# GENOTYPIC RESPONSE TO DROUGHT STRESS IN GROUNDNUT ( *Arachis hypogaea* L. )


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**SEPTEMBER, 2000**

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*Thesis submitted to the University of Agricultural Sciences, Dharwad in partial fulfillment of the requirement for the*

***Degree of***

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**in**

**GENETICS AND PLANT BREEDING**

By

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# Certificate

This is to certify that the thesis entitled **"GENOTYPIC RESPONSE TO DROUGHT STRESS IN GROUNDNUT** (*Arachis hypogaea* L.)" submitted by **Miss SUVARNA** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **GENETICS AND PLANT BREEDING**, the University of Agricultural Sciences, Dharwad, is a record of research work done by her during the period of her study in this university under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

**RAICHUR**
**September, 2000**

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3: **(M.K. NAIK)**

AFFECTIONATELY
DEDICATED
TO
MY PARENTS

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Suvarna

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# INTRODUCTION

# I INTRODUCTION

Groundnut (*Arachis hypogaea* L) is one of the important oilseed and cash crops in India, which ranks the highest in groundnut production in the world During 1996-97, groundnut occupied an area of about 7 8 million ha in India with a production of 9 03 million tons contributing 29 14 % and 36 15% to the average area and production of total oilseeds respectively (Bandhopadhyaya *et al* 2000)

The present area and average productivity of rainy (*kharif*) season groundnut are 7 million ha and 900 kg/ha and those of the winter (rabi / summer) groundnut (low risk and high productivity crop) around 1 4 million ha and 1500 kg/ha respectively About 87 7% of groundnut area in India is sown in the *kharif* season and is rain fed and irrigated area is about 20% only In the semi-arid tropics about 80% of the world groundnut production comes from seasonally rainfed areas where the climate is characterized by low and erratic rainfall, which creates water deficit or drought condition This drought is recognized as one of the major constraints limiting groundnut productivity in these regions (Gibbons 1980)

Information on the response of different genotypes to various patterns of drought and exploitation of this variability is an important requirement for crop improvement in drought prone areas Several workers have investigated effects of drought on peanut at different stages of growth and drawn different conclusions (Boote *et al*, 1982, Golakiya and Patel, 1992 and Pathak *et al*, 1988) But the limited information is available on genotypic variability under different drought period and their interaction to genotype x environment

Many physiological features decide the tolerance to drought in groundnut like relative water content in leaf (Ketring, 1986), specific leaf area, which is the surrogate measure to water use efficiency (Wright *et al*, 1988, Wright *et al*, 1994), partitioning of dry matter to pods (Greenberg *et al*, 1992) and crop growth rate (Srinivasan *et al*, 1987) Existence of genotypic differences for physiological traits under drought condition may help in selection of genotypes tolerant to drought But the studies on this aspect are limited

The availability of genetic variation is a prerequisite for crop improvement There are many reports regarding the existence of genetic variations, heritability and genetic advance for different characters under natural conditions But the studies under drought conditions are lacking Association of yield with its components and some physiological parameters were reported by earlier workers But under drought condition reports are limited Keeping in view of all these situations, the present investigation was taken up at ICRISAT Patancheru with three drought regimes viz, control, mid-season and end-season droughts to evaluate the performance of nine released groundnut varieties and eleven advanced breeding lines The investigation was carried out with the following objectives

I To evaluate groundnut genotypes for drought tolerance

II To assess physiological basis of response to drought in groundnut genotypes

III To study the genetic variability, heritability and genetic advance for physiological parameters and yield, and its components under normal and drought conditions

IV To estimate the association of yield with its components and physiological parameters under normal and drought conditions

# REVIEW OF LITERATURE

# II REVIEW OF LITERATURE

In semi-arid environments, drought stress is considered as a major factor limiting yield in plants (Simpson, 1981). The yield losses due to drought ranged from 5-75% depending on time, intensity, and duration of drought during crop growth. The effect of stress on growth and yield parameters is through its effect on various physiological and developmental processes. A thorough understanding of effects of drought on physiology, growth, and yield is absolutely essential. Further, information on magnitude of variability and its genetic components for these characters and association of these characters with yield helps in improvement of drought tolerance in groundnut.

Hence, the literature, which focuses the attention on certain morphological and physiological traits related to yield, is reviewed here under.

## 2.1 Physiological traits in relation to drought resistance

### 2.1.1 Relative Leaf Water Content (RWC)

Leaf water status affects numerous physiological processes which contribute to plant growth and yield. The status of water in plants represents an integration of atmospheric demand, soil water potential, rooting density and distribution, and is therefore a true measure of drought stress in plants (Kramer, 1969). The water status of crop plant is usually defined in terms of its water content, water potential, or its components, osmotic and turgor potential (Turner, 1986).

Leaf relative water content has been successfully used to monitor water content and status in groundnuts (Bennett *et al.*, 1981 and Bennett *et al.*, 1984). Sinclair and Ludlow (1985) argued that RWC is a more useful integrator of plant water balance than leaf water potential and should provide universal relationships between physiological traits and level of drought stress.

RWC values in well-watered groundnuts are typically in the range of 85-98% (Bhagsari *et al*., 1976; Joshi *et al*., 1988; Bennett *et al*., 1981,1984 and Prabowo *et al*., 1990) Under drought conditions, RWC as low as 29% has been measured (Bhagsari *et al*., 1976) indicating that groundnut has a very low lethal water status. This attribute should contribute to high level of dehydration tolerance and leaf survival in groundnut during intermittent drought stress (Ludlow and Muchow, 1988), in a similar fashion to that reported for pigeon pea (Flower and Ludlow, 1986) and may be useful in breeding varieties for cultivation under semi-arid condition (Kimani *et al*., 1994). Ravindra *et al* (1990) reported significant reduction in RWC due to moisture stress at vegetative growth stage in four groundnut genotypes.

### 2.1.2 Specific leaf area (SLA)

Specific leaf area is a reflection of leaf thickness. It is defined as the ratio of leaf area to the leaf dry weight. Attempts have been made to correlate SLA with water use efficiency (W) and also with carbon isotope discrimination (Δ). W is one of the traits that can contribute to productivity when water resources are scarce, but it is difficult to measure. A significant negative correlation between Δ and W has been shown among peanut genotypes, suggesting that measurement of Δ can potentially be used to identify genotypes with greater W (Hubick *et al*., 1986; Wright *et al*., 1988 and Wright *et al*., 1994). However, Δ was positively and W was negatively correlated with SLA in peanut.

Rubisco content was negatively related with Δ, and in upper leaves positively and significantly correlated with leaf thickness. Genotype x leaf position interaction was significant for and Rubisco (Nageswara Rao *et al*. 1995), indicating the importance of leaf position in selecting for WUE, using leaf traits like leaf thickness in groundnut.

Differences in photosynthetic rates were positively correlated with leaf thickness in alfa alfa (Pearce *et al* 1989), soybean (Dornhoff and Shibles, 1976), oats (Criswell and Shibles, 1971) and chickpea (Gupta *et al* 1989), indicating that thicker leaves might have more photosynthetic machinery per unit leaf area.

SLA and Δ exhibited a strong positive relationship with harvest index in parents as well as F1 hybrid in peanut. The large additive gene effects and high heritability values for SLA and Δ suggest that selection may be effective for these characters in early generations (Jayalakshmi *et al*., 1999).

Recently, the SPAD Chlorophyll Meter has been widely used to non-destructively determine leaf nitrogen content in a number of crops including maize (Ma and Dwyer, 1997), barley (Araus *et al*., 1997) and tobacco (Mackown and Sutton, 1998). SLA and leaf nitrogen content per unit leaf area (SLN) were significantly and negatively correlated with Chlorophyll Meter (SPAD 502) readings (Nageswara Rao Rachapati *et al*., unpublished data) in groundnut genotypes, suggesting that SPAD can be used as an effective tool to assess leaf nitrogen content and hence photosynthetic capacity in groundnut genotypes. They also noticed the relative insensitivity of SPAD readings to environmental effects surrounding the leaf, indicating that SPAD could be used as a reliable and stable surrogate measure of SLA and SLN (Δ and hence TE) across environments. Similarly, Araus *et al*. (1997) had the same opinion of possibility of using it as a surrogate for assessment of Δ (and hence TE) in barley breeding.

### 2.1.3 Light Interception (LI)

Radiation interception (both in terms of space and time) is an important requirement for carbon assimilation during photosynthesis. It is well documented that the total dry matter produced is linearly related to the cumulative radiation intercepted.

Mathews *et al* (1988) observed that the four genotypes of groundnut involved in the study had intercepted the same amount of solar radiation but had produced different amounts of dry matter resulting in significant difference in the radiation use efficiency between genotypes particularly during the later parts of the growing season. Total accumulated radiation interception values reduced with decreasing soil moisture from 749 to 554 MJ $m^{-2}$ (Collinson *et al*, 1996). A linear relationship between WUE and RUE was observed under two different drought patterns (Wright *et al*. 1994).

In case of pigeonpea, Nam *et al* (1998) observed significant reduction in the cumulative intercepted photosynthetically active radiation (CIR). The relationship between the biomass accumulation and CIR was linear and water deficit affected the slope of the relationship (i.e. RUE). They also reported existence of genotypic differences for these traits under both natural and drought conditions.

Photosynthetically active radiation absorption and conversion use efficiency (CUE) at maturity could be used to evaluate variation among groundnut genotypes. (Gajjar *et al*, 1994).

### 2.1.4 Crop Growth Rate (CGR)

The crop growth rate in general is dependent on the amount and intensity of energy intercepted and the photosynthetic efficiency of the leaf or crop canopy. Stresses may operate to modify growth and development.

The crop growth rate was maximum under stress-free environment as against under stressed environment. Cultivars showed considerable differences in their CGR under both the conditions (Srinivasan *et al.*, 1987 and Greenberg *et al.*, 1992). CGR was ranged from 12-17 g $m^{-2}$ $day^{-1}$ under irrigation and 2-8 g $m^{-2}$ $day^{-1}$ in stressed crops (Nageswara Rao *et al.*, 1993).

### 2.1.5 Pod growth rate (PGR)

Pod growth rates are affected by moisture status in the soil. They varied from 6 to 8 g $m^{-2}$ $day^{-1}$ under irrigated condition and from 2 to 4 g $m^{-2}$ $day^{-1}$ under drought condition (Nageswara Rao *et al.*, 1993).

### 2.1.6 Partitioning of dry matter to pods (PDM)

Partitioning of dry matter to pods is the ratio of pod growth rate to the crop growth rate during filling of pods expressed in percentage. Existence of large variations for PDM among genotypes grown under irrigated or drought condition was reported in groundnut (Mathews, *et al.*, 1988; Nageswara Rao *et al.*, 1993 and Harris *et al.*, 1988), but the genotypic variation for PDM was much more predominant during recovery phase following release of mid-season drought condition (Nageswara Rao *et al.*, 1989). As pod yield potential of groundnut is determined by three attributes viz., crop growth rate, portioning and duration, Nageswara Rao *et al.* (1989) with single and multiple periods of drought during various crop growth phases reported that the majority of pod yield variations were associated with differences in PDM. Similarly Greenberg *et al.* (1992)

reported differences in the stability of PDM were the dominant attribute of genotypes adapted to the drought prone Sahelian region. In water-stressed condition during *kharif* season, JL 24 partitioned more of the total dry matter to pods than other five genotypes studied (Dhopte and Ramkete, 1994).

### 2.1.7 Harvest Index (HI)

Harvest index defined as the proportion of pod to total biomass can vary enormously depending on the timing and severity of water deficit relative to pod set (Ong, 1986).

It is an important physiological index that provides a useful measure of source to sink relationship (Donald, 1962). Improvement in harvest index reflects increased physiological activities leading to more efficient mobilization and translocation of photosynthates to the organs of economic importance. Chavan *et al.* (1992) reported highest harvest index in natural condition and 0.63-10.63% decreases in moisture stress condition in groundnut crop. The groundnut genotypes under drought conditions did not account for the major variation in the harvest index (Mathews *et al.*, 1988).

Sharma and Varshney (1995) reported high genetic variability, broad sense heritability and genetic advance (GA) in groundnut. Reddy and Gupta (1992) under three simulated environments namely entirely rainfed, rainfed but supplemented with protective irrigation and irrigated at ten day intervals reported high estimates of coefficients of variation and high heritability and GA in all the three environments. In chickpea, Jagannath *et al.*, (1999) reported higher phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), and GA in stressed condition than in irrigated and higher heritability in irrigated than stressed conditions.

## 2.2 Yield and yield components in relation to drought

### 2.2.1 Number of Immature Pods per Plant

Immature or undeveloped pods per plant were more in water stress during pod development stage (Patel and Golakiya, 1988 and Golakiya and Patel, 1992).

In a two-season study Lakshmaiah (1978) recorded wide differences between *kharif* and rabi seasons for the GCV (66.37% *Kharif* and 39.63% Rabi), PCV (79.53% *kharif* and 41.17% Rabi), heritability (69.57% *kharif* and 41.17% Rabi) and GA (1.38% *kharif* and 5.10% Rabi) in groundnut. Chaudhary (1993) observed high GCV, GA, and heritability in four groups of groundnut for unfilled pods.

### 2.2.2 Number of Mature Pods per Plant

Andani Gowda and Hegde (1986) reported that the number of mature pods per plant did not vary significantly between water-stressed and stress-free environments at 30-45 DAS in TMV 2. However, the pod number was more under stress-free environment and greatly reduced under the stress at pod development stage (Patel and Golakiya, 1988 and Golakiya and Patel, 1992).

Selection for more number of mature pods per plant would help in breeding productive cultivars in the Virginia runner group (Deshmukh *et al.*, 1987). Lakshmaiah (1978) recorded 15.29% and 40.09% GCV values, 26.22% and 41.81% PCV values, 34.00% and 91.94% heritability in *kharif* and rabi, respectively and reported lower GA value in *kharif* and a moderate in rabi.

Reddi *et al*. (1986) observed high heritability and GA in long duration varieties of Virginia bunch and runner under rainfed condition, but moderate to high heritability and high genotypic variance were observed by Singh (1998) during *kharif* season. Moderate heritability (Manoharan *et al*., 1993) and low heritability (Reddy *et al*., 1995) were also exhibited by this trait during *kharif* season. Reddy and Gupta (1992) in a variability study under three simulated environments namely, entirely rainfed, rainfed but supplemented with protective irrigation, and irrigated at ten days intervals reported high estimates of coefficients of variation and high heritability and GA in all the three environments.

### 2.2.3 Pod Yield

Pod yield was less in water-stress condition compared to the irrigated condition (Nageswara Rao *et al*., 1985; Chavan *et al*., 1992; Patel and Golakiya, 1988; Collinson *et al*., 1996; and Polara *et al*., 1984). Pod yield was significantly reduced during stress at pod development stage (Ravindra *et al*., 1990). There were no significant interactions for pod yield between genotype and irrigation treatment (Greenberg and Ndunguru, 1989), but significant differences for ten varieties were observed for pod yield (Del Rosario and Fajardo, 1988).

Chavan and Dhoble (1994) observed moderate heritability for this character under both water-stress and irrigated situations. Maximum PCV, GCV and fairly high heritability were reported by Ali *et al*. (1996) and Bansal *et al*. (1992) during *kharif* season. During same season high GA and heritability were observed by Hossain and Islam (1989), Reddy *et al*. (1987) and Singh (1998). High heritability was also reported by Kale and Dhoble (1998) during the same season, but Manoharan *et al*. (1993) reported low heritability during *kharif* season. In all the three simulated environments Reddy and Gupta (1992) reported high estimates of variation, heritability and GA.

### 2.2.4 Shelling Percentage

Shelling percentage was lesser under moisture-stress condition than that of under the normal condition. The reduction in shelling percentage was maximum in stress during pod development stage (Patel and Golakiya, 1988; Pathak *et al*., 1988 and Golakiya and Patel, 1992).

PCV was higher than GCV and heritability was high for this character (Reddy, 1994), suggesting a possibility of selection based on phenotypic expression. Low PCV, GCV, and heritability and low GA were exhibited for shelling percentage (Deshmukh *et al*., 1987; Manoharan *et al*., 1990 and Reddy 1994) during *kharif* season. Nadaf and Habib (1987) also reported similar results, but heritability was moderate. A high heritability combined with high GA during kharif season was reported by Reddy *et al*. (1987). Reddy and Gupta (1992) under all the three simulated environments in groundnut reported high heritability for this trait.

### 2.2.5 Hundred Kernel Weight

The seed weight was not affected if the moisture stress occurred in early growth stages (Andani Gowda and Hegde, 1986), but was reduced greatly under moisture-stress at pod development stage (Vanangamudi *et al*., 1987), and at seed development stage (Yao *et al*., 1982). Hundred kernel weight was greater in irrigated crop than in rainfed crop in *kharif* season (Padma and Subba Rao, 1992).

During *kharif* season, high PCV and GCV for this trait were reported in groundnut (Deshmukh *et al*., 1987 and Manoharan *et al*., 1990). A high heritability together with high GAM was reported during *kharif* season by Deshmukh *et al*., 1987, Manoharan and Ramalingam, 1993, Manoharan *et al.*, 1990 and Manoharan *et al.*, 1993 and Reddi *et al.*, 1991. This character exhibited high phenotypic and genotypic variability and heritability both under natural and drought conditions, but high GA under stress condition (Chavan and Dhoble, 1994). Reddy and Gupta (1992) reported high heritability under all the three simulated environments.

### 2.2.6 Sound Mature Kernel Percentage

Seed quality was most affected by the early season drought extended upto 70 day which significantly reduced peanut sound mature kernel and significantly increased percent other kernel (OK) and hulls (Pallas *et al.*, 1979).

Manoharan *et al.* (1990) reported lowest PCV, GCV, GAM and high heritability, but high heritability combined with high GA was reported by Reddy *et al* (1987), and Reddi *et al.* (1991) during *kharif* season.

### 2.2.7 Oil Content

Oil content in kernels was more in irrigated crop than in rainfed crop in *kharif* Season (Padma and Subbarao, 1992). But there were no significant differences in oil content under normal and drought conditions (30 DAS-45 DAS) (Andani Gowda and Hegde, 1986). Similar observations were reported in sunflower (Razi and Assad, 1999).

Deshmukh *et al.* (1987) in Virginia runner and Nadaf and Habib (1987) in erect bunch genotypes reported low GCV, PCV, heritability and GA during *kharif* season. During the same season, low GCV, low GAM, but high heritabillity were reported by Manoharan *et al.* (1993). High

Hoque *et al.* 1993) and fairly high heritability (Ali *et al.*, 1996) were observed for this character in groundnut during *kharif* season. In sunflower oil content showed considerable phenotypic and genotypic variations under drought and normal conditions (Razi and Assad, 1999).

## 2.3 Correlation studies

A knowledge of inter-relationship of physiological traits with yield and harvest index and among yield components is essential in order to improve the yield potential of any crop. This information helps the breeder in determining the selection procedures for exploiting the correlated responses to effect simultaneous improvement for various characters.

Scanning through the literature, it appears that so far no attempts have been made to work out the association between light interception, SLA, chlorophyll, and yield. However, there is a report on correlation between yield and RWC and HI.

Therefore, correlation studies of yield with its components, RWC and HI and were presented here.

