lowest root to shoot ratio was observed in ICGV-91104 (0.33). However, the highest root shoot ratio was recorded in ICGV-99171 (0.66), ICGV-95017 (0.66) and ICGV-00440 (0.65) under normal condition. Similar finding was obtained by Thakur *et al.* (2011) for ICGV-980100 with higher root shoot ratio. The genotype exhibiting deeper root has more capacity of water absorption from deeper layer of soil in water deficit situation.

The physiological parameter for drought tolerance of groundnut genotypes differed much in SLA value in water stress and normal condition. SLA was negatively correlated with water use efficiency in turn pod yield (Basu and Nautiyal 2004). The result indicated that the highest SLA was observed in ICGV-95017, Jyanti, Baidehi, ICGV-91114 and ICGV-98088 with 156.8, 141.2, 140.7 and 139.6 respectively. These genotypes were found having thinner leaves and low water use efficiency. However, the lowest level of SLA was observed in ICGV-97100, B-4, Rajshree, ICGV-98089 and ICGV-99171 with 77.3, 89.5, 94.80, 96.86 and 96.93 respectively in water stress. Similarly, the ICGV-97100, B-4, Rajshree, ICGV-98089 and ICGV-99171 genotypes showed lower SLA in normal condition, have advantage in drought condition. Rao and Wright (2006) also observed that low SLA and high SCMR and high harvest index have advantage under drought condition. Similarly, Basu and Nautyal (2004) conferred that low SLA types are capable of retaining more water in the leaves under water stress situation than high SLA genotypes.

On the other hand the SCMR value also differed among the genotypes studied. The highest SCMR value was recorded in ICGV-00440 (41.5), ICGV-980100 (40.3) and ICGV-98089 (38.4). These genotypes were more water efficient under water deficit situation due to more chlorophyll density. Painawadee *et al.* (2009) and Arunyanark *et al.* (2008 and 2009) reported that SCMR was positively closely related with chlorophyll density and it is an indicator of the photo-synthetically active light-transmittance characteristics of the leaf (Richardson *et al.* 2002).

The lowest SCMR was recorded in ICGV-97093 with 33.1 under water stress. However, Rajashri, ICGV-98089 and ICGV-95017 recorded the highest SCMR of 43.0, 42.9 and 41.1 respectively under normal condition. This result is in agreement with finding of Rao and Wright (2006) indicating higher SCMR related to higher water use efficiency.

Based on physical observation of the drought score ICGV-97098, ICGV-97100, ICGV-91114, ICGV-95005 and Jyanti showed the highest level of incidence to drought with 3.0, 2.7, 2.7 and 2.7 respectively under water stress condition. However, the genotype ICGV-88473, ICGV-98089, and ICGV-91058 showed highest level of

tolerance to drought with 1.7 score to drought. These genotypes may be used as the parent material in breeding program for drought tolerance of groundnut.

ICGV-99171 was found having highest yield, higher shelling % , highest level of root shoot ratio (0.54), lower SLA (96.9), highest level of SCMR (38.11) and low level of reaction to drought (2.0) under water stress. The genotype ICGV-98089 had high yielding; high root and shoot ratio (0.50) and SCMR (38.41), and the lowest drought score and lower SLA of 96.867 indicating the highest tolerance to drought. Among the recommended high yielding variety Baidehi showed the highest root shoot ratio ( 0.55), SLA of 141.22, moderate SCMR of 36.60 and comparatively low incidence to drought (2.3). The moderate yielding ICGV-00440 had high root shoot ratio (0.55) and SCMR (41.54) and moderate SLA (114.41) and low score to drought (2.0). However, ICGV-95017 showed low yield but moderate root shoot ratio, highest pod per plant (23.13), SLA of 157.65 and SCMR of 38.01 and with moderate level of drought tolerance. The variety ICGV-980100 recorded low yield but high shelling%.

However, it showed the highest root shoot ratio (0.53), SCMR of 40.33 and moderate SLA (111.22) and moderate score to drought (2.3).

ICGV-91114 showed the medium SLA, medium SCMR, medium root shoot ratio and low drought score with medium pod yield and haulm yield. This finding is in agreement with ICRISAT report (2012) that ICGV-91114 resists drought and disease, and has good fodder quality and high shelling turnover of 75%. Similar result was observed by Upadhyya *et al.* (2011) showing high SLA and SCMR genotype had highest yield. Basu and Nautiyal (2004) also recorded that low SLA and high SCMR genotype had high WUE exhibiting direct indication of drought tolerance.

The genotypes ICGV-99171, Baidehi, ICGV-98089, ICGV-00440, ICGV-980100 and ICGV-91114 are termed as drought tolerant genotypes, as drought tolerance has been defined as the ability of one genotype to be more productive with a given amount of soil moisture than another genotype (Quizenberry 1982).