### 2.3.1 Association of Pod Yield with Other Characters

Pod Yield was positively associated with number of mature pods during *kharif* season (Lakshmaiah, 1978; Badwal and Harbans Singh, 1973; Deshmukh *et al.*, 1986; Nagabhushanam, 1981; Reddi *et al.*, 1986 and Reddi *et al.*, 1991). Pod Yield was strongly correlated with shelling percentage (Badwal and Harbans Singh, 1973 and Reddi *et al.*, 1986) and sound mature kernel ppercentage (Reddi *et al.*, 1991) during *kharif* season.

Pod yield was positively correlated with 100 kernel weight during *kharif* season Badwal and Harbans Singh, 1973; Kataria, 1984 and Reddi *et al.*, 1986) and significantly orrelated with 100 kernel weight (Reddi *et al.*, 1986; Nagabushanam, 1981; Yadav *et al.*, 1984; )eshmukh, 1986; Rao, 1978 and Reddi *et al.*, 1991).

Pod yield was positively correlated with harvest index (Manoharan *et al.*, 1990). Chhonkar and Arvind Kumar (1987) observed significant and positive association between pod yield and CGR at 60-90 DAS, however at other stages of crop growth these parameters had negative relationship. Non significant and positive association of yield with CGR at 45-60 DAS and HI was reported (Edna Antony *et al.*, 2000). Ravindra *et al.* (1990) reported significant and positive association of pod yield with RWC.

Reddy and Gupta (1992) under all the three simulated environments reported significant and positive association of pod yield with number of mature pods, shelling out-turn and harvest index.

# MATERIAL AND METHODS

# III MATERIAL AND METHODS

The details of genotypes selected for the study, experimental design, conduct of experiment and statistical procedure followed in the present investigation are outlined as under

## 3.1 Experimental material

The material for the present study consisted of 20 genotypes of groundnut, which includes released cultivars and breeding lines viz , JL 24, TMV 2, S 206, KRG 1, TAG 24, K 134, R 8808, R 9251, R 9214, R 9227, D 39d, ICGVs 86031, 86635, 92113, 92118, 92120, 93260, 93261, 93269 and 93277 (The detailed information of genotypes are furnished in Table 1)

## 3.2 Field experiment

A field experiment was conducted at International Crops Research Institute for the Semi -arid Tropics (ICRISAT), Patancheru, A P , India ($17^{O}$ 32' N, $78^{O}$ 16' E) during the post rainy season (Dec 99- April 2000), on Alfisol The weather data for the year 1999 and 2000 are presented in Table 2

### 3.2.1 Experimental Design and Layout

The experiment was laid out in a strip plot design with 3 drought treatments and 20 genotypes Each treatment was replicated thrice The experiment was sown on 4th December 1999 with row to row spacing of 30cm and plant to plant 10cm The plot size was 4m x 1 2m A buffer

**Table :1 Characterstics of genotypes used in the study**

| | Genotype | Habit Type | Pedigree | Year of Release | Centre Developed |
|---|---|---|---|---|---|
| 1 | JL 24 | Spanish Bunch | Selection from EC94943 | 1978 | MPKV Jalgaon |
| 2 | TMV 2 | Spanish Bunch | Mass selection from Gudhiantham Bunch | 1940 | TNAU Tindivanam |
| 3 | S 206 | Spanish Bunch | Selection from Manvi Local | 1969 | RRS Raichur |
| 4 | KRG 1 | Spanish Bunch | Selection from Argentina variety | 1981 | RRS Raichur |
| 5 | TAG 24 | Spanish Bunch | TMS 1 X TGE 1 | 1978 | BARC Bombay |
| 6 | D 39d | Spanish Bunch | VG 101 X KRG 1 | a | UAS Dharwad |
| 7 | R 8808 (KRG-2) | Spanish Bunch | ICGS 11 X Chico | 1994 | RRS Raichur |
| 8 | R 9251 (KRG-3) | Spanish Bunch | JLM 1 X TG 23 | 1996 | RRS Raichur |
| 9 | R 9214 | Spanish Bunch | ICGS 7 X NCAC 2214 X ICGV 86031 | a | RRS Raichur |
| 10 | R 9227 | Spanish Bunch | ICGS 7 X NCAC 2214 X ICGV 86031 | a | RRS Raichur |
| 11 | K 134 | Spanish Bunch | Kadiri 3 X JL 24 | 1993 | APAU Kadiri |
| 12 | ICGV 86031 | Spanish Bunch | F 334A-B-14 X NC Ac 2214 | 1982 | ICRISAT Patancheru |
| 13 | ICGV 86635 | Spanish Bunch | NC Ac 2768 X NC Ac 17090 | a | ICRISAT Patancheru |
| 14 | ICGV 92113 | Spanish Bunch | ICG 1697 X ICG 4790 | a | ICRISAT Patancheru |
| 15 | ICGV 92118 | Spanish Bunch | ICGV 87340 X ICGS 11 | a | ICRISAT Patancheru |
| 16 | ICGV 92120 | Virginia Bunch | ICG 3736 X (TMV10 X Chico) | a | ICRISAT Patancheru |
| 17 | ICGV 93260 | Spanish Bunch | ICGS 11 X ICG 4728 | a | ICRISAT Patancheru |
| 18 | ICGV 93261 | Spanish Bunch | ICGS 11 X ICG 4728 | a | ICRISAT Patancheru |
| 19 | ICGV 93269 | Spanish Bunch | ICGS 11 X JL 24 | a | ICRISAT Patancheru |
| 20 | ICGV 93277 | Spanish Bunch | ICGV 87339 X Ah 7827 | a | ICRISAT Patancheru |

a = Genotypes are either improved germplasm or advanced breeding lines

**Table 2 : Monthly average weather data for the year 1999 and 2000 at ICRISAT, Patancheru**

| Month | Rainfall (mm) | | Temparature( °C) | | | |
|---|---|---|---|---|---|---|
| | | | Maximum | | Minimum | |
| | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 |
| January | 0 | 0 | 27 91 | 29.83 | 11 40 | 11.37 |
| February | 3 | 0 | 31 23 | 31.18 | 16 11 | 15.66 |
| March | 2 39 | 0 | 35 62 | 35.04 | 18 10 | 15.80 |
| Apnl | 0 | 0 | 38 92 | 39.31 | 21 73 | 20.53 |
| May | 76 | 122 59 | 36 79 | 36 67 | 23 38 | 21 76 |
| June | 62 2 | 150 29 | 32 82 | 31 58 | 22 05 | 20 48 |
| July | 183 19 | | 30 69 | | 20 97 | |
| August | 129 3 | | 29 06 | | 20 49 | |
| September | 80 09 | | 29 12 | | 20 40 | |
| October | 38 4 | | 30 63 | | 18 38 | |
| November | 5 | | 29 85 | | 12 74 | |
| December | 0 | | 28.13 | | 09.94 | |

area of 3 6m was left between the drought treatments to minimize the seepage of water across the treatments

Before sowing, a basal dose 40 kg/ha of $P_2O_5$ was incorporated in the soil at the time of land preparation Fertilizer and gypsum application was carried out according to the package of practices recommended for groundnut crop cultivation Intensive plant protection measures were undertaken to raise a successful and good crop of groundnut

### 3.2.2 Imposition of Drought Treatments

There were three drought treatments

1 No drought (Normal condition)

2 Mid-Season drought (MSD)

3 End-Season drought (ESD)

The treatment 'No drought' received full irrigation during the whole crop duration through the line source sprinkler irrigation system The mid-season and end-season drought treatments were imposed by withholding irrigation between 50-100 days after sowing (DAS) and 100 DAS-Final harvest respectively

## 3.3 Observations and measurements

In each treatment the following observations were recorded at 90 DAS and at maturity

### 3.3.1 Physiological Parameters

#### 3.3.1.1 Relative Leaf Water Content (RWC %)

From each plot 2nd or 3rd leaf from the apex of the main stem was sampled from andomly selected eight plants The leaves were collected in labeled polythene bags and placed in ice box The fresh weight was recorded in the laboratory Leaflets were separated and were floated in water in plastic trays for 5-6 hrs Leaflets were taken out from the trays, free water on leaflets was removed by tissue paper and turgid weight of leaflets was recorded The leaflets were put in labeled paper bags and dried in an oven at $80^0$C for 48 hrs Oven dried weight was recorded RWC was calculated by the equation

RWC (%) = [(Fresh Weight - Dry weight) / (Turgid weight -Dry weight)] X 100

### 3.3.1.2 SPAD and SLA measurements

SLN measured was made by Chlorophyll Meter SPAD 502 The second or third healthy leaf from the apex on the main axis was collected from 8 plants and brought to laboratory as described for RWC measurement The samples were stored in refrigarator On each leaf eight readings were taken (two readings/ leaflet) Like this, measurements were made on eight leaves The average value of eight leaves was taken as SPAD value of each plot

After measuring the SPAD value, the leaflets were separated and floated in water in petriplates for 2-3 hrs at room temperature After this period, the leaflets were carefully dried with tissue paper, then leaf area was measured by using an automatic leaf area meter (LICOR 3100) Dry weight was recorded after oven drying the sample for 48 hrs at $80^0$C The specific leaf area was calculated as follows

SLA ($cm^2/g$) = Leaf area / Oven dry weight

### 3.3.1.3 Light interception (%)

Canopy light interception (LI) was measured at mid-day by using a ceptometer (Degagon instruments, Washington, USA) at 90 DAS and before final harvest The readings were recorded two times in each plot by placing the sensor across the rows below the canopy The fractional radiation intercepted by the canopy at a given time was calculated as follows

LI (%) = [(I0-I)/I] X 100

Where, LI% is the light interception expressed in percentage

Io = is the total incoming radiation

I = is the radiation transmitted to the ground

### 3.3.2 Growth Analysis

Plants were harvested from a ground area of 0 6 $m^2$ [1 2m (4 rows) x 0 5 m (length)] from each plot at 90 DAS and at maturity After harvest, the plants were transferred in polythene bags, washed in the laboratory to remove soil particles and stored in a cold room at $4^0C$ until separation into different plant parts A sub sample of five plants was picked at random for detailed analysis of growth components The rest of the plants were treated as a bulk sample

The schedule for growth analysis is shown in Fig 1 As shown in the scheme, the bulk sample plants were dissected into leaves, stems, pods These components were oven dried at $80^0C$ for 48 hrs before recording their weights The pods were shelled, kernel weights were determined after oven drying

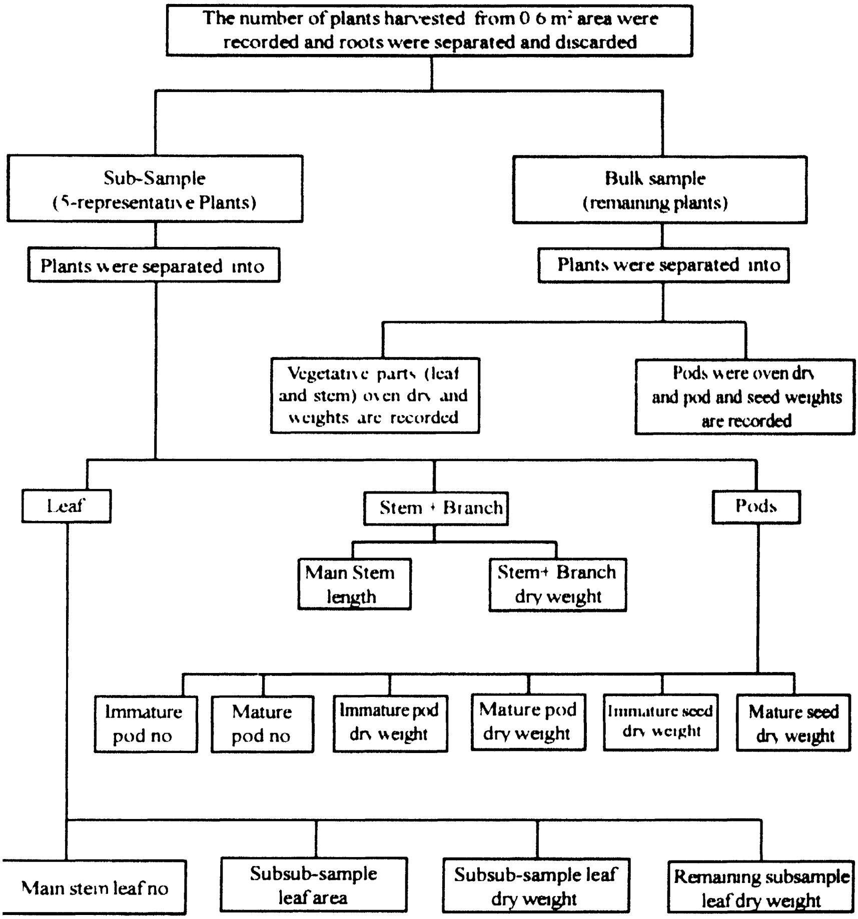



**Fig 1. Scheme for growth analysis**

### .2.1 Sub-Sample Measurements

The plants of sub sample were separated into leaves, stems, reproductive structures and roots Roots were discarded The main stem length, number of branches, aerial pegs and subterranean pegs were recorded on each plant From the leaves, a sub-sub sample was taken for leaf area measurement The leaf area was measured using a LI-3100 automatic leaf area meter (LI-COR, Inc, Lincoln, NE) The sub-sub sample leaf dry weight and remaining sub-sub leaf dry weight were recorded after oven drying Reproductive parts were separated into immature pods and mature pods The numbers in each class were counted and weights were recorded after oven drying The pods were shelled and the kernel weights were measured The pod weights were adjusted for higher energy content by multiplying a coefficient of 1 65 as suggested by Duncan *et al.* (1978).

#### Computation of components of crop growth rates and development

1 Specific leaf area = Sub sample leaf area / Sub sample leaf dry weight

2 Total leaf weight = Sub sample leaf dry weight + Remaining leaf dry weight + Bulk leaf dryweight

3 Leaf weight $m^{-2}$ = Total leaf weight /GA

4 Leaf area index $m^{-2}$ = (Total leaf weight X SLA) / (GA X 100 X 100)

5 Aerial pegs $m^{-2}$ = (Aerial Peg number plant $^{-1}$ X Total number of plants) /GA

6 Subterranean pegs $m^{-2}$= (Subterranean peg number X Total number of plants)/GA

7 Mature pods $m^{-2}$ area = [(Mature pod number / 5) X (Total number of plants)]/ GA

8 Immature pods $m^{-2}$ = [(Immature pod number /5) X (Total number of plants)]/ GA

9 Total pegs $m^{-2}$ = Aerial pegs $m^{-2}$ + Subterranean pegs $m^{-2}$ + Immature pods $m^{-2}$ + Mature pods $m^{-2}$

10 Stem weight $m^{-2}$ = (Sample stem dry weight + Bulk stem dry weight)/GA

11 Vegetative weight $m^{-2}$ = Leaf weight $m^{-2}$ + Stem weight $m^{-2}$

12 Mature pod weight $m^{-2}$ = [Mature pod weight / (Mature + Immature pod weight) ) X Bulk pod weight] + Mature pod weight] /GA

13 Immature pod weight $m^{-2}$ = [(Immature pod weight / (Mature + Immature Pod weight) X Bulk pod weight] + Immature pod weight] /GA

14 Pod weight $m^{-2}$ = Mature pod weight $m^{-2}$ +Immature pod weight $m^{-2}$ + Bulk pod weight $m^{-2}$

15 Adjustable pod weight $m^{-2}$ = Pod weight $m^{-2}$ X 1 65

16 Adjustable biomass $m^{-2}$ = Vegetative weight $m^{-2}$ + Adjustable pod weight $m^{-2}$

17 Adjustable harvest index = Adjustable pod weight $m^{-2}$ / Adjustable biomass $m^{-2}$

18 Kernel weight $m^{-2}$ = (Immature seed weight + Mature seed weight +Bulk seed weight ) / GA

19 Adjustable kernel weight $m^{-2}$ = Kernel weight $m^{-2}$ X 1 65

20 Shelling Percentage = (Adjustable kernel weight $m^{-2}$/Adjustable pod weight $m^{-2}$) X 100

Where GA= ground area=0 6$m^2$

### Computation of crop growth rates

Growth rates were computed by regressing a given growth parameter against the DAS from the sequential growth analysis data The slope of regression indicated the rate of growth of the given variable per day The 'X' and 'Y' coefficient used in computation of growth rates using regression analysis are given in the Table 3

Partitioning of dry matter = Pod growth rate / Crop growth rate

### 3.3.3 Yield parameters

#### 3.3.3.1 Number of mature pods per plant

Five plants were selected randomly after harvest in each plot and number of mature pods was recorded on them

#### 3.3.3.2 Number of immature pods per plant

Number of immature pods was recorded from the same five plants, which were selected for previous observation

The above two observations of yield parameters were taken from the five plants which were selected for growth analysis at harvest

#### 3.3.3.3 Pod yield per plot (g/plot)

A net plot of 2m X 1 2m (2 4 $m^2$) was harvested The plants after harvest were sun dried Pods were separated, dried uniformly and pod yield per plot was determined by weighing the pods

**Table 3 : Regression components used in computation of crop growth or development rates**

| Growth rate | | X |
|---|---|---|
| Crop growth rate ($g\ m^{-2}\ day^{-1}$) | Adjustable biomass weight $m^{-2}$ | DAS |
| Pod growth rate ($g\ m^{-2}\ day^{-1}$) | Adjustable total pod weight $m^{-2}$ | DAS |
| Rate of pod development ($g\ m^{-2}\ day^{-1}$) | Pod weight $m^{-2}$ | DAS |
| Rate of addition (No. of pods $m^{-2}\ day^{-1}$) | Pod number $m^{-2}$ | DAS |
| Rate of Kernel development ($g\ m^{-2}\ day^{-1}$ | Kernel weight $m^{-2}$ | DAS |
| Rate of maturity (percent $day^{-1}$) | Shelling percentage $m^{-2}$ | DAS |

### 3.3.3.4 Shelling Percentage

From the net plot pod yield, 100 g pods (randomly) were shelled. Kernel weight was taken and the shelling percentage was determined according to the formula

Shelling percentage = (Kernel weight / Pod weight) x 100

### 3.3.3.5 Hundred kernel weight (g)

Hundred seeds from each plot were taken randomly after shelling the pods. 100 seed weight was obtained after weighing the 100 randomly selected seeds

### 3.3.3.6 Sound mature kernel percentage

This observation was made on the 100 randomly selected seeds for previous observation. From 100 seeds, mature sound and healthy seeds were separated, counted and recorded as sound mature kernel percentage according to the formula

SMK% = (Number of mature sound kernel / Total number of kernels) X 100

### 3.3.3.7 Harvest Index (HI)

Harvest index in percentage was calculated by the following formula

HI(%) = [Pod yield /(Pod yield + Vegetative dry yield )]X 100

### 3.3.3.8 Oil content (%)

A sample of 20g seeds from each plot was subjected to oil estimation by Nuclear Magnetic Resonance Spectrometer (NMR) at Regional Research Station, Raichur The oil content was expressed in percentage.

## 3.4 Abbreviations

Following is the list of abbreviations used for various terms in the text

| | Term | Abbreviations |
|---|---|---|
| 1. | Relative leaf water content | RWC |
| 2. | Specific leaf area | SLA |
| 3. | Light interception | LI |
| 4. | Crop growth rate | CGR |
| 5. | Pod growth rate | PGR |
| 6. | Partitioning of dry matter to pods | PDM |
| 7. | Rate of pod development | RPD |
| 8. | Rate of pod addition | RPA |
| 9. | Rate of kernel development | RKD |
| 10 | Rate of maturity | RMT |
| 11. | Number of mature pods per plant | NMP |
| 12. | Number of immature pods per plant | NIMP |
| 13. | Pod yield per plot | Pod yield |
| 14. | Sound mature kernel percentage | SMK percentage |

| | | |
|---|---|---|
| 15 | Phenotypic coefficient of variation | PCV |
| 16 | Genotypic coefficient of variation | GCV |
| 17 | Heritability in broad sense | Heritability |
| 18 | Genetic advance percent over mean | GAM |
| 19 | Mid-season drought | MSD |
| 20 | End- season drought | ESD |
| 21 | Days after sowing | DAS |
| 22 | Hours | hrs |
| 23 | Water use efficiency | WUE |

## 3.5 Statistical procedure

### 3.5.1 Analysis of variance

The data were analyzed in Genstat package as per the procedure of strip plot design at ICRISAT, Patancheru

**Anova table for strip plot design**

| Source | D F | M S S | Cal F |
|---|---|---|---|
| Replication | (r-1) | Mr | Mr/ Meg |
| Genotype(g) | (g-1) | Mg | Mg/ Meg |
| Error(eg) | (g-1) (r-1) | Meg | |
| Drought | (d-1) | Md | Md/ Med |
| Error(ed) | (d-1) (r-1) | Med | |
| Interction | (g-1) | Mi | Mi/ Mei |
| Error(ei) | (g-1) (r-1) | Mei | |

### 3.5.1.1 Phenotypic and genotypic variance

Phenotypic and genotypic variances were computed according to formula dealt by Singh and Chaudhary (1977) for each drought treatment separately using the mean sum of squares from the anova table done for each treatment separately by considering each treatment as RBD design

Genotypic variance ($\sigma^2 g$) = (Mg - Me) /r

Phenotypic variance ($\sigma^2 p$) = $\sigma^2 g + \sigma^2 e$

Error variance ($\sigma^2 e$)= E (Me)

where,

Mg = Mean Sum of Squares for genotype

Me = Mean Sum of Squares for error

E(Me) = Expected mean sum of squares for error

r = Number of replications

### .5.1.2 Phenotypic and Genotypic coefficient of variability (PCV and GCV)

PCV and GCV were computed according to formula dealt with by Singh and haudhary (1977)

PCV = ($\sigma^2 p$ / x) X 100

GCV = ($\sigma^2 g$ / x) X 100

where x = Mean

$\sigma^2 p$ = Phenotypic Variance

$\sigma^2 g$ = Genotypic Variance

### 3.5.1.3 Heritability percentage ($h^2$)

The estimates of heritability in the broad sense were obtained by applying formula given by Singh and Chaudhary (1977)

$h^2 = (\sigma^2g/ \sigma^2p)$ X 100

where, $\sigma^2p$ = Phenotypic Variance

$\sigma^2g$ = Genotypic Variance

### .5.1.4 Genetic Advance (GA)

Genetic advance was computed by using the formula elucidated by Johnson *et al.* 1955).

Genetic advance $= (\sigma^2g / \sigma^2p) \times K$

Where,

$\sigma^2p$ = Phenotypic Variance

$\sigma^2g$ = Genotypic Variance

K = Selection differential, a constant (z/p) the value of which is 2 06

### 3.5.1.5 Genetic advance over per cent of mean (GAM)

Genetic advance over percent mean was calculated as follows

GA % over mean = (GA/mean) X 100

### 3.5.1.6 Correlation coefficient

Correlation coefficients were computed by using the formula

rxy = cov (xy) / v(x). v(y)

where r = correlation coefficient

x,y = variables

cov (x,y) = Covariance between x and y

v(x), v(y) = variance of x and y variable

## 3.5.2 Analysis of inter treatment variability

Data collected on plant basis were used for the purpose The following statistics were calculated by using the Genstat package

### 3.5.2.1 Mean

Mean = $\Sigma X / n$

where X = sum of all the observations

n = Number of observations

Means were obtained for each drought treatment separately and also for each genotype.

### 3.5.2.2 Standard error of mean

Standard error =S.D. / √ n

where,

S.D = Standard Deviation,

n = Number of observations

### 3.5.2.3 Least significant difference (LSD)

LSD = SE x t value at 0.05 p level

### 3.5.2.4 Coefficient of variability (%)

C.V. = (S.D. / x) X 100

S.D. = Standard deviation

x = Mean

# EXPERIMENTAL RESULTS

# IV. EXPERIMENTAL RESULTS

The experiment with 20 groundnut genotypes was carried out during rabi/ summer season to evaluate their performance and genetic variability and to assess the association of yield with yield components and physiological parameters under drought condition The results of this investigation are presented under the following different headings

**4.1 Analysis of variance**

**4.2 Genetic Parameters : variability, heritability and genetic advance**

**4.3 Character association**

**4.4 *Per se* performance**

## 4.1 Analysis of variance

Analysis of variance for physiological characters, yield and yield components is presented in Table 4 Significant differences for drought treatment were observed for all the characters except SLA at harvest and NIMP Genotypes also differed significantly for all the characters except RWC at 90 DAS Characters namely, RWC at harvest, LI at harvest, CGR, HI NIMP, pod yield, and shelling percentage exhibited significant for drought X genotype interaction Rest of the characters showed non-significant differences

## 4.2 Genetic parameters : variability, heritability and genetic advance

Estimates of genetic parameters namely, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, and genetic advance as percent of mean were worked out for all the characters and are presented in Tables 5 and 6

**Table 4: Analysis of variance for various characters studied**

| Source of variance | DF | RWC at 90 DAS | RWC at harvest | SLN at 90 DAS | SLN at harvest | SLA at 90 DAS | SLA at harvest | LI at 90 DAS | LI at harvest | CGR | PGR | PDM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 2 | 22.61 | 25.72 | 15.428 | 15.45 | 180.73 | 202.5 | 1223.29 | 142.56 | 21.872 | 5.849 | 0.00209 |
| Drought (D) | 2 | 3612.18** | 1427.01** | 1715.75** | 152.13* | 4238.33** | 957.5 | 46274.48** | 31504.93** | 288.785** | 139.07** | 0.07254** |
| Error | 4 | 11.98 | 8.28 | 17.931 | 14.07 | 107.78 | 382.8 | 603.17 | 54.75 | 8.606 | 3.417 | 0.00265 |
| Genotype (G) | 19 | 22.17 | 271.02** | 67.21** | 134.70** | 593.60** | 908.4* | 232.81** | 146.26** | 16.089** | 4.40** | 0.02449** |
| Error | 38 | 15.88 | 33.01 | 5.502 | 21.99 | 31.89 | 382.3 | 68.78 | 50.08 | 2.114 | 1.025 | 0.00511 |
| G X D interaction | 38 | 14.83 | 45.03* | 5.757 | 30.78 | 49.93 | 470.2 | 102.98 | 231.99** | 4.392* | 1.622 | 0.00519 |
| Error | 76 | 22.03 | 28.81 | 5.374 | 24.90 | 35.18 | 315.0 | 78.40 | 53.07 | 2.738 | 1.410 | 0.00486 |
| Total | 179 | | | | | | | | | | | |

* and ** significant at 5% and 1% level respectively

Table 4 : Continued

| Source of variance | RPD | RPA | RKD | RMT | HI | NMP | NIMP | Pod yield | Shelling % | 100 kernel weight | SMK % | Oil % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 2.1435 | 0.221E-5 | 1.0046 | 0.00421 | 42.40 | 47.429 | 22.22 | 108114 | 9.328 | 10.55 | 314.32 | 15.26 |
| Drought (D) | 51.0372** | 0.467E-5* | 34.1603** | 0.28602** | 640.98* | 301.821* | 12.48 | 1778556** | 529.39** | 686.39** | 1672.35* | 258.237* |
| Error | 1.2537 | 0.522E-6 | 0.5682 | 0.00557 | 66.49 | 17.518 | 57.76 | 29918 | 4.574 | 2.54 | 219.22 | 15.957 |
| Genotype (G) | 1.6168** | 0.153E-4** | 0.8737** | 0.06835** | 474.61** | 26.447** | 84.21** | 80604** | 150.257** | 194.48** | 131.58** | 39.493* |
| Error | 0.3780 | 0.672E-6 | 0.2305 | 0.00996 | 47.97 | 4.709 | 22.20 | 13955 | 6.424 | 7.13 | 44.38 | 2.788 |
| G X D interaction | 0.5961 | 0.123E-5 | 0.4202 | 0.00945 | 107.78** | 10.402 | 43.81** | 23968** | 17.825** | 27.39 | 64.61 | 3.634 |
| Error | 0.5184 | 0.837E-6 | 0.3146 | 0.01205 | 44.36 | 9.791 | 21.33 | 9389 | 6.336 | 10.07 | 46.75 | 2.639 |
| Total | | | | | | | | | | | | |

* and ** significant at 5% and 1% level respectively

### 4.2.1. Physiological parameters

For RWC at harvest, GCV and PCV were low under normal condition (3 61 and 5 54), but they increased slightly under drought stress PCV was moderate under ESD (13 51) Heritability was in the moderate range (42.37) and it increased further under drought stress GAM was also low under normal (4.86), but increased under ESD (14 02)

Low GCV and moderate PCV values for SLN at harvest (7 90 and 11 87) were observed. Drought stress did not affect GCV, but PCV increased considerably under MSD (20 28) Heritability was moderate under normal condition (44 27), low under MSD (23 76) and high under ESD (74 02). GAM was moderate under normal (10 83), but low under MSD (9 92) It increased under ESD (17.54)

SLA at harvest also had low GCV and moderate PCV under all the three drought conditions. Heritability and GAM were also low under all the three treatments Both these parameters were very low under ESD (14 27 and 5 26)

For LI at harvest, GCV and PCV values were maximum under MSD (25 86 and 34 00). GCV was moderate under MSD (11 25) and low under ESD (4 82) PCV also decreased under both MSD and ESD. Heritability was moderate under normal condition (57 48) and MSD (57 85), but decreased markedly under ESD (13 16) GAM was high under MSD (40 53), moderate in normal (17.57) and low in ESD (3.61)

For CGR, moderate GCV and high PCV values (15 60 and 21 33) were observed under normal condition. These values were not much altered under both the stress conditions Heritability

Table 5: Genetic components for physiological characters

| Characters | Drought | GCV (%) | PCV (%) | Heritability (%) | GAM (%) |
|---|---|---|---|---|---|
| RWC at harvest | 1 | 3.61 | 5.54 | 42.37 | 4.86 |
| | 2 | 6.16 | 8.53 | 52.15 | 9.17 |
| | 3 | 9.59 | 13.51 | 50.38 | 14.02 |
| SLN at harvest | 1 | 7.90 | 11.87 | 44.27 | 10.83 |
| | 2 | 9.88 | 20.28 | 23.76 | 9.92 |
| | 3 | 9.90 | 11.51 | 74.02 | 17.54 |
| SLA at harvest | 1 | 7.66 | 14.63 | 27.40 | 8.25 |
| | 2 | 6.06 | 10.05 | 36.32 | 7.52 |
| | 3 | 6.76 | 17.90 | 14.27 | 5.26 |
| LI at harvest | 1 | 11.25 | 14.83 | 57.48 | 17.57 |
| | 2 | 25.86 | 34.00 | 57.85 | 40.53 |
| | 3 | 4.82 | 13.30 | 13.16 | 3.61 |
| CGR | 1 | 15.60 | 21.33 | 53.47 | 23.55 |
| | 2 | 13.86 | 22.11 | 39.29 | 17.96 |
| | 3 | 12.93 | 23.59 | 30.17 | 14.60 |
| PGR | 1 | 14.25 | 21.09 | 45.70 | 19.84 |
| | 2 | 8.87 | 29.10 | 9.15 | 5.64 |
| | 3 | 7.26 | 25.28 | 8.03 | 4.33 |
| PDM | 1 | 7.35 | 12.17 | 37.03 | 9.30 |
| | 2 | 7.92 | 18.17 | 19.23 | 7.20 |
| | 3 | 9.82 | 13.33 | 52.94 | 14.59 |
| RPD | 1 | 14.24 | 21.11 | 45.68 | 19.88 |
| | 2 | 8.86 | 29.11 | 8.93 | 5.43 |
| | 3 | 7.29 | 25.29 | 8.00 | 4.28 |
| RPA | 1 | 13.70 | 15.63 | 76.82 | 24.73 |
| | 2 | 14.14 | 17.91 | 62.33 | 22.99 |
| | 3 | 12.62 | 15.34 | 67.68 | 21.34 |
| RKD | 1 | 17.51 | 25.09 | 49.09 | 25.33 |
| | 2 | 7.42 | 33.29 | 4.97 | 3.40 |
| | 3 | 2.67 | 32.25 | 6.96 | 0.45 |
| RMT | 1 | 10.36 | 15.77 | 43.26 | 14.05 |
| | 2 | 10.61 | 21.14 | 25.45 | 11.07 |
| | 3 | 8.60 | 13.95 | 38.26 | 10.97 |
| HI | 1 | 12.80 | 14.24 | 80.73 | 25.49 |
| | 2 | 18.82 | 23.03 | 66.79 | 30.95 |
| | 3 | 17.10 | 26.59 | 41.36 | 21.46 |

1 = Normal condition   2 = MSD   3 = ESD

estimate was moderate (53.47) under normal condition and it decreased markedly and was low under both MSD and ESD (39.29 and 30.17). GAM was high under normal condition (23.55) and moderate under MSD (17.96) and ESD (14.60).

For PGR also, moderate GCV and high PCV (14.25 and 21.09) values were noticed under normal condition. PCV increased under both the stress conditions and was high under MSD (29.10). But GCV decreased markedly under both the stress conditions and was least in ESD (7.26). Heritability estimate was moderate under normal condition (45.70) and a substantial decrease was observed under both MSD (9.15) and ESD (8.03). GAM also showed similar trend as that of heritability, as it was moderate under normal (19.84), low under MSD (5.64) and ESD (4.33).

GCV and PCV values were moderate for PDM under all the three drought conditions. PCV was little enhanced under MSD, but still remained in moderate range (18.17). Heritability was moderate under ESD (52.94) and reduced highly under MSD (19.23) and ESD (37.03). Similarly GAM was also moderate under ESD (14.59) and low under MSD (7.20) and ESD (9.30).

For RPD, GCV was moderate (14.24) and PCV was high (21.11) under normal condition. GCV reduced and PCV increased under MSD (8.86 and 29.11) and ESD (7.29 and 25.29). Heritability and GAM were moderate (45.68 and 19.88) under normal condition, but reduced substantially under MSD (8.93 and 5.43) and ESD (8.00 and 4.28).

Moderate GCV and PCV values and high heritability and GAM were exhibited by RPA under all the three conditions. Heritability decreased marginally under both MSD (62.33) and ESD (67.68).

For RKD, GCV was moderate (17.51) and PCV high (25.09) under normal condition. GCV value reduced to low and PCV increased under both MSD (7.42 and 33.29) and ESD (2.67

and 32.25). Moderate heritability (49.09) and high GAM (25.33) were observed under normal condition, but this character showed substantial reduction in heritability and GAM under both MSD (4.97 and 4.40) and ESD (6.96 and 0.45).

For RMT, GCV and PCV were moderate (10.36 and 15.77) under normal condition and these values did not alter much under both the stress conditions, except for PCV under MSD, which was increased (21.14). Heritability estimate was moderate under normal condition (43.26) and it reduced and low under both MSD (25.45) and ESD (38.26). GAM was moderate under normal condition (14.05) and it reduced slightly, but still in moderate range, under MSD (11.07) and ESD (10.97).

For HI, GCV was moderate under all conditions, but PCV was moderate under normal (14.24) and high under MSD (23.03) and ESD (26.59). Heritability was high under normal condition (80.73) and it decreased under MSD (66.79) and substantially under ESD (41.36). GAM was high under normal condition (25.49) and increased further under MSD (30.95).

### 4.2.2 Yield and yield components

For NMP, GCV and PCV values were high (25.57 and 40.64) under normal condition. GCV decreased and became low under ESD (9.87), but PCV enhanced under both MSD (58.48) and ESD (48.38). Heritability was low under normal (39.61) and still lower under MSD (18.65) and very low under ESD (4.18). GAM was high under normal (33.11) and reduced under MSD (22.50) and further reduced under ESD (4.17).

GCV and PCV were high (23.77 and 39.74) for NIMP under normal condition. GCV was reduced to a moderate range under MSD. PCV was also reduced under both the stress

Table 6: Genetic components for yield and yield components

| characters | Drought | GCV(%) | PCV(%) | Heritability(%) | GAM(%) |
|---|---|---|---|---|---|
| NMP | 1 | 25.57 | 40.64 | 39.61 | 33.11 |
| | 2 | 25.24 | 58.48 | 18.65 | 22.50 |
| | 3 | 9.87 | 48.38 | 4.18 | 4.17 |
| NIMP | 1 | 23.77 | 39.74 | 35.78 | 29.27 |
| | 2 | 13.85 | 30.78 | 20.23 | 12.82 |
| | 3 | 23.44 | 34.58 | 45.95 | 32.70 |
| Pod yield | 1 | 18.17 | 25.58 | 50.47 | 26.59 |
| | 2 | 17.25 | 23.96 | 51.85 | 25.60 |
| | 3 | 13.65 | 21.51 | 40.29 | 17.85 |
| Shelling percentage | 1 | 3.70 | 5.15 | 51.59 | 5.47 |
| | 2 | 8.85 | 9.70 | 83.29 | 16.64 |
| | 3 | 5.79 | 6.81 | 72.24 | 10.14 |
| Hundred kernel weight | 1 | 15.79 | 17.77 | 78.98 | 28.90 |
| | 2 | 8.80 | 13.64 | 41.65 | 11.70 |
| | 3 | 17.84 | 19.98 | 79.77 | 32.83 |
| SMK percentage | 1 | 4.16 | 8.67 | 22.96 | 4.10 |
| | 2 | 1.74 | 9.83 | 3.12 | 0.63 |
| | 3 | 7.92 | 13.35 | 35.20 | 9.69 |
| Oil percentage | 1 | 5.20 | 5.80 | 80.12 | 9.85 |
| | 2 | 3.66 | 4.57 | 64.04 | 6.21 |
| | 3 | 5.56 | 7.96 | 48.79 | 7.56 |

1= Normal condition 2 = MSD 3 = ESD

conditions, but it remained in a high range Heritability estimate was low under normal condition (35 78) and it reduced further under MSD (20 23), but increased to a moderate range under ESD (45.95). GAM was high under normal (29 27) and ESD (32 70) but moderate under MSD (12 82)

For pod yield, GCV was moderate and PCV was high under normal condition (18 17 and 25.58). Low deviations in GCV and PCV values under both the stress conditions were noticed. Heritability was moderate under all the three conditions, but under ESD (40 29) it was lower than normal. GAM was high under normal (26 59) and MSD (25 60), but moderate under ESD (17.85)

GCV and PCV values were low for shelling percentage under normal condition (3 70 and 5.15). Under MSD and ESD also these values, slightly increased but remained low Heritability estimate was high under MSD (83 29) followed by under ESD (72 24) and moderate under normal condition (51.59) GAM was moderate under MSD (16 64) and ESD (10 14) and low under normal condition (5 47)