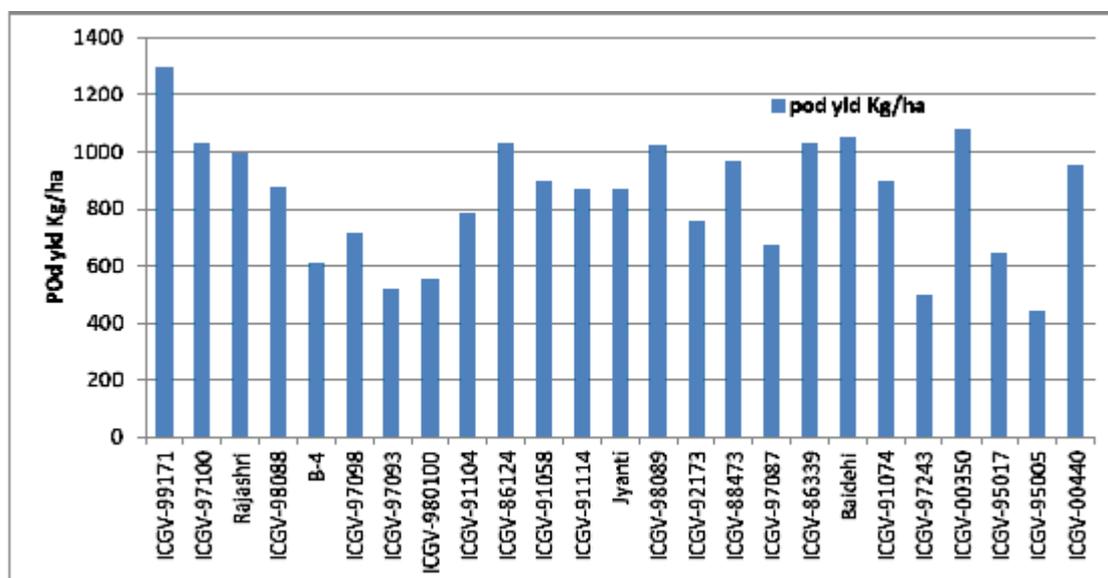


Fig. 1. Average pod yield (kg ha<sup>-1</sup>) of various groundnut genotypes under water stress condition during 2010 and 2011

Thus, the remarkable level of variability existing among the groundnut genotypes studied indicated a positive step for their improvement (Fig.2). The presence of genetic variability in crop plants have been described

as essential in plant breeding by Falconer (1989) and Izege *et al.* (2005). Genetic variability encourages selection, because selection on its own does not create variability.

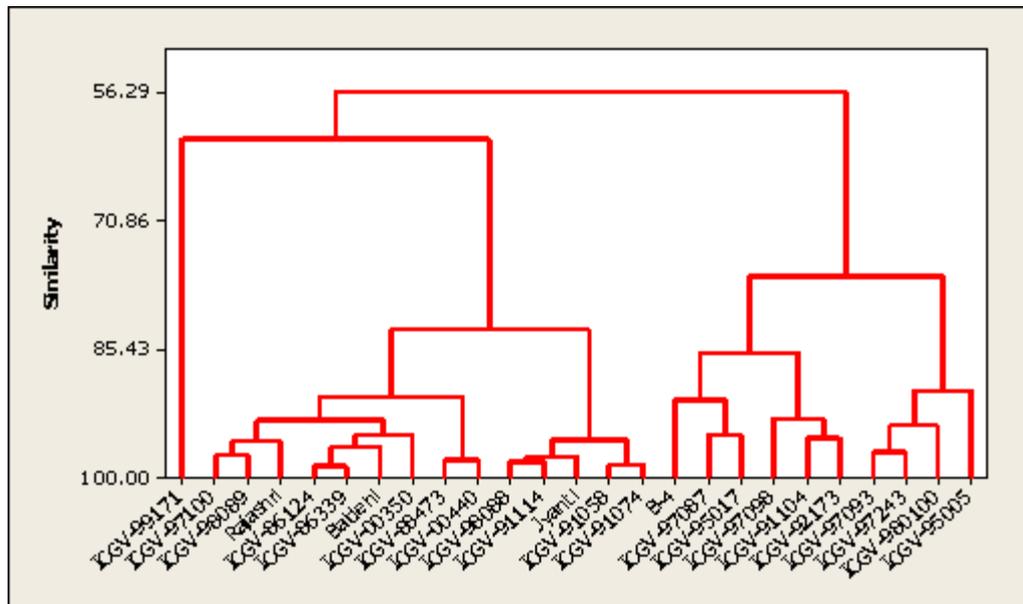


Fig. 2. Dendrogram exhibiting the clusters of groundnut genotypes reaction to drought tolerance and yield component traits

Most of the indicators used in the study were significant among the genotypes. The results indicated that the genotypes ICGV-99171, ICGV-98089, ICGV-97100, Baidehi, ICGV-00440, and B-4 showed tolerance to drought related traits and pod yield traits. Hence, it is suggested that these genotypes could be grown under regions of limited rainfall and adverse situation of climate change in future. These lines may be used as source of parents in breeding programmes for developing drought tolerant cultivars. This will be an advantage to semiarid groundnut farmers. Further study is required on drought resistance for groundnut improvement.

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