For 100 kernel weight, GCV and PCV were moderate under normal condition (15 79 and 17 77) GCV was reduced to low under MSD (8 80), but PCV did not differ much under both the stress conditions. Heritability and GAM were high under normal (78 98 and 28 90) and ESD (79.77 and 32.83) and moderate under MSD (41 65 and 11 70)

GCV for SMK percentage was low under all the stress treatments PCV was also in lower range under normal condition (8 67) and MSD (9 83), but it increased under ESD (13.35). Heritability and GAM were low under normal (22 96 and 4 10) and ESD (35.20 and 9.69), but very low under MSD (3.12 and 0.63)

For oil content, GCV, PCV and GAM were low under normal condition (5 20, 5 80 and 9 85) and the other two drought treatments did not differ from normal for the above values Heritability was high under normal condition (80 12) and it reduced under MSD (64 04) and further reduced to moderate under ESD (48 79)

## 4.3 Character association

Association of yield with physiological parameters and yield components is given in Table 7 Under normal condition, yield was positively and significantly correlated with SLN at harvest (0 588), LI at 90 DAS (0 712), CGR (0 622), PGR and RPD (0 686) and RKD (0 525) and it was negatively and significantly associated with SLA at 90DAS (-0 473) and at harvest (-0 520), RPA (-0 482) and NIMP (-0 489) Under MSD most of these associations disappeared and only significant and negative correlation was noticed for yield with RWC at 90DAS (-0 496), SLA at harvest (-0 494) and RPA (-0 468) But under ESD, yield was positively associated with SLN at harvest (0 444), PGR (0 555), RPD (0 554), RKD (0 531), 100 kernel weight (0 475) and SMK percentage (0 492)

## 4.4 *Per se* performance

### 4.4.1 Relative leaf water content (RWC)

At 90 DAS, mean RWC was significantly less in MSD than in normal condition (Table 8) But at harvest, ESD recorded the lowest RWC (Table 9) At 90 DAS under normal condition, TMV 2 recorded the highest RWC (91 91) and D 39d the lowest (81 05) Except for JL 24, ICGV 86635, ICGV 93260, and D 39d, other genotypes did not differ significantly from TMV 2 At

**Table 7: Correlation of yield with its components and with physiological parameters**

| Characters | Yield (g/plot) | | |
|---|---|---|---|
| | Normal | MSD | ESD |
| RWC at 90 DAS | 0.172 | -0.496* | 0.383 |
| RWC at harvest | 0.071 | 0.394 | -0.164 |
| SLN at 90DAS | 0.307 | 0.343 | 0.431 |
| SLN at harvest | 0.588** | 0.105 | 0.444* |
| SLA at 90 DAS | -0.473* | -0.32 | -0.557* |
| SLA at harvest | -0.520* | -0.494* | -0.140 |
| LI at 90 DAS | 0.712** | 0.022 | -0.144 |
| LI at harvest | 0.190 | -0.375 | 0.036 |
| CGR | 0.622** | 0.280 | 0.279 |
| PGR | 0.686** | 0.360 | 0.555* |
| PDM | 0.026 | 0.135 | 0.298 |
| RPD | 0.686** | 0.359 | 0.554* |
| RPA | -0.482* | -0.468* | -0.102 |
| RKD | 0.525* | 0.152 | 0.531* |
| RMT | -0.241 | -0.374 | 0.146 |
| HI | 0.039 | 0.217 | 0.094 |
| NMP | 0.322 | 0.224 | 0.124 |
| NIMP | -0.489* | -0.116 | 0.174 |
| Shelling percentage | -0.333 | -0.224 | 0.017 |
| 100 kernel weight | 0.381 | 0.187 | 0.475* |
| SMK percentage | -0.031 | -0.039 | 0.492* |
| Oil percentage | 0.011 | 0.078 | 0.426 |

* and **significant at 5% and 1% level respectively

**TABLE 8: Mean leaf relative water content (%) measured at 90 DAS in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.**

| Genotype | No drought | Mid-season drought | End-season drought* | Mean |
|---|---|---|---|---|
| JL 24 | 83.04 | 77.16 | 89.13 | 83.11 |
| TMV 2 | 91.91 | 74.44 | 87.43 | 84.59 |
| KRG 1 | 85.02 | 69.24 | 86.14 | 80.13 |
| R 8808 | 87.12 | 75.69 | 87.10 | 83.30 |
| S 206 | 85.76 | 72.89 | 85.53 | 81.39 |
| R 9251 | 85.19 | 75.06 | 89.03 | 83.09 |
| R 9214 | 86.75 | 69.93 | 85.68 | 80.79 |
| TAG 24 | 86.76 | 72.39 | 86.50 | 81.88 |
| R 9227 | 87.26 | 71.26 | 89.28 | 82.60 |
| K 134 | 85.85 | 73.18 | 84.09 | 81.04 |
| D 39d | 81.05 | 74.52 | 86.76 | 80.78 |
| ICGV 92118 | 86.07 | 75.65 | 88.10 | 83.28 |
| ICGV 86031 | 86.25 | 75.08 | 88.41 | 83.25 |
| ICGV 86635 | 83.31 | 73.24 | 84.22 | 80.26 |
| ICGV 92113 | 89.07 | 76.03 | 83.19 | 82.77 |
| ICGV 92120 | 88.08 | 72.60 | 91.40 | 84.03 |
| ICGV 93260 | 84.41 | 68.66 | 82.22 | 78.43 |
| ICGV 93261 | 86.66 | 71.71 | 86.69 | 81.69 |
| ICGV 93269 | 88.28 | 74.95 | 88.79 | 84.01 |
| ICGV 93277 | 90.35 | 70.37 | 87.51 | 82.74 |
| Mean | 86.41 | 73.20 | 86.86 | 82.16 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.447 | 1.755 | 0.9 |
| Genotype(G) | 1.328 | 3.803 | 2.8 |
| G X T | 2.548 | 7.137 | 5.7 |
| G at the same level of T | 2.581 | 7.232 | |
| T at the same level of G | 2.679 | 7.540 | |

* similar to no drought condition as End season drought was imposed after 90 DAS

**TABLE 9: Mean leaf relative water content(%) measured at harvest in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center. 1999-2000.**

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 88.31 | 90.41 | 80.07 | 86.26 |
| TMV 2 | 77.95 | 66.29 | 46.45 | 63.56 |
| KRG 1 | 85.09 | 83.25 | 73.48 | 80.61 |
| R 8808 | 81.05 | 86.20 | 84.28 | 83.84 |
| S 206 | 86.96 | 87.92 | 72.58 | 82.49 |
| R 9251 | 80.52 | 85.65 | 80.12 | 82.10 |
| R 9214 | 82.27 | 88.86 | 75.20 | 82.11 |
| TAG 24 | 74.34 | 73.71 | 64.96 | 71.00 |
| R 9227 | 85.54 | 86.16 | 81.20 | 84.30 |
| K 134 | 84.27 | 89.93 | 81.87 | 85.36 |
| D 39d | 86.10 | 82.45 | 79.12 | 82.56 |
| ICGV 92118 | 86.31 | 88.78 | 80.75 | 85.28 |
| ICGV 86031 | 86.36 | 89.33 | 81.57 | 85.75 |
| ICGV 86635 | 84.92 | 87.86 | 81.73 | 84.84 |
| ICGV 92113 | 85.94 | 84.95 | 80.44 | 83.78 |
| ICGV 92120 | 89.95 | 91.10 | 81.20 | 87.42 |
| ICGV 93260 | 80.45 | 85.99 | 78.74 | 81.73 |
| ICGV 93261 | 84.02 | 84.55 | 77.53 | 82.03 |
| ICGV 93269 | 83.94 | 83.72 | 71.52 | 79.72 |
| ICGV 93277 | 84.65 | 91.47 | 73.97 | 83.36 |
| Mean | 83.95 | 85.43 | 76.34 | 81.91 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.372 | 1.459 | 0.8 |
| Genotype(G) | 1.915 | 5.483 | 4.0 |
| G X T | 3.119 | 8.737 | 6.6 |
| G at the same level of T | 3.173 | 8.891 | |
| T at the same level of G | 3.043 | 8.5 | |

harvest under normal conditions, ICGV 92120 recorded the highest RWC (89.95) and TAG 24 the lowest (74.34). Only five genotypes, TMV 2, R 8808, R 9251, TAG 24, and ICGV 93260, had significantly lower RWC than ICGV 92120. At 90 DAS under MSD, JL 24 had the highest RWC (77.16) and it was significantly greater than KRG 1 and ICGV 93260, the latter being the lowest (68.66). At harvest under MSD, ICGV 93277 had the highest RWC (91.47) and it was significantly higher than TMV 2, TAG 24, and D 39d. The first being the lowest (66.29). The remaining genotypes did not differ significantly with each other. At harvest under ESD, R 8808 had the highest RWC (84.28) and TMV 2, the lowest (46.45). Twelve genotypes did not differ significantly with R 8808.

### 4.4.2 Specific leaf area (SLA)

SLA at 90 DAS was significantly lower in MSD than in normal and ESD conditions (Table 10). But SLA at harvest did not show significant differences between drought treatments (Table 11). D 39d recorded the highest SLA at 90 DAS (158.7) followed by ICGV 92118 (157.5) and R 8808(154.8). ICGV 86031 recorded the lowest SLA (121.3). For SLA at harvest, genotypic differences were mostly blurred. ICGV 93269 recorded the highest SLA at harvest (159.3) followed by TMV 2 (157.3) and ICGV 92113(157.1). ICGV 86031 recorded the lowest SLA (120.3).

For SLA at 90 DAS under normal condition ICGV 92118 recorded the highest value (164.7) and ICGV 86031, the lowest (125.5). JL 24, TMV 2, KRG 1, R 8808,and D 39d did not differ significantly from ICGV 92118. All genotypes had significantly higher SLA than ICGV 86031. For SLA at harvest under normal condition, ICGV 92113 had the highest value (179.0) and ICGV 86635 the lowest (1114.1). TMV 2 and D 39d did not differ significantly from the former. Fourteen other genotypes did not differ significantly from the latter. At 90 DAS under MSD, D 39d

TABLE 10: Mean specific leaf area($cm^2/g$) measured at 90 DAS in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought* | Mean |
|---|---|---|---|---|
| JL 24 | 156.2 | 135.7 | 150.1 | 147.3 |
| TMV 2 | 158.1 | 136.6 | 152.9 | 149.2 |
| KRG 1 | 156.0 | 141.7 | 152.2 | 150.0 |
| R 8808 | 157.4 | 143.2 | 163.9 | 154.8 |
| S 206 | 147.8 | 136.3 | 161.7 | 148.6 |
| R 9251 | 152.7 | 137.4 | 148.4 | 146.1 |
| R 9214 | 132.8 | 129.2 | 142.0 | 134.7 |
| TAG 24 | 143.3 | 133.8 | 154.3 | 143.8 |
| R 9227 | 139.3 | 135.9 | 145.1 | 140.1 |
| K 134 | 147.6 | 135.1 | 151.8 | 144.8 |
| D 39d | 157.6 | 153.6 | 164.9 | 158.7 |
| ICGV 92118 | 164.7 | 146.5 | 161.3 | 157.5 |
| ICGV 86031 | 125.5 | 110.8 | 127.7 | 121.3 |
| ICGV 86635 | 150.8 | 146.0 | 162.8 | 153.2 |
| ICGV 92113 | 150.5 | 140.3 | 152.6 | 147.8 |
| ICGV 92120 | 144.4 | 137.8 | 158.3 | 146.8 |
| ICGV 93160 | 148.5 | 140.9 | 153.1 | 147.5 |
| ICGV 93161 | 154.7 | 139.9 | 157.5 | 150.7 |
| ICGV 93269 | 151.2 | 138.0 | 153.4 | 147.6 |
| ICGV 93277 | 155.2 | 130.5 | 157.4 | 147.7 |
| Mean | 149.7 | 137.5 | 153.6 | 146.9 |

| | SEm† | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 1.340 | 5.262 | 1.6 |
| Genotype(G) | 1.882 | 5.389 | 2.2 |
| G X T | 3.546 | 9.967 | 4.0 |
| G at the same level of T | 3.371 | 9.444 | |
| T at the same level of G | 3.597 | 10.149 | |

* similar towo drought condition as End season drought was imposed after 90 DAS

TABLE 11: Mean specific leaf area($cm^2/g$) measured at harvest in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 132.8 | 155.8 | 147.1 | 145.2 |
| TMV 2 | 155.6 | 158.5 | 157.7 | 157.3 |
| KRG 1 | 148.1 | 143.8 | 152.9 | 148.3 |
| R 8808 | 142.8 | 138.9 | 147.1 | 142.9 |
| S 206 | 139.4 | 138.9 | 162.0 | 146.8 |
| R 9251 | 138.5 | 137.0 | 143.5 | 139.7 |
| R 9214 | 127.0 | 134.1 | 128.5 | 129.9 |
| TAG 24 | 148.7 | 134.0 | 145.3 | 142.7 |
| R 9227 | 128.8 | 123.1 | 130.1 | 127.3 |
| K 134 | 142.3 | 134.4 | 151.0 | 142.6 |
| D 39d | 149.4 | 165.4 | 144.8 | 153.2 |
| ICGV 92118 | 136.7 | 154.3 | 144.5 | 145.2 |
| ICGV 86031 | 114.9 | 123.6 | 122.4 | 120.3 |
| ICGV 86635 | 114.1 | 150.6 | 141.5 | 135.4 |
| ICGV 92113 | 179.0 | 144.6 | 147.7 | 157.1 |
| ICGV 92120 | 133.3 | 139.8 | 132.0 | 135.0 |
| ICGV 93260 | 128.8 | 151.1 | 142.2 | 140.7 |
| ICGV 93261 | 135.0 | 144.1 | 134.9 | 138.0 |
| ICGV 93269 | 125.7 | 146.8 | 205.3 | 159.3 |
| ICGV 93277 | 139.4 | 145.3 | 136.7 | 140.5 |
| Mean | 138.0 | 143.2 | 145.9 | 142.4 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 2.53 | 9.92 | 3.1 |
| Genotype(G) | 6.52 | 18.66 | 7.9 |
| G X T | 10.66 | 29.86 | 12.5 |
| G at the same level of T | 10.60 | 29.71 | |
| T at the same level of G | 10.30 | 28.99 | |

recorded the highest value (153 6) and ICGV 86031, the lowest for SLA Except for ICGV 92118 and ICGV 86635, the remaining genotypes recorded significantly lower SLA than D 39d All the genotypes recorded significantly higher SLA than ICGV 86031 At harvest, under MSD D 39d again recorded the highest SLA (165 4) followed by TMV 2 (158 5), JL 24 (155 8), and ICGV 92118 (154 3) and R 9214, TAG 24, R 9227, K 134, and ICGV 86031 recorded significantly lower SLA than D 39d Lowest SLA was observed for R 9227 (123 1) and ICGV 86031 (123 1) Four genotypes namely, JL 24, TMV 2, D 39d and ICGV 92118 had significantly higher SLA than R 9227 At harvest, under ESD, ICGV 93269 (205 3) had the highest SLA and ICGV 86031), the lowest (122 4) Only four genotypes, ICGV 93269, TMV 2, KRG 1and S 206, recorded significantly greater SLA than ICGV 86031

### 4.4.3 Specific leaf nitrogen content (SLN)

Mean SLN was significantly increased only under MSD at 90 DAS (49 38) and at harvest (41 75) (Table 12 and 13) ICGV 92113 recorded the highest mean SLN (48 58) and D 39d the lowest (39 32) The two genotypes ICGV 86031 and ICGV 93269 did not differ significantly from the former, where as JL 24, TMV 2, KRG 1, S 206 and ICGV 92118 from the latter genotype At harvest ICGV 86031 had the highest SLN (45 36) and ICGV 92118 the lowest (34 25) Nine genotypes did not differ significantly from ICGV 86031 and eight genotypes from ICGV 92118

At 90 DAS, under normal condition ICGV 92113 (45 92) recorded the highest SLN followed by ICGV 93261 (45 71) and the genotypes TAG 24, ICGVs 86031, 92120, 93260, and 93269 did not differ significantly from ICGV 92113 JL 24 recorded the lowest Seven genotypes namely TMV 2, KRG 1, S 206, K 134, D 39d, ICGV 92118 and ICGV 86635 did not differ significantly from JL 24 At harvest, ICGV 86031(47 24) maintained the highest SLN followed by

TABLE 12: Mean SLN measured at 90 DAS in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought* | Mean |
|---|---|---|---|---|
| JL 24 | 34.53 | 49.85 | 37.39 | 40.59 |
| TMV 2 | 37.00 | 48.00 | 37.53 | 40.85 |
| KRG 1 | 35.78 | 47.42 | 38.35 | 40.52 |
| R 8808 | 41.62 | 50.51 | 41.55 | 44.56 |
| S 206 | 38.21 | 47.86 | 35.99 | 40.69 |
| R 9251 | 41.35 | 47.90 | 39.10 | 42.78 |
| R 921 | 42.13 | 49.39 | 40.16 | 43.89 |
| TAG 24 | 43.48 | 47.45 | 42.03 | 44.32 |
| R 9227 | 40.10 | 50.13 | 41.28 | 43.83 |
| K 134 | 38.16 | 48.27 | 39.11 | 41.85 |
| D 39d | 35.65 | 45.74 | 36 57 | 39.32 |
| ICGV 92118 | 36.83 | 44.96 | 36.02 | 39.27 |
| ICGV 86031 | 44.28 | 53.45 | 44.27 | 47.33 |
| ICGV 86635 | 36.41 | 49.05 | 39.60 | 41.69 |
| ICGV 92113 | 45.92 | 53.28 | 46.55 | 48.58 |
| ICGV 92120 | 43.92 | 51.67 | 42 72 | 46.10 |
| ICGV 93260 | 42.24 | 49 78 | 41.23 | 44.42 |
| ICGV 93261 | 40.81 | 49.63 | 39.07 | 43.17 |
| ICGV 93269 | 45.71 | 53.05 | 44.55 | 47.77 |
| ICGV 93277 | 39.21 | 50.22 | 38.30 | 42.57 |
| Mean | 40.17 | 49.38 | 40.07 | 43.21 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.547 | 2.146 | 2.2 |
| Genotype(G) | 0.782 | 2.239 | 3.1 |
| G X T | 1.419 | 3.992 | 5.4 |
| G at the same level of T | 1.344 | 3.764 | |
| T at the same level of G | 1.414 | 3.993 | |

similar to no drought condition as End season drought was imposed after 90 DAS

TABLE 13: Mean SLN measured at harvest in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 36.46 | 34.22 | 34.52 | 35.07 |
| TMV 2 | 35.13 | 40.20 | 36.92 | 37.42 |
| KRG 1 | 34.57 | 40.13 | 35.67 | 36.79 |
| R 8808 | 41.80 | 42.89 | 40.35 | 41.68 |
| S 206 | 37.44 | 39.32 | 30.26 | 35.67 |
| R 9251 | 37.70 | 40.21 | 39.76 | 39.22 |
| R 9214 | 42.73 | 43.05 | 40.88 | 42.22 |
| TAG 24 | 41.93 | 42.88 | 43.86 | 42.89 |
| R 9227 | 42.32 | 40.25 | 42.00 | 41.52 |
| K 134 | 36.95 | 37.79 | 31.95 | 35.56 |
| D 39d | 35.12 | 37.74 | 38.84 | 37.23 |
| ICGV 93118 | 33.20 | 34.65 | 34.89 | 34.25 |
| ICGV 86031 | 47.24 | 45.26 | 43.58 | 45.36 |
| ICGV 86635 | 35.46 | 39.67 | 38.70 | 37.94 |
| ICGV 92113 | 36.48 | 42.64 | 45.45 | 41.52 |
| ICGV 92120 | 40.93 | 44.65 | 44.00 | 43.19 |
| ICGV 93260 | 41.03 | 43.38 | 39.87 | 41.43 |
| ICGV 93261 | 38.48 | 45.85 | 40.88 | 41.74 |
| ICGV 93269 | 43.49 | 42.90 | 42.24 | 42.88 |
| ICGV 93277 | 38.66 | 37.40 | 38.58 | 38.21 |
| Mean | 38.86 | 41.75 | 39.16 | 39.92 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 0.484 | 1.901 | 2.1 |
| Genotype (G) | 1.563 | 4.475 | 6.8 |
| G X T | 2.792 | 7.820 | 12.5 |
| G at the same level of T | 2.824 | 7.913 | |
| T at the same level of G | 2.850 | 8.021 | |

ICGV 93269 (43.49). Genotypes namely ICGV 93269, 9260, 92120, R 9227, TAG 24, R 9214 and R 8808 did not differ significantly from ICGV 86031.Under MSD, at 90 DAS ICGV 86031(53.45) had the highest SLN followed by ICGV 92113 (53.28) and ICGV 93269 (53.05). Seven genotypes JL 24, R 8808, R 9227, ICGVs 92113, 92120, 93260, 93269 and 93277 did not differ significantly from ICGV 86031.At harvest SPAD reading was highest for ICGV 93261 (45.85) followed by ICGV 86031(45.26). JL 24, K 134, D 39d, ICGV 92118 and ICGV 93277 recorded significantly lower values. Under ESD, at harvest highest value was exhibited by ICGV 92113(45.45) and followed by ICGV 92120 (44.00). Genotypes namely, S 206, JL 24, TMV 2, KRG 1, K134, ICGV 92118 recorded significantly low SPAD reading than ICGV 92113. The first being the lowest (35.99).

### 4.4.4 Light interception (LI)

Mean LI under MSD at 90 DAS (27.10) and at harvest (31.80) was significantly lower than that of either under normal or ESD conditions (Table 14 and 15).

LI at 90 DAS under normal and ESD conditions did not differ significantly from each other. But at harvest, significantly more light was intercepted under normal conditions than ESD. At 90 DAS under normal condition, R 9227 intercepted maximum light (94.03) and S 206, the least (59.11). R 9227 did not differ significantly from ICGV 92118, JL 24, TMV 2, R 8808, R 9214, ICGVs 86031, 86635, 93269, and 93277. At harvest under normal condition, maximum light was intercepted by ICGV 92120 (88.69) followed by ICGV 86031(88.51) and minimum by TMV 2 (47.06) followed by TAG 24 (59.74). Genotypes namely, R 9227, TAG 24, ICGV 93261, ICGV 93269, JL 24, and TMV 2 intercepted significantly lesser light than ICGV 92120. Under MSD at 90 DAS, R 9227 intercepted maximum light (35.96) followed by ICGV 92120 (33.11). ICGV 93261

TABLE 14: Mean canopy light interception(%) at 90 DAS in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought* | Mean |
|---|---|---|---|---|
| JL 24 | 83.12 | 30.26 | 73.60 | 62.33 |
| TMV 2 | 82.02 | 29.87 | 72.70 | 61.53 |
| KRG 1 | 66.78 | 27.41 | 72.57 | 55.59 |
| R 8808 | 87.27 | 21.87 | 60.28 | 56.47 |
| S 206 | 59.11 | 26.46 | 77.89 | 54.49 |
| R 9251 | 63.73 | 21.30 | 70.58 | 51.87 |
| R 9214 | 84.86 | 32.24 | 74.62 | 63.91 |
| TAG 24 | 62.11 | 26.61 | 59.83 | 49.52 |
| R 9227 | 94.03 | 35.96 | 82.13 | 70.71 |
| K 134 | 77.33 | 27.00 | 76.47 | 60.27 |
| D 39d | 70.62 | 20.88 | 68.62 | 53.37 |
| ICGV 92118 | 91.79 | 28.95 | 77.97 | 66.24 |
| ICGV 86031 | 84.77 | 26.27 | 76.26 | 62.44 |
| ICGV 86635 | 83.80 | 26.73 | 73.60 | 61.38 |
| ICGV 92113 | 70.40 | 30.67 | 62.92 | 54.66 |
| ICGV 92120 | 79.41 | 33.11 | 72.89 | 61.80 |
| ICGV 93260 | 78.41 | 23.93 | 71.07 | 57.80 |
| ICGV 93261 | 77.60 | 19.00 | 75.62 | 57.41 |
| ICGV 93269 | 81.77 | 26.51 | 68.23 | 58.84 |
| ICGV 93277 | 81.04 | 27.03 | 68.28 | 58.79 |
| Mean | 78.00 | 27.10 | 71.81 | 58.97 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 3.171 | 12.449 | 9.3 |
| Genotype(G) | 2.764 | 7.914 | 8.1 |
| G X T | 5.815 | 16.650 | 15.0 |
| G at the same level of T | 5.007 | 14.027 | |
| T at the same level of G | 5.906 | 16.932 | |

similar to no drought condition as End season drought was imposed after 90 DAS

TABLE 15: Mean canopy light interception(%) at harvest in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 74.87 | 44.99 | 59.20 | 59.69 |
| TMV 2 | 47.06 | 51.08 | 56.75 | 51.63 |
| KRG 1 | 79.21 | 26.09 | 59.71 | 55.00 |
| R 8808 | 82.59 | 27.14 | 63.89 | 57.87 |
| S 206 | 79.50 | 24.44 | 54.46 | 52.80 |
| R 9251 | 81.36 | 15.55 | 54.57 | 50.49 |
| R 9214 | 81.27 | 35.92 | 57.39 | 58.19 |
| TAG 24 | 59.47 | 50.83 | 46.58 | 52.29 |
| R 9227 | 76.92 | 31.57 | 55.42 | 54.64 |
| K 134 | 80.63 | 30.01 | 64.29 | 58.31 |
| D 39d | 81.01 | 24.11 | 58.24 | 54.46 |
| ICGV 92118 | 79.85 | 32.90 | 65.57 | 59.44 |
| ICGV 86031 | 88.51 | 39.51 | 59.60 | 62.54 |
| ICGV 86635 | 82.11 | 31.17 | 56.17 | 56.49 |
| ICGV 92113 | 83.87 | 28.94 | 56.19 | 56.33 |
| ICGV 92120 | 88.69 | 34.27 | 61.26 | 61.41 |
| ICGV 93260 | 78.41 | 25.10 | 47.32 | 50.27 |
| ICGV 93261 | 68.11 | 21.73 | 54.75 | 48.20 |
| ICGV 93269 | 73.35 | 27.93 | 55.22 | 52.17 |
| ICGV 93277 | 83.61 | 32.80 | 62.67 | 59.69 |
| Mean | 77.52 | 31.80 | 57.46 | 55.60 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.955 | 3.751 | 3.0 |
| Genotype(G) | 2.359 | 6.754 | 7.3 |
| G X T | 4.170 | 11.679 | 13.1 |
| G at the same level of T | 4.166 | 11.673 | |
| T at the same level of G | 4.209 | 11.847 | |

intercepted the least light (19.00). Four genotypes R 8808, R 9251, D 39d, and ICGV 93261 intercepted significantly lesser light than R 9227. At harvest under MSD, the maximum light was intercepted by TMV 2 (51.08) followed by TAG 24 (50.83) and the least light by R 9251 (15.55). TMV 2 was significantly superior to all genotypes except ICGV 86031, TAG 24, and JL 24.

Under ESD at harvest, maximum LI was recorded by ICGV 92118 (65.57) followed by R 8808 (63.89) and the least by TAG 24 (46.50) followed by ICGV 93260 (47.32). Except TAG 24 and ICGV 93260, the rest of the genotypes intercepted significantly lesser light than ICGV 92118.

### 4.4.5 Crop growth rate (CGR)

The mean CGR was significantly reduced under both the stress conditions and it was the least in MSD (7.572). Both the stress conditions did not differ for this trait (Table 16). Overall, ICGV 86031 recorded the highest CGR (12.292) and D 39d the lowest (7.367). R 9214 and R 9227 did not differ significantly from ICGV 86031.

Under normal condition, the highest CGR was recorded by R 9214 (16.403) and the lowest by R 9251 (8.713). Except JL 24, R 9227, and ICGV 86031, the rest of the genotypes showed significantly less CGR from R 9214. Under MSD also, ICGV 86031 exhibited the highest CGR (11.377) and D 39d the lowest (5.660). Except for ICGV 92113, the rest of the genotypes exhibited significantly lesser CGR than ICGV8603. Under ESD, R 9227 (12.317) had the highest CGR and ICGV 92113 the lowest (6.540). Four genotypes viz.; TMV 2, R 9214, K 134, and ICGV 86031 did not differ significantly from R 9227. ICGV 86031 maintained higher CGR under all the three situations.

**TABLE 16:** Mean crop growth rate ($g/m^2/day$) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 13.913 | 7.957 | 8.763 | 10.211 |
| TMV 2 | 12.447 | 8.370 | 10.203 | 10.340 |
| KRG 1 | 10.403 | 6.707 | 8.730 | 8.613 |
| R 8808 | 13.417 | 6.130 | 8.720 | 9.422 |
| S 206 | 10.317 | 7.770 | 8.247 | 8.778 |
| R 9251 | 8.713 | 6.603 | 7.110 | 7.476 |
| R 9214 | 16.403 | 7.407 | 10.587 | 11.466 |
| TAG 24 | 12.550 | 6.997 | 8.790 | 9.446 |
| R 9227 | 15.250 | 7.703 | 12.317 | 11.757 |
| K 134 | 11.900 | 6.863 | 9.907 | 9.557 |
| D 39d | 8.427 | 5.660 | 8.013 | 7.367 |
| ICGV 92118 | 12.183 | 8.403 | 8.463 | 9.683 |
| ICGV 86031 | 14.450 | 11.377 | 11.050 | 12.292 |
| ICGV 86635 | 11.570 | 6.133 | 7.353 | 8.352 |
| ICGV 92113 | 9.783 | 8.973 | 6.540 | 8.432 |
| ICGV 92120 | 10.450 | 8.057 | 8.403 | 8.970 |
| ICGV 93260 | 11.343 | 8.283 | 7.097 | 8.908 |
| ICGV 93261 | 10.857 | 6.270 | 6.633 | 7.920 |
| ICGV 93269 | 10.160 | 7.280 | 8.367 | 8.602 |
| ICGV 93277 | 11.610 | 8.497 | 8.643 | 9.583 |
| Mean | 11.807 | 7.572 | 8.697 | 9.359 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 0.379 | 1.487 | 7.0 |
| Genotype (G) | 0.485 | 1.388 | 9.0 |
| G X T | 0.970 | 2.729 | 17.7 |
| G at the same level of T | 0.918 | 2.573 | |
| T at the same level of G | 1.005 | 2.837 | |

### 4.4.6 Pod growth rate (PGR)

Mean PGR was significantly low under both the stress conditions than in normal condition and it was lowest in MSD (4.254) (Table 17). Overall ICGV 86031 had the highest PGR (7.150) and D 39d the lowest (4.468). Except for R 9214, the rest were differed significantly from ICGV 86031.

Under normal condition, highest PGR was exhibited by R 9214 (9.577) and the lowest by D 39d (5.500). Except for ICGV 86031 and R 8808, the rest of the genotypes recorded significantly lower PGR than R 9214. Under MSD condition, ICGV 86031 recorded the highest PGR (5.830) and seven genotypes viz., JL 24, R 8808, K 134, D39d, ICGVs 92118, 93261, and 86635 recorded significantly lower PGR than ICGV 86031. The last was being the lowest (2.750). Under ESD also, ICGV 86031 recorded the highest PGR (6.277) and it was significantly higher than eight genotypes, JL 24, R 8808, S 206, D 39d, ICGVs, 86635, 92113, 93261, and 92118, the last genotype being the lowest (3.680).

### 4.4.7 Partitioning of dry matter to pods (PDM)

All the three drought treatments differed significantly from each other and the mean PDM was significantly lower under both MSD and ESD. The latter showed the lowest (0.5338) (Table 18). Overall, R 9251 recorded the highest PDM (0.6511) and JL 24 the lowest (0.4733). The four genotypes S 206, TAG 24, D 39d, ICGV 93260, 93261,and 93269 did not differ significantly from R 9251. Under normal condition, R 9251 partitioned more dry matter to pods (0.700), whereas the genotypes, K 134, JL 24, TMV 2, KRG 1, R 9214, R 9227, ICGV 92118 and 92120 partitioned significantly lower dry matter to pods. The cultivar K 134 showed the lowest PDM (0.5167). But

TABLE 17: Mean pod growth rate($g/m^2$/day) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 7.253 | 3.667 | 3.983 | 4.968 |
| TMV 2 | 6.777 | 4.567 | 5.247 | 5.530 |
| KRG 1 | 5.777 | 4.130 | 4.597 | 4.834 |
| R 8808 | 8.610 | 2.853 | 4.307 | 5.257 |
| S 206 | 6.640 | 4.863 | 4.240 | 5.248 |
| R 9251 | 6.120 | 4.080 | 4.507 | 4.902 |
| R 9214 | 9.577 | 4.300 | 5.760 | 6.546 |
| TAG 24 | 7.613 | 4.707 | 5.550 | 5.957 |
| R 9227 | 8.643 | 4.320 | 5.537 | 6.167 |
| K 134 | 6.147 | 3.927 | 4.793 | 4.956 |
| D 39d | 5.500 | 3.493 | 4.410 | 4.468 |
| ICGV 92118 | 6.400 | 3.570 | 3.680 | 4.550 |
| ICGV 86031 | 9.343 | 5.830 | 6.277 | 7.150 |
| ICGV 86635 | 7.200 | 2.750 | 3.693 | 4.548 |
| ICGV 92113 | 5.807 | 5.013 | 3.717 | 4.846 |
| ICGV 92120 | 5.693 | 4.353 | 4.473 | 4.840 |
| ICGV 93260 | 7.053 | 5.080 | 4.467 | 5.533 |
| ICGV 93261 | 7.187 | 3.930 | 3.883 | 5.000 |
| ICGV 93269 | 6.837 | 4.290 | 4.810 | 5.312 |
| ICGV 93277 | 6.933 | 5.350 | 4.517 | 5.600 |
| Mean | 7.055 | 4.254 | 4.622 | 5.310 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 0.2386 | 0.9370 | 7.8 |
| Genotype (G) | 0.3375 | 0.9662 | 11.0 |
| G X T | 0.6788 | 1.9060 | 22.4 |
| G at the same level of T | 0.6537 | 1.8318 | |
| T at the same level of G | 0.7096 | 1.9998 | |

TABLE 18: Mean partitioning of dry matter to pods in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 0.5233 | 0.4433 | 0.4533 | 0.4733 |
| TMV 2 | 0.5467 | 0.5500 | 0.5167 | 0.5378 |
| KRG 1 | 0.5533 | 0.6267 | 0.5300 | 0.5700 |
| R 8808 | 0.6500 | 0.4600 | 0.4833 | 0.5311 |
| S 206 | 0.6500 | 0.6233 | 0.5133 | 0.5956 |
| R 9251 | 0.7000 | 0.6267 | 0.6267 | 0.6511 |
| R 9214 | 0.5833 | 0.5667 | 0.5367 | 0.5622 |
| TAG 24 | 0.6167 | 0.6733 | 0.6333 | 0.6411 |
| R 9227 | 0.5667 | 0.5533 | 0.4333 | 0.5178 |
| K 134 | 0.5167 | 0.5733 | 0.4900 | 0.5267 |
| D 39d | 0.6567 | 0.6133 | 0.5533 | 0.6078 |
| ICGV 92118 | 0.5267 | 0.4267 | 0.4333 | 0.4622 |
| ICGV 86031 | 0.6433 | 0.5100 | 0.5633 | 0.5722 |
| ICGV 86635 | 0.6300 | 0.4467 | 0.5033 | 0.5267 |
| ICGV 92113 | 0.5900 | 0.5633 | 0.5667 | 0.5733 |
| ICGV 92120 | 0.5467 | 0.5400 | 0.5333 | 0.5400 |
| ICGV 93260 | 0.6200 | 0.6100 | 0.6267 | 0.6189 |
| ICGV 93261 | 0.6633 | 0.6267 | 0.5867 | 0.6256 |
| ICGV 93269 | 0.6767 | 0.5900 | 0.5733 | 0.6133 |
| ICGV 93277 | 0.5967 | 0.5933 | 0.5200 | 0.5700 |
| Mean | 0.6028 | 0.5608 | 0.5338 | 0.5658 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 0.00664 | 0.02607 | 2.0 |
| Genotype (G) | 0.02383 | 0.06822 | 7.3 |
| G X T | 0.04013 | 0.11240 | 12.3 |
| G at the same level of T | 0.04059 | 0.11371 | |
| T at the same level of G | 0.03978 | 0.11199 | |

under MSD, it was highest in TAG 24 (0.6733) and seven genotypes viz., R 8808, JL 24, TMV 2, R 9227, ICGV 86635, 92120, ICGV 92118 recorded significantly lower PDM than TAG 24, the last genotype being the lowest (0.4267) for this trait. TAG 24, which had the highest PDM under MSD (0.6333), also maintained it under ESD condition, but the other genotypes viz., R 9227, ICGV 92118, JL 24, TMV 2, R 8808, S 206, K 134, and ICGV 86635 showed significantly lesser PDM. The former two genotypes recorded the lowest (0.4333).

ICGV 93260 (0.6200, 0.1600 and 0.6267), R 9251 (0.7000, 0.6267, 0.6267) and TAG 24 (0.6167, 0.6733 and 0.6333) maintained their performance under three situations.

### 4.4.8 Rate of pod development (RPD)

Mean RPD was significantly reduced under both the stress conditions than the normal condition and this reduction was more under MSD (2.578) (Table 19).

Under normal condition, R 9214 (5.803) recorded the highest RPD and D 39d the lowest (3.337), whereas the rest of the genotypes except for ICGV 86031, R 9227, and R 8808 showed significantly lesser RPD. Under MSD, ICGV 86031 recorded the highest RPD (3.533) and was significantly greater than the genotypes R 8808, JL 24, K 134, D39d, ICGV 92118, 93261 and 86635. RPD was the least in ICGV 86635 (1.667) and R 8808 (1.730). Under ESD, ICGV 86031 maintained its highest RPD (3.807) and seven genotypes JL 24, R 8808, S 206, D 39d, ICGV 86635, 93261 and 92118 recorded significantly lesser rate and the last being the least (2.230).

TABLE 19: Mean rate of pod development ($g/m^2/day$) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 4.397 | 2.223 | 2.413 | 3.011 |
| TMV 2 | 4.107 | 2.767 | 3.180 | 3.351 |
| KRG 1 | 3.500 | 2.503 | 2.783 | 2.929 |
| R 8808 | 5.220 | 1.730 | 2.610 | 3.187 |
| S 206 | 4.017 | 2.947 | 2.570 | 3.178 |
| R 9251 | 3.707 | 2.473 | 2.733 | 2.971 |
| R 9214 | 5.803 | 2.603 | 3.493 | 3.967 |
| TAG 24 | 4.617 | 2.853 | 3.360 | 3.610 |
| R 9227 | 5.240 | 2.620 | 3.360 | 3.740 |
| K 134 | 3.723 | 2.380 | 2.907 | 3.003 |
| D 39d | 3.337 | 2.117 | 2.673 | 2.709 |
| ICGV 92118 | 3.880 | 2.163 | 2.230 | 2.758 |
| ICGV 86031 | 5.660 | 3.533 | 3.807 | 4.333 |
| ICGV 86635 | 4.363 | 1.667 | 2.240 | 2.757 |
| ICGV 92113 | 3.517 | 3.037 | 2.253 | 2.936 |
| ICGV 92120 | 3.453 | 2.640 | 2.710 | 2.934 |
| ICGV 93260 | 4.273 | 3.080 | 2.707 | 3.353 |
| ICGV 93261 | 4.353 | 2.380 | 2.353 | 3.029 |
| ICGV 93269 | 4.143 | 2.600 | 2.913 | 3.219 |
| ICGV 93277 | 4.200 | 3.243 | 2.737 | 3.393 |
| Mean | 4.275 | 2.578 | 2.802 | 3.218 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.1446 | 0.5676 | 7.8 |
| Genotype(G) | 0.2049 | 0.5867 | 11.0 |
| G X T | 0.4117 | 1.1559 | 22.4 |
| G at the same level of T | 0.3965 | 1.1110 | |
| T at the same level of G | 0.4302 | 1.2123 | |

### 4.4.9 Rate of pod addition (RPA)

Significant reduction was noticed only under MSD (0 0094) (Table 20) Under normal condition, the rate of pod addition was the highest in TAG 24 (0 0126) and the least in ICGV 92120 (0.0077). Except for R 9251, R 8808, D 39d, and TMV 2, the rest had significantly lower RPA than TAG 24. Under MSD, TAG 24 (0 0124) and TMV 2 (0 0124) recorded the highest RPA and the rest of the genotypes recorded significantly lower RPA than these cultivars RPA was the least in ICGV 92118 (0.0065). Under ESD, TAG 24 (0 0121) again recorded the highest RPA and ICGV 92113(0.0074) the least. All genotypes recorded significantly lower RPA than TAG 24 except for JL 24, TMV 2, S 206, R 9251

### 4.4.1 Rate of kernel development (RKD)

Mean RKD was significantly reduced under both the stress conditions and this reduction more under MSD (1 585) (Table 21) RKD was the highest in R 9214 (4.377) and the lowest in ICGV 92120 (2 073) under normal condition R 9214 did not differ significantly from R 8808, R 9227, and ICGV 86031 Under MSD, ICGV 93277 (1 963) showed the highest RKD and it was significantly greater than R 8808 and ICGV 86635 The latter was being the lowest (0.837) But under ESD, highest RKD was recorded by ICGV 86031(2 287) ICGV 86635 and ICGV 92118 recorded significantly lesser RKD and the former being the lowest (1 273)

### 4.4.11 Rate of maturity (RMT)

Mean RMT was significantly reduced under both the MSD and ESD. The former being the lowest (0.7085) (Table 22) Under normal condition, it was highest in R 8808 (1.0333) followed

TABLE 20: Mean rate of pod addition (No./$m^2$/day) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 0.0109 | 0.0097 | 0.0107 | 0.0104 |
| TMV 2 | 0.0119 | 0.0124 | 0.0114 | 0.0119 |
| KRG 1 | 0.0102 | 0.0103 | 0.0102 | 0.0102 |
| R 8808 | 0.0113 | 0.0108 | 0.0100 | 0.0107 |
| S 206 | 0.0102 | 0.0096 | 0.0110 | 0.0103 |
| R 9251 | 0.0116 | 0.0100 | 0.0114 | 0.0110 |
| R 9214 | 0.0094 | 0.0092 | 0.0101 | 0.0095 |
| TAG 24 | 0.0126 | 0.0124 | 0.0121 | 0.0124 |
| R 9227 | 0.0095 | 0.0095 | 0.0089 | 0.0093 |
| K 134 | 0.0099 | 0.0100 | 0.0099 | 0.0099 |
| D 39d | 0.0116 | 0.0103 | 0.0106 | 0.0108 |
| ICGV 92118 | 0.0075 | 0.0065 | 0.0087 | 0.0076 |
| ICGV 86031 | 0.0088 | 0.0086 | 0.0083 | 0.0086 |
| ICGV 86635 | 0.0086 | 0.0080 | 0.0087 | 0.0084 |
| ICGV 92113 | 0.0085 | 0.0089 | 0.0074 | 0.0083 |
| ICGV 92120 | 0.0077 | 0.0086 | 0.0084 | 0.0082 |
| ICGV 93260 | 0.0093 | 0.0091 | 0.0088 | 0.0091 |
| ICGV 93261 | 0.0101 | 0.0086 | 0.0090 | 0.0092 |
| ICGV 93269 | 0.0088 | 0.0081 | 0.0077 | 0.0082 |
| ICGV 93277 | 0.0109 | 0.0076 | 0.0100 | 0.0095 |
| Mean | 0.010 | 0.0094 | 0.0097 | 0.0097 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.00009 | 0.00037 | 1.7 |
| Genotype(G) | 0.00027 | 0.00078 | 4.9 |
| G X T | 0.00051 | 0.00142 | 9.4 |
| G at the same level of T | 0.00051 | 0.00143 | |
| T at the same level of G | 0.00052 | 0.00147 | |

TABLE 21: Mean rate of kernel development(g/m²/day) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 3.077 | 1.363 | 1.463 | 1.968 |
| TMV 2 | 2.703 | 1.883 | 2.020 | 2.202 |
| KRG 1 | 2.383 | 1.710 | 1.750 | 1.948 |
| R 8808 | 4.020 | 1.013 | 1.513 | 2.182 |
| S 206 | 3.023 | 1.873 | 1.427 | 2.108 |
| R 9251 | 2.583 | 1.633 | 1.770 | 1.996 |
| R 9214 | 4.377 | 1.593 | 2.167 | 2.712 |
| TAG 24 | 3.293 | 1.907 | 2.160 | 2.453 |
| R 9227 | 3.610 | 1.570 | 2.190 | 2.457 |
| K 134 | 2.437 | 1.597 | 1.797 | 1.943 |
| D 39d | 2.540 | 1.447 | 1.770 | 1.919 |
| ICGV 92118 | 2.390 | 1.130 | 1.077 | 1.532 |
| ICGV 86031 | 3.730 | 1.853 | 2.287 | 2.623 |
| ICGV 86635 | 2.760 | 0.837 | 1.273 | 1.623 |
| ICGV 92113 | 2.283 | 1.843 | 1.457 | 1.861 |
| ICGV 92120 | 2.073 | 1.313 | 1.657 | 1.681 |
| ICGV 93260 | 2.930 | 1.920 | 1.760 | 2.203 |
| ICGV 93261 | 3.060 | 1.550 | 1.580 | 2.063 |
| ICGV 93269 | 2.890 | 1.703 | 1.993 | 2.196 |
| ICGV 93277 | 3.067 | 1.963 | 1.637 | 2.222 |
| Mean | 2.961 | 1.585 | 1.737 | 2.095 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.0973 | 0.3821 | 8.0 |
| Genotype(G) | 0.1600 | 0.4581 | 13.2 |
| G X T | 0.1358 | 0.8856 | 26.8 |
| G at the same level of T | 0.3090 | 0.8660 | |
| T at the same level of G | 0.3303 | 0.9299 | |

TABLE 22: Mean rate of maturity ($g/m^2/day$) of 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 0.8967 | 0.6767 | 0.7800 | 0.7844 |
| TMV 2 | 0.9333 | 0.8800 | 0.9033 | 0.9056 |
| KRG 1 | 0.8733 | 0.7867 | 0.8167 | 0.8256 |
| R 8808 | 1.0333 | 0.5567 | 0.7967 | 0.7956 |
| S 206 | 0.7200 | 0.7200 | 0.7300 | 0.7233 |
| R 9251 | 0.8933 | 0.7600 | 0.8167 | 0.8233 |
| R 9214 | 0.9433 | 0.6700 | 0.7267 | 0.7800 |
| TAG 24 | 1.0133 | 0.9400 | 0.9233 | 0.9589 |
| R 9227 | 0.8500 | 0.6633 | 0.7733 | 0.7622 |
| K 134 | 0.8467 | 0.7533 | 0.7867 | 0.7956 |
| D 39d | 0.9833 | 0.7933 | 0.8667 | 0.8811 |
| ICGV 92118 | 0.7100 | 0.5900 | 0.5600 | 0.6200 |
| ICGV 86035 | 0.7533 | 0.5800 | 0.6900 | 0.6744 |
| ICGV 86635 | 0.7200 | 0.5867 | 0.6633 | 0.6567 |
| ICGV 92113 | 0.7400 | 0.6733 | 0.7400 | 0.7178 |
| ICGV 92120 | 0.6867 | 0.5500 | 0.7067 | 0.6478 |
| ICGV 93260 | 0.8000 | 0.7133 | 0.7500 | 0.7544 |
| ICGV 93261 | 0.8067 | 0.7300 | 0.7800 | 0.7722 |
| ICGV 93269 | 0.8067 | 0.7267 | 0.7833 | 0.7722 |
| ICGV 93277 | 0.9167 | 0.8200 | 0.8100 | 0.8489 |
| Mean | 0.8463 | 0.7085 | 0.7702 | 0.775 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 0.00964 | 0.03784 | 2.2 |
| Genotype (G) | 0.03327 | 0.09525 | 7.4 |
| G X T | 0.06063 | 0.16982 | 14.2 |
| G at the same level of T | 0.06152 | 0.17236 | |
| T at the same level of G | 0.06252 | 0.17599 | |

by TAG 24 (1.0133) and the least in ICGV 92120 (0.6867). K 134, R 9227, S 206, and all ICGV lines except ICGV 93277 recorded significantly lower RMT. Under MSD, TAG 24 (0.9400) recorded the highest RKD and the least was recorded by ICGV 92120 (0.5500). Except for TMV 2, KRG 1, D 39d, and ICGV 93277, all other genotypes recorded significantly lower RMT than TAG 24. Under ESD, TAG 24 (0.9233) again recorded the highest RMT and eight genotypes namely, ICGVs 92118, 86031, 86635, 92118, 93260, 92120 S 206, and R 9214 recorded significantly lower RMT, the first being the lowest (0.5600).

### 4.4.12 Harvest index (HI)

Mean HI reduced significantly under both MSD and ESD and more under ESD (45.78). Both the stress conditions did not differ from each other (Table 23). Under normal condition, R 9251(66.81) recorded the highest HI and did not differ significantly from R 8808, ICGV 93261 and ICGV 93269, whereas TMV 2 recorded the lowest HI (40.36) Under MSD, TAG 24 (60.79) exhibited the highest HI and JL 24 (24.97) the lowest. But the genotypes, namely KRG 1, R 8808, S 206, R 9214, and ICGVs 92118, 93260, and 93261 did not differ significantly from TAG 24. Under ESD, R 9251 (70.55) again recorded the highest HI and R 9227 (31.64) the lowest. Rest of the genotypes expressed significantly lower HI than R 9251.

Genotypes namely, R 9251, TAG 24 and S 206 faired well under all the three drought situations and ICGV 86031 under ESD

### 4.4.13. Number of mature pods per plant (NMP)

Both MSD and ESD recorded significantly lower NMP than that of under normal condition, the MSD being the lowest (4.977) and did not differ from ESD (Table 24). Under normal

TABLE 23: Mean harvest index(%) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 44.57 | 24.97 | 41.68 | 37.07 |
| TMV 2 | 40.36 | 47.49 | 36.01 | 41.29 |
| KRG 1 | 50.52 | 55.28 | 43.50 | 49.77 |
| R 8808 | 59.31 | 52.02 | 45.18 | 52.17 |
| S 206 | 53.14 | 51.19 | 58.34 | 54.22 |
| R 9251 | 66.81 | 60.40 | 70.55 | 65.92 |
| R 9214 | 49.12 | 58.88 | 46.07 | 51.36 |
| TAG 24 | 50.85 | 60.79 | 50.36 | 54.00 |
| R 9227 | 51.68 | 44.58 | 31.64 | 42.64 |
| K 134 | 47.85 | 44.20 | 39.55 | 43.87 |
| D 39d | 55.41 | 53.96 | 44.60 | 51.32 |
| ICGV 93118 | 43.77 | 34.02 | 32.80 | 36.86 |
| ICGV 86031 | 52.82 | 37.30 | 50.12 | 46.74 |
| ICGV 86635 | 43.71 | 35.83 | 36.50 | 38.68 |
| ICGV 92113 | 49.25 | 44.82 | 60.93 | 51.67 |
| ICGV 92120 | 49.77 | 36.89 | 39.67 | 42.11 |
| ICGV 93260 | 65.17 | 51.73 | 46.92 | 54.61 |
| ICGV 93261 | 59.37 | 54.81 | 48.47 | 54.22 |
| ICGV 93269 | 56.66 | 48.07 | 49.07 | 51.27 |
| ICGV 93277 | 50.10 | 46.75 | 43.55 | 46.80 |
| Mean | 52.01 | 47.20 | 45.78 | 48.33 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 0.01053 | 0.04133 | 3.8 |
| Genotype (G) | 0.02309 | 0.06609 | 8.3 |
| G X T | 0.03944 | 0.11051 | 13.8 |
| G at the same level of T | 0.03897 | 0.10918 | |
| T at the same level of G | 0.03893 | 0.10958 | |

**TABLE 24:** Mean number of mature pods per plant at harvest of 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 10.133 | 3.867 | 6.067 | 6.689 |
| TMV 2 | 9.467 | 5.067 | 7.333 | 7.289 |
| KRG 1 | 13.600 | 6.933 | 6.400 | 8.978 |
| R 8808 | 4.200 | 5.667 | 6.267 | 5.378 |
| S 206 | 16.733 | 6.600 | 6.467 | 9.933 |
| R 9251 | 10.533 | 6.000 | 10.067 | 8.867 |
| R 9214 | 9.333 | 4.667 | 6.867 | 6.956 |
| TAG 24 | 8.067 | 7.467 | 9.667 | 8.400 |
| R 9227 | 6.067 | 5.867 | 7.200 | 6.378 |
| K 134 | 11.200 | 10.000 | 5.800 | 9.000 |
| D 39d | 12.133 | 4.933 | 4.667 | 7.244 |
| ICGV 92118 | 5.067 | 1.667 | 2.933 | 3.222 |
| ICGV 86031 | 8.533 | 3.933 | 3.667 | 5.378 |
| ICGV 86635 | 7.267 | 1.800 | 3.067 | 4.044 |
| ICGV 92113 | 7.400 | 3.400 | 6.533 | 5.778 |
| ICGV 92120 | 8.467 | 3.000 | 7.067 | 6.178 |
| ICGV 93160 | 11.067 | 3.600 | 5.667 | 6.778 |
| ICGV 93161 | 11.267 | 6.067 | 7.400 | 8.244 |
| ICGV 93269 | 8.667 | 4.600 | 5.533 | 6.267 |
| ICGV 93277 | 7.467 | 4.400 | 5.933 | 5.933 |
| Mean | 9.333 | 4.977 | 6.230 | 6.847 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.540 | 2.122 | 13.7 |
| Genotype(G) | 0.723 | 2.071 | 18.3 |
| G X T | 1.682 | 4.720 | 45.7 |
| G at the same level of T | 1.643 | 4.607 | |
| T at the same level of G | 1.842 | 5.186 | |

condition, S 206 (16.733) recorded the highest NMP and the rest of the genotypes recorded significantly lower NMP. R 8808 (4.200) recorded the lowest NMP Under MSD, K 134 (10 00) recorded the highest NMP and ICGV 92118 (1 667) the lowest The genotypes viz , JL 24, TMV 2, R 9214, D 39d and all ICGV lines except for ICGV 93261 recorded significantly lower NMP than K 134. Under ESD, R 9251 (10 067) recorded the highest NMP and was significantly greater than ICGV 92118, ICGV 86031, ICGV 86635 and D 39d The first genotype recorded the lowest NMP (2.933).

### 4.4.14 Number of immature pods per plant (NIMP)

The three drought treatments did not differ significantly from each other for this trait (Table 25) ICGV 93277 (27 60) recorded the highest NIMP under normal condition and the rest of the genotypes recorded significantly lower NIMP than ICGV 93277 Among these, K 134 (11 00) recorded the least NIMP Under MSD, the highest NIMP was recorded by ICGV 86031 (22 13) and six genotypes JL 24, KRG 1, R 9251, R 9227, K 134, D 39d recorded significantly lower NIMP The last was being the lowest (10 53) Under ESD, ICGV 92118 maintained the highest NIMP (25.47) and ten genotypes JL 24, KRG 1, TAG 24, R 9227, D39d, and ICGVs 86635, 92113, 93260, 93261, and 93269 recorded significantly lower NIMP ICGV 93269 (8 53) recorded the lowest.

### 4.4.15 Pod yield

In MSD and ESD, pod yield reduced significantly from normal condition and both the stress conditions did not differ from each other Reduction in yield was the highest under ESD

TABLE 25: Mean number of immature pods per plant at harvest in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 13.67 | 14.40 | 13.60 | 13.89 |
| TMV 2 | 23.67 | 20.53 | 20.67 | 21.62 |
| KRG 1 | 15.93 | 13.07 | 16.33 | 15.11 |
| R 8808 | 22.40 | 16.20 | 18.40 | 19.00 |
| S 206 | 11.13 | 18.07 | 22.27 | 17.16 |
| R 9251 | 13.27 | 12.67 | 22.93 | 16.29 |
| R 9214 | 19.00 | 16.33 | 18.40 | 17.91 |
| TAG 24 | 16.13 | 16.33 | 16.67 | 16.38 |
| R 9227 | 17.80 | 11.13 | 16.07 | 15.00 |
| K 134 | 11.00 | 13.20 | 18.13 | 14.11 |
| ICGV 92118 | 23.67 | 15.47 | 25.47 | 21.53 |
| D 39d | 11.13 | 10.53 | 10.13 | 10.60 |
| ICGV 86031 | 13.13 | 22.13 | 21.67 | 18.98 |
| ICGV 86635 | 11.33 | 12.27 | 14.27 | 12.62 |
| ICGV 92113 | 13.27 | 18.27 | 11.13 | 14.22 |
| ICGV 92120 | 15.00 | 19.87 | 20.40 | 18.42 |
| ICGV 93260 | 15.73 | 21.73 | 12.80 | 16.76 |
| ICGV 93261 | 18.67 | 17.60 | 11.60 | 15.96 |
| ICGV 93269 | 11.67 | 16.73 | 8.33 | 12.24 |
| ICGV 93277 | 27.60 | 14.93 | 19.53 | 20.69 |
| Mean | 16.26 | 16.07 | 16.94 | 16.42 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 0.981 | 3.852 | 10.6 |
| Genotype (G) | 1.571 | 4.496 | 16.3 |
| G X T | 2.795 | 7.849 | 28.1 |
| G at the same level of T | 2.685 | 7.521 | |
| T at the same level of G | 2.778 | 7.833 | |

(443.6) (Table 26). Overall ICGV 86031 recorded the highest pod yield (823.1) and JL 24 the lowest (434.2). All the genotypes yielded significantly lower than ICGV 86031.

Among all the genotypes, ICGV 86031 registered high yield i.e. 1132.9, 713.4, and 622.9 g/plot under normal, MSD and ESD respectively. Under normal condition, R 9214 (1080.4) did not differ significantly from ICGV 86031 and the rest of the genotypes recorded significantly lower yield. Among these, R 9251(548.3) yielded the lowest. But under MSD, R 9214 (675.2) again and ICGV 93260, S 206, KRG 1, ICGV 93261, 93269, and 93277 did not differ significantly from ICGV 86031. The rest were significantly poor yielders. Under ESD also, R 9214, ICGV 93261, 93269 and 93277 maintained high yield, and R 8808, TMV 2, ICGV 92120 were statistically at par with ICGV 86031.

Across the treatments, the genotypes like ICGV 86031, R 9214, 93260, 93261, 93269, 93277 and R 8808 performed better under three conditions.

### 4.4.16 Shelling Percentage

Mean shelling percentage was significantly reduced under both the MSD and ESD. The former being the lowest (64.85) (Table 27). Under normal condition, R 9251 (74.92) recorded the highest shelling percentage. JL 24, R 9214, R 9227, ICGV 92118, 86635, 92120, and 93277 recorded significantly lower shelling percentage than R 9251. Under MSD, D 39d (73.00) had the highest shelling percentage and ICGV 86031(52.93) the lowest. Genotypes JL 24, R 9214, R 9227, TMV 2, TAG 24 and all ICGV lines were significantly inferior to D 39d for this trait. But under ESD, genotype K 134 (74.06) recorded high shelling percentage. S 206 (73.51) and KRG 1 (73.37) were statistically at par with K 134. Genotypes R 9214, R 9227, TAG 24 and some ICGV lines

TABLE 26: Mean pod yield per net plot (g) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 590.9 | 274.4 | 437.3 | 434.2 |
| TMV 2 | 730.5 | 345.8 | 487.5 | 521.3 |
| KRG 1 | 684.5 | 568.0 | 482.1 | 578.2 |
| R 8808 | 898.6 | 542.5 | 507.3 | 649.5 |
| S 206 | 645.4 | 571.4 | 358.5 | 525.1 |
| R 9251 | 548.3 | 437.3 | 430.1 | 471.9 |
| R 9214 | 896.3 | 675.2 | 487.7 | 686.4 |
| TAG 24 | 665.3 | 428.3 | 453.5 | 515.7 |
| R 9227 | 1080.4 | 632.3 | 389.9 | 700.9 |
| K 134 | 620.9 | 473.0 | 376.6 | 490.2 |
| D 39d | 614.5 | 501.6 | 343.0 | 486.4 |
| ICGV 92118 | 955.1 | 535.3 | 352.5 | 614.3 |
| ICGV 86031 | 1132.9 | 713.4 | 622.9 | 823.1 |
| ICGV 86635 | 761.8 | 510.8 | 327.8 | 533.5 |
| ICGV 92113 | 652.3 | 525.3 | 382.2 | 520.0 |
| ICGV 92120 | 781.7 | 524.5 | 523.2 | 609.8 |
| ICGV 93260 | 938.0 | 637.0 | 450.8 | 675.3 |
| ICGV 93261 | 791.4 | 564.7 | 489.8 | 615.3 |
| ICGV 93269 | 787.1 | 585.0 | 492.5 | 621.5 |
| ICGV 93277 | 739.3 | 574.6 | 477.1 | 597.0 |
| Mean | 775.8 | 531.0 | 443.6 | 583.5 |

| | SEm± | LSD (0.05P) | CV (%) |
|---|---|---|---|
| Drought treatment (T) | 22.33 | 87.68 | 6.6 |
| Genotype (G) | 39.38 | 112.74 | 11.7 |
| G X T | 63.08 | 117.21 | 16.6 |
| G at the same level of T | 60.31 | 169.03 | |
| T at the same level of G | 58.92 | 166.30 | |

**TABLE 27: Mean shelling percentage in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.**

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 70.60 | 63.81 | 71.79 | 68.73 |
| TMV 2 | 72.43 | 67.85 | 71.28 | 70.52 |
| KRG 1 | 74.48 | 69.49 | 73.37 | 72.45 |
| R 8808 | 70.88 | 69.71 | 72.20 | 70.93 |
| S 206 | 73.32 | 70.04 | 73.51 | 72.29 |
| R 9251 | 74.92 | 72.26 | 69.98 | 72.39 |
| R 9214 | 68.88 | 66.97 | 66.66 | 67.50 |
| TAG 24 | 72.04 | 67.03 | 68.58 | 69.22 |
| R 9227 | 68.66 | 64.25 | 64.13 | 65.68 |
| K 134 | 72.56 | 68.38 | 74.06 | 71.67 |
| D 39d | 73.18 | 73.00 | 72.80 | 73.00 |
| ICGV 92118 | 66.31 | 58.30 | 61.79 | 62.13 |
| ICGV 86031 | 72.10 | 52.93 | 67.05 | 64.03 |
| ICGV 86635 | 66.12 | 54.93 | 61.11 | 60.72 |
| ICGV 92113 | 69.71 | 63.30 | 69.53 | 67.51 |
| ICGV 92120 | 64.30 | 53.36 | 61.52 | 59.72 |
| ICGV 93260 | 72.14 | 67.25 | 69.82 | 69.74 |
| ICGV 93261 | 71.92 | 66.59 | 70.12 | 69.54 |
| ICGV 93269 | 72.71 | 66.43 | 71.54 | 70.23 |
| ICGV 93277 | 66.49 | 61.21 | 64.03 | 63.91 |
| Mean | 70.69 | 64.85 | 68.74 | 68.10 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.276 | 1.084 | 0.7 |
| Genotype(G) | 0.845 | 2.419 | 2.1 |
| G X T | 1.446 | 4.051 | 3.7 |
| G at the same level of T | 1.457 | 4.081 | |
| T at the same level of G | 1.443 | 4.062 | |

which recorded lower values under normal and MSD, also recorded significantly lower values. D 39d recorded almost similar shelling percentage under the three drought conditions. JL 24, TMV 2, KRG 1, R 8808, S 206, K 134, and ICGVs 93261, 93269, and 93277 maintained their shelling percentage under ESD, and R 9251, and S 206 under MSD

### 4.4.17 Hundred kernel weight

All the three drought treatments differed significantly from each other for this trait and it was the lowest in MSD (30 13) (Table 28) ICGV 93269 recorded the highest 100 kernel weight (43.38) and TMV 2 the lowest (26 92). Except for ICGV 86031, the rest of the genotypes recorded significantly lower weight than ICGV 93269, but KRG 1, S 206, and K 134 did not differ significantly from TMV 2.

Under normal condition, hundred kernel weight observed was the highest in ICGV 93269 (51.40) and the least in TMV 2 (29 29) followed by KRG 1 (29 68) All genotypes recorded significantly lower kernel weight than ICGV 93269 and 86031 Under MSD ICGV 93269 (36.37) recorded the highest kernel weight and S 206 (24 79) followed by TMV 2 (24.95) recorded the lowest. ICGV 93269 did not differ significantly from R 9214, TAG 24, R 9227, D 39d, ICGV 92113 and the rest of the genotypes recorded significantly lower kernel weight Under ESD, ICGV 86031 (49.28) recorded the highest hundred kernel weight All genotypes recorded significantly lower weight than ICGV 86031.

### 4.4.17 Sound mature kernel percentage (SMK percentage)

Mean value was significantly reduced only under ESD (67.73) (Table 29). Under normal condition, R 8808 (86.67) had the highest SMK percentage and five genotypes KRG 1, R

**TABLE 28:** Mean 100 seed weight(g) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 37.38 | 30.22 | 35.53 | 34.38 |
| TMV 2 | 29.29 | 24.95 | 26.51 | 26.92 |
| KRG 1 | 29.68 | 30.25 | 26.72 | 28.89 |
| R 8808 | 40.63 | 31.73 | 35.24 | 35.87 |
| S 206 | 30.89 | 24.79 | 26.16 | 27.28 |
| R 9251 | 32.43 | 29.82 | 28.14 | 30.13 |
| R 9214 | 37.19 | 34.25 | 33.66 | 35.03 |
| TAG 24 | 38.93 | 33.08 | 36.34 | 36.12 |
| R 9227 | 38.42 | 33.96 | 32.00 | 34.79 |
| K 134 | 33.80 | 26.68 | 26.05 | 28.84 |
| D 39d | 34.64 | 32.25 | 26.92 | 31.27 |
| ICGV 92118 | 35.49 | 29.50 | 31.83 | 32.27 |
| ICGV 86031 | 49.63 | 29.18 | 49.28 | 42.70 |
| ICGV 86635 | 37.05 | 31.68 | 33.48 | 34.07 |
| ICGV 92113 | 45.24 | 32.50 | 38.44 | 38.73 |
| ICGV 92120 | 33.78 | 28.03 | 31.29 | 31.03 |
| ICGV 93260 | 32.77 | 26.27 | 30.20 | 29.75 |
| ICGV 93261 | 33.47 | 27 05 | 29.39 | 29.97 |
| ICGV 93269 | 51.40 | 36.67 | 42.07 | 43.38 |
| ICGV 93277 | 33.22 | 29.63 | 27.42 | 30.09 |
| Mean | 36.77 | 30.13 | 32.33 | 33.07 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.206 | 0.808 | 1.1 |
| Genotype(G) | 0.890 | 2.548 | 4.7 |
| G X T | 1.704 | 4.773 | 9.6 |
| G at the same level of T | 1.740 | 4.877 | |
| T at the same level of G | 1.797 | 5.060 | |

TABLE 29: Mean sound mature kernel percentage in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 81.67 | 74.67 | 74.33 | 76.89 |
| TMV 2 | 76.67 | 74.33 | 62.67 | 71.22 |
| KRG 1 | 73.33 | 73.33 | 68.67 | 71.78 |
| R 8808 | 86.67 | 80.00 | 72.67 | 79.78 |
| S 206 | 77.33 | 75.67 | 71.33 | 74.78 |
| R 9251 | 72.67 | 73.67 | 61.67 | 69.33 |
| R 9214 | 76.00 | 81.33 | 73.33 | 76.89 |
| TAG 24 | 74.67 | 68.67 | 71.33 | 71.56 |
| R 9227 | 74.33 | 72.33 | 55.33 | 67.33 |
| K 134 | 85.67 | 73.33 | 64.33 | 74.44 |
| D 39d | 78.67 | 77.67 | 70.00 | 75.44 |
| ICGV 92118 | 76.00 | 69.33 | 51.67 | 65.67 |
| ICGV 86031 | 78.33 | 68.67 | 79.67 | 75.56 |
| ICGV 86635 | 77.67 | 65.33 | 65.33 | 69.44 |
| ICGV 92113 | 80.67 | 71.00 | 70.33 | 74.00 |
| ICGV 92120 | 84.00 | 74.33 | 72.33 | 76.89 |
| ICGV 93260 | 76.33 | 72.67 | 70.67 | 73.22 |
| ICGV 93261 | 80.00 | 69.67 | 59.33 | 69.67 |
| ICGV 93269 | 86.00 | 71.67 | 70.67 | 76.11 |
| ICGV 93277 | 69.00 | 65.00 | 69.00 | 67.67 |
| Mean | 78.28 | 72.63 | 67.73 | 72.88 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 1.911 | 7.505 | 4.5 |
| Genotype(G) | 2.221 | 6.358 | 5.3 |
| G X T | 4.265 | 12.052 | 9.4 |
| G at the same level of T | 3.914 | 10.965 | |
| T at the same level of G | 4.296 | 12.177 | |

9251, TAG 24, R 9227, ICGV 93277 recorded significantly lower SMK% than R 8808. The last being the lowest (69.00). Under MSD, R 9214 (81 33) recorded the highest SMK percentage and ICGV 93277 (65.00) followed by ICGV 86635 (65 33) the least TAG 24, and ICGVs 92118, 86031, 86635, 93261, and 93277 recorded significantly lower SMK% than ICGV 93277 Under ESD, SMK percentage observed was the highest in ICGV 86031 (79 67) and it was significantly greater than the eight genotypes, TMV 2, KRG 1, R 9251, R 9227, K 134, ICGVs 92118, 86635, and 93261.

### 4.4.20 Oil content

Oil content was significantly reduced only under ESD (40 45) (Table 30) Under normal condition, oil content estimated was the highest in D 39d (48 80) and it did not differ significantly from ICGV 86031, ICGV 92113 and ICGV 93269 But ICGV 92118 (39 30) and R 9251(39.92) recorded the lowest. Under MSD, D 39d (47 22) maintained the highest oil content and R 9251(40.53) was the lowest D 39d did not differ significantly from genotypes viz., JL 24, TAG 24, S 206, R 9227, ICGV 86031, 93269, and 92120 Under ESD, ICGV 86031 (45 20) and D 39d (45.11) had the higher oil percentage and they did not differ significantly from ICGVs 92113, 92120, and 93269. ICGV 86635 (36 60) exhibited the lowest oil percentage

TABLE 30: Mean oil content(%) in 20 groundnut genotypes studied under 3 drought regimes, ICRISAT Center, 1999-2000.

| Genotype | No drought | Mid-season drought | End-season drought | Mean |
|---|---|---|---|---|
| JL 24 | 43.41 | 44.99 | 40.20 | 42.87 |
| TMV 2 | 43.02 | 42.02 | 38.78 | 41.28 |
| KRG 1 | 45.14 | 44.02 | 40.63 | 43.26 |
| R 8808 | 44.08 | 44.42 | 40.62 | 43.04 |
| S 206 | 44.17 | 44.62 | 37.66 | 42.15 |
| R 9251 | 39.92 | 40.53 | 37.16 | 39.21 |
| R 9214 | 44.70 | 44.39 | 40.40 | 43.16 |
| TAG 24 | 43.70 | 45.53 | 41.87 | 43.70 |
| R 9227 | 43.16 | 45.00 | 39.97 | 42.71 |
| K 134 | 44.30 | 44.32 | 37.53 | 42.05 |
| D 39d | 48.80 | 47.22 | 45.11 | 47.04 |
| ICGV 92118 | 39.30 | 41.33 | 38.29 | 39.64 |
| ICGV 86031 | 47.77 | 44.98 | 45.20 | 45.98 |
| ICGV 86635 | 42.46 | 42.52 | 36.60 | 40.53 |
| ICGV 92113 | 47.33 | 46.46 | 43.74 | 45.84 |
| ICGV 92120 | 44.68 | 45.86 | 43.51 | 44.68 |
| ICGV 93260 | 43.10 | 42.20 | 39.80 | 41.70 |
| ICGV 93261 | 43.28 | 43.05 | 38.78 | 41.70 |
| ICGV 93269 | 46.87 | 44.80 | 43.53 | 45.07 |
| ICGV 93277 | 41.89 | 42.36 | 39.56 | 41.27 |
| Mean | 44.05 | 44.03 | 40.45 | 42.84 |

| | SEm± | LSD(0.05P) | CV(%) |
|---|---|---|---|
| Drought treatment(T) | 0.516 | 2.025 | 2.1 |
| Genotype(G) | 0.557 | 1.593 | 2.3 |
| G X T | 1.057 | 3.001 | 3.8 |
| G at the same level of T | 0.947 | 2.652 | |
| T at the same level of G | 1.050 | 2.989 | |

# DISCUSSION

# V DISCUSSION

Groundnut is a leading oilseed crop in India it is primarily grown in the ***kharif*** season It suffers from several biotic and abiotic constraints, which keep its productivity in the ***kharif*** season low. Drought is the most significant constraint that affects groundnut productivity in rainfed agriculture. Drought resistance breeding in most crops is based on empirical approach, which has given only limited success Recently, various physiological traits such as specific leaf area and specific leaf nitrogen content have been reported to be associated with water-use efficiency in groundnut (Wright *et al*., 1994; Nageswara Rao and Wright, 1994 and Nageswara Rao *et al*, 1995) Instead of empirical approach, if the selection for drought resistance is trait based, the success in developing resistance genotypes will be high and more assured

For a successful planning of a breeding programme, knowledge of the extent and nature of genetic variability present in genetic resources for the desired traits is essential Further, how these traits are associated with each other and with yield decide the selection strategy, which a breeder should follow. In the present study 20 groundnut genotypes were evaluated for their response to imposed drought during rabi / summer season Results obtained are discussed under the following headings

**5.1 Analysis of variance**

**5.2 Genetic parameters: variability, heritability and genetic advance**

**5.3 Correlation coefficients**

**5.4 Effect of drought treatment on different characters**

**5.5 *Per se* performance of genotypes.**

## 5.1 Analysis of variance

Genotypes included in the study had significant variation for all the traits except for RWC at 90 DAS For most of these traits, previous studies also reported significant genotypic differences Like for PDM (Mathews *et al*, 1986), for SLA (Nageswara Rao and Wright, 1994 and Jayalakshmi *et al.*, 1999), for CGR and LI (Nam, *et al*, 1998) and for pod yield (Del Rosario and Fajardo, 1988, Chavan *et al.*, 1992 and Nageswara Rao *et al*, 1989) Some studies also reported no genotypic differences for some traits like for RWC (Ketring, 1986) and for hundred Kernel weight (Vanangamudi, 1987) Presence of significant genotypic variation allows a breeder to select suitable diverse material for use in the breeding programme

Drought treatments also affected all the traits significantly except for SLA at harvest and NIMP However, Nageswara Rao and Wright (1994) reported significant differences for SLA due to irrigation treatments And similar result was reported for hundred kernel weight due to six moisture stress treatments by Vanangamudi (1987)

Highly significant G x D interaction for NIMP, Pod yield, shelling percentage, CGR, HI, RWC at harvest, and LI at harvest indicated a differential response of genotypes to different drought situation A detailed scrutiny of genotypes across drought treatments for these characters may give a better picture of their response and help in selection of better genotypes Significant genotype X drought interaction was reported earlier for pod yield (Nageshwara Rao *et al.*, 1989 and Parmar *et al.*, 1989) For the rest of the characters, non significant G x D interaction was observed, implying that genotypic differences for these traits were consistent across the drought environments Similar results were reported for SLA (Nageshwar Rao and Wright, 1994) and hundred kernel weight (Vanangamudi, 1987 )

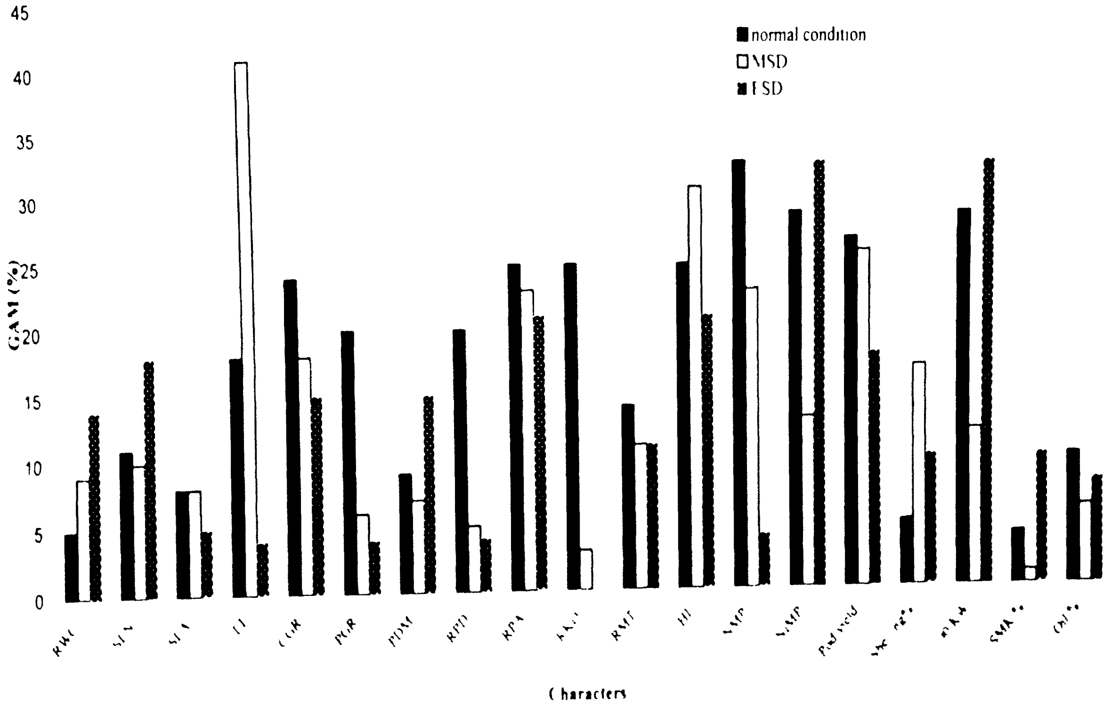
## 5.2 Genetic variability, heritability and genetic advance

Genetic advance is the measure of genetic gain under selection The genetic advance under selection depends on three main factors like genetic variability, heritability, and selection intensity. Therefore, a high genetic advance may be attributed either due to high genetic variability or heritability or due to both If a character shows high genetic advance, selection will be rewarding for improvement of such trait

Among physiological parameters, under normal condition, a high GAM was exhibited for CGR, PGR, RPD, RPA, RKD, and HI, which imply that selection for these characters could be effective for further improvement (Fig 2) The high GAM for RPA and HI was mainly due to high heritability. Sharma and Varshney (1995) reported high genetic variability, broad sense heritability, and GA for HI. The rest of the characters like RWC, SLN, SLA, LI, and PDM showed a moderate and low GAM, which indicated the existence of limited scope for selection of these characters in the materials included in the study

But under stress condition, characters for which GAM deviated from that under normal condition, namely for LI, GAM was substantially increased under MSD It was due to high heritability and high magnitude of variation But under ESD, GAM was enhanced for RWC, SLN, and PDM, mainly due to high heritability and for RWC, it was also due to increase in magnitude of variation. Therefore, a better scope exists for these characters for improvement under respective drought conditions. GAM decreased markedly for LI under ESD, and for PGR, RPD, and RKD under both the stress conditions. Even though these characters showed potential under normal condition, but limited scope exists for their selection under respective stress conditions.

Fig. 2 GAM (%) of different characters under three drought condition



From this study, it is concluded that the physiological characters that have potential for improvement of genotypes are CGR, RPA and HI under both the stress conditions, and LI under MSD and RWC, SLN and PDM under ESD

For yield components, under normal condition, the characters that showed their potential for selection in breeding programme, are NMP, NIMP, hundred kernel weight, and pod yield, as these exhibited a high GAM High GAM was mainly because of high PCV and low heritability for NMP, and NIMP, high PCV and moderate heritability for pod yield, and moderate PCV and high heritability for hundred kernel weight Similar results were reported for GAM by Reddi *et al.* (1986), Singh (1998) for NMP, Chaudhary (1993) for NIMP, Hossain and Islam (1989) Reddy *et al.* (1987) and Singh (1998) for pod yield and Deshmukh *et al* (1987), Manoharan *et al.* (1990 and 1993), Manoharan and Ramalingam (1993), and Reddi *et al* (1991) for hundred kernel weight and for heritability by Reddy *et al.* (1995) for NMP, Deshmukh *et al* (1987), Manoharan *et al.* (1990 and 1993) and Reddi *et al* (1991) for hundred kernel weight and for PCV Ali *et al* (1996) and Bansal *et al.* (1992) for pod yield during kharif season In contrast to this reported high heritability for NIMP (Chaudhary, 1993), and for NMP (Reddi *et al.*, 1986 and Singh, 1998), and for pod yield (Ali *et al*, 1996, Bansal *et al*, 1992, Hossain and Islam, 1989, Reddy *et al.*, 1987, Singh 1998 and Kale and Dhoble, 1998) and moderate heritability for NMP (Manoharan *et al.*, 1993) and low heritability for pod yield (Manoharan *et al*, 1993) and high PCV for 100 kernel weight.

Low GAM was observed for oil percent, SMK percentage and shelling percentage, which indicates the limited scope for selection in the material under normal condition Similar results for GAM were reported for SMK percentage (Manoharan *et al.*, 1990), for oil content (Deshmukh *et al.*, 1987; Manoharan *et al.*, 1993 and Nadaf and Habib, 1987) and for shelling percentage (Deshmukh *et al.*, 1987, Manoharan *et al.*, 1990, Nadaf and Habib, 1987 and Reddy 1994). In contrast to this, high GAM was reported for SMK percentage (Reddy *et al.*, 1987, Reddi *et al.*, 1991) and for shelling percentage (Reddy *et al* , 1987)

But for some characters, potential of selection under stress condition deviated from that under normal condition, viz , shelling percentage, which gained its scope in improvement of genotypes under MSD, as GAM was enhanced This reflected due to high heritability But for the characters, NIMP, and hundred kernel weight, GAM declined under MSD and for NMP under ESD Because of this, though they expressed potential under normal condition, they lost it under respective stress conditions A decrease in heritability for all these and also a decrease in magnitude of variation for hundred kernel weight resulted in low GAM Chavan and Dhoble (1994) reported moderate heritability for pod yield and high heritability for 100 kernel weight under both the water stress and normal condition and higher GAM for 100 kernel weight under water stress than normal Reddy and Gupta (1992) reported high PCV, heritability and GAM for NMP and pod yield and high heritability for shelling percentage and 100 kernel weight under all the three simulated environments

From the variability studies, it revealed that, there is a scope to improve the genotypes based on the potential characters like pod yield under both the stress conditions, NMP and shelling percentage under MSD and NIMP, hundred kernel weight under ESD

## 5.3 Correlation studies

Correlation among traits shows their interdependence. An understanding of the inter relationships of pod yield with yield influencing traits and physiological parameters is vital under normal and drought condition to gain an understanding of physiological basis of drought tolerance Further this would facilitate effective selection for simultaneous improvement in one or more yield influencing components and physiological parameters under drought conditions

Pod yield was positively associated with SLN at harvest, PGR, RPD, RKD, LI at 90 DAS and CGR under normal condition, selection for higher values for strongly associated characters results in higher pod yield Therefore, these characters under normal condition could be used as an indirect measure of pod yield Chhonkar and Arvind kumar (1987) reported positive association of yield with CGR at 60-90 DAS

Significant and negative correlation of yield with SLA, RPA, and NIMP was observed under normal condition. SLA is an indirect and inexpensive measure of WUE, which contributes to productivity when water resources are scarce (Wright *et al*, 1994 and 1998) Low SLA indicates thick leaves and more WUE Genotypes with thick leaves (low SLA) have better WUE and reflect high pod yield.

Most of the associations, which existed under normal condition, disappeared under MSD that started at the beginning of reproductive phase Under MSD, yield was negatively and significantly associated only with RWC at 90DAS, SLA at harvest, and RPA Genotypes with thick leaves, low leaf water retention, and slow rate of pod addition tended of have higher pod yield

But under ESD, yield was positively associated with SLN at harvest, RKD, RPD, PGR, hundred kernel weight and SMK percentage As ESD coincides with seed development and pod maturation, they are severely affected due to moisture stress and result in low yield Therefore selection based on these characters under ESD will bring about improvement in yield

Surprisingly, HI, NMP, and shelling percentage, which have a direct bearing on pod yield (Manoharan *et al.*, 1990; Lakshmaiah *et al.*, 1978, Badwal and Harbans Singh, 1973; Deshmukh, 1986; Nagabhushanam, 1981, Reddi *et al.*, 1986, Reddi *et al.*, 1991, Badwal and Harbans Singh, 1973 and Reddi *et al.*, 1986) did not show any association with it in the present set of material. Rapid pod and kernel development, which result in synchronous maturity ensure high pod yield under both normal and ESD conditions From a perusal of various associations under normal, MSD, and ESD conditions, the associations of pod yield with SLN at harvest, SLA at 90 DAS and at harvest was stable These characters can easily be measured In segregating populations where plant numbers are large, SPAD values can provide an effective and efficient screening tool for high yield under normal and ESD conditions

## 5.4 Effect of drought on different characters

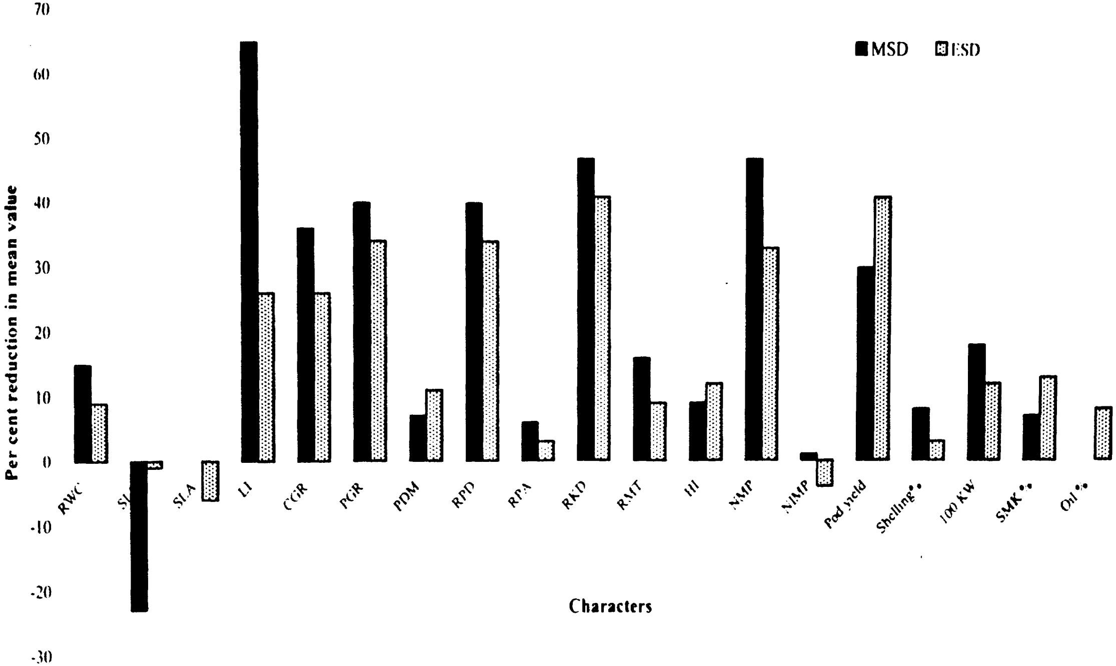
The drought had significant influence on most of the characters studied (Table 31 and Fig. 3). LI at harvest, CGR, PGR, PDM, RPD, RKD, RMT, HI, NMP, pod yield, shelling percentage, and hundred kernel weight were significantly reduced under both the drought conditions. PDM, NMP, and pod yield were more sensitive to ESD Oil content and SMK percentage were also reduced significantly under ESD RWC at harvest and SLN at harvest showed differential response to two drought treatments Both of them increased under MSD but the former declined at ESD and the latter remained unaffected RWC and SLA at 90 DAS showed significant decline but SLN showed a significant increase under MSD SLA at harvest remained unaffected with drought treatments and could probably be used as a stable measure of yield and other drought related traits.

Table 31. Effect of drought on different characters

| Characters | Normal mean | MSD mean | %reduction | ESD mean | % reduction | C.D. value |
|---|---|---|---|---|---|---|
| RWC at 90DAS | 86.41 | 73.20 | 15.29* | | | 1.755 |
| RWC at harvest | 83.95 | 85.43 | -1.88* | 76.34 | 9.06* | 1.459 |
| SLN at 90DAS | 40.17 | 49.38 | -22.92* | | | 2.146 |
| SLN at harvest | 38.86 | 41.75 | -7.44* | 39.16 | -0.77 | 1.901 |
| SLA at 90DAS | 149.7 | 137.5 | 8.15* | | | 5.262 |
| SLA at harvest | 138.0 | 143.2 | -3.77 | 145.9 | -5.72 | 9.92 |
| LI at 90DAS | 78.0 | 27.10 | 65.26* | | | 12.449 |
| LI at harvest | 77.52 | 31.80 | 58.98* | 57.46 | 25.88* | 3.751 |
| CGR | 11.807 | 7.572 | 35.87* | 8.697 | 26.34* | 1.487 |
| PGR | 4.254 | 4.254 | 39.70* | 4.622 | 34.49* | 0 9370 |
| PDM | 0.6028 | 0.5608 | 6.97* | 0.5338 | 11 45* | 0.02607 |
| RPD | 4.272 | 2.578 | 39 65* | 2.802 | 34.41* | 0.5676 |
| RPA | 0.010 | 0.0094 | 6.00* | 0.0097 | 3.00 | 0 00037 |
| RKD | 2.961 | 1.585 | 46.47* | 1.737 | 41.34* | 0.3821 |
| RMT | 0.8463 | 0.7085 | 16.28* | 0.7702 | 8.99* | 0.03784 |
| HI | 52.01 | 47.20 | 9.25* | 45.70 | 12.13* | 4.133 |
| NMP | 9.333 | 4.977 | 46.67* | 6.230 | 33.25* | 2.122 |
| NIMP | 16.26 | 16.07 | 1.17 | 16.94 | -4.18 | 3.852 |
| Pod yield | 755.8 | 531 | 29.74* | 443.6 | 41.31* | 87.68 |
| Shelling % | 70.69 | 64.85 | 8.26* | 68.74 | 2.76* | 1.084 |
| 100 kernel weight | 36.77 | 30.13 | 18.06* | 32.33 | 12.08* | 0.808 |
| SMK % | 78.28 | 72.63 | 7.22 | 67.73 | 13.48* | 7.505 |
| Oil % | 44.05 | 44.03 | 0.05 | 40.45 | 8.17* | 2.025 |

* significant at 5% level

**Fig. 3 Per cent reduction of mean for different characters under MSD and ESD over that under normal condition**



Similar results of reduction under moisture stress condition were reported for RWC (Ravindra *et al.*, 1990), LI (Collinson *et al*, 1996 and Nam *et al*, 1998), for CGR (Srinivasan *et al*, 1987), for HI (Chavan *et al*, 1992), for NMP, and shelling percentage (Patel and Golakiya, 1988 and Golakiya and Patel, 1992), for pod yield (Nageswara Rao *et al*, 1985, Chavan *et al*, 1992, Collinson *et al*, 1996; Polara *et al*, 1984 and Ravindra *et al*, 1990), for hundred kernel weight (Padma and Subbarao, 1992, Andani Gowda and Hegde, 1986 and Vanaganamudi *et al*, 1987), for SMK percentage (Pallas *et al*, 1979), and for oil content (Padma and subbarao, 1992 )

When the magnitude of reduction is considered in terms of percentage, among the characters, LI was most severely affected during MSD (65 26% at 90 DAS and 58 98% at harvest) Other severely affected characters were RKD, NMP, CGR, RPD, PGR, and pod yield These characters are most sensitive to moisture stress

## 5.5 *Per se* performance

The information on *per se* performance of the genotypes is of basic importance in selecting better parents for any crop breeding programme In present study, the results of *per se* performance of genotypes for yield and its attributes are briefly discussed here under

Under normal condition, ICGV 86031 and R 9227 were in the highest yielding group It may be due to higher potential of these genotypes for pod yield than the other genotypes Under both the stress conditions, ICGV 86031 maintained its high yield, but R 9227 was sensitive to ESD Other genotypes which did well under MSD included ICGV 93260, R 9214, and others under ESD, R 8808, TMV 2, KRG 1, ICGVs 93261, 93269 and 93277 faired well for this trait Whether these genotypes performed well due to their early maturity in addition to efficient water utilization cannot be ascertained from the present study.

When percent yield reduction was considered, it was more under ESD (42.82) than MSD (31.55) (Table 32). All genotypes exhibited this trend of percent reduction except JL 24, TMV 2, and TAG 24, which showed higher reduction under MSD. It may be due to their earliness in maturity as compared to other genotypes.

The genotypes, which showed less percent yield reduction than the mean reduction under both the stress conditions, were R 8808, R 9251, K 134, ICGVs 92113, 93261, 93269 and 93277 under MSD, S 206, R 9214 and D 39d and under ESD genotypes namely JL24, and TMV 2 They were tolerant to respective stress conditions

But when the percent yield reduction and pod yield were considered together, the genotypes with less percent yield reduction and high yield potential under both the stress conditions were KRG 1, R 9251, and ICGVs 93261, 93269, 93277 and 92120 and ICGV 92113 and S 206 under MSD (Fig. 4 and 5), which implies that these genotypes were more efficient in utilizing moisture for growth and yield under respective moisture stress conditions. ICGV 86031 and R 9214 recorded the highest yield under both the stress conditions but when percent yield reduction was observed it was slightly higher than the mean reduction in them. Nageshwara Rao *et al.* (1989) also identified groundnut genotypes having high yield potential with low sensitivity to drought. High yield and less sensitivity of these genotypes were attributed due to different characters (Table 33). Therefore, selection of these genotypes in breeding programme may be helpful in developing varieties with improved drought tolerance.

For individual characters, some genotype showed superiority, which are listed in Table 34. These genotypes, though they are better for these characters, but are low yielders.

Table 32: Per cent yield reduction under stress condit over that under normal condition

| Genotype | yield in normal condition (g/plot) | Per cent yield reduction | |
|---|---|---|---|
| | | MSD | ESD |
| JL 24 | 590.9 | 53.56 | 25.99 |
| TMV 2 | 730.5 | 52.66 | 33.26 |
| KRG 1 | 684.5 | 17.02 | 29.57 |
| R 8808 | 898.6 | 39.63 | 43.55 |
| S 206 | 645.4 | 11.47 | 44.45 |
| R 9251 | 548.3 | 20.24 | 21.56 |
| R 9214 | 896.3 | 24.67 | 45.59 |
| TAG 24 | 665.3 | 35.62 | 31.84 |
| R 9227 | 1080.4 | 41.48 | 63.91 |
| K 134 | 620.9 | 23.82 | 39.35 |
| D 39d | 614.5 | 18.37 | 44.18 |
| ICGV 92118 | 955.1 | 43.95 | 63.09 |
| ICGV 86031 | 1132.9 | 37.03 | 45.02 |
| ICGV 86635 | 761.8 | 32.95 | 56.97 |
| ICGV 92113 | 652.3 | 19.47 | 41.41 |
| ICGV 92120 | 781.7 | 32.90 | 33.07 |
| ICGV 93260 | 938.0 | 32.09 | 51.94 |
| ICGV 93261 | 791.4 | 28.65 | 38.11 |
| ICGV 93269 | 787.1 | 25.68 | 37.43 |
| ICGV 93277 | 739.3 | 22.28 | 35.47 |
| Mean | 775.8 | 31.55 | 42.82 |

**Fig. 4 Per cent reduction in pod yield under MSD and pod yield potential under normal condition**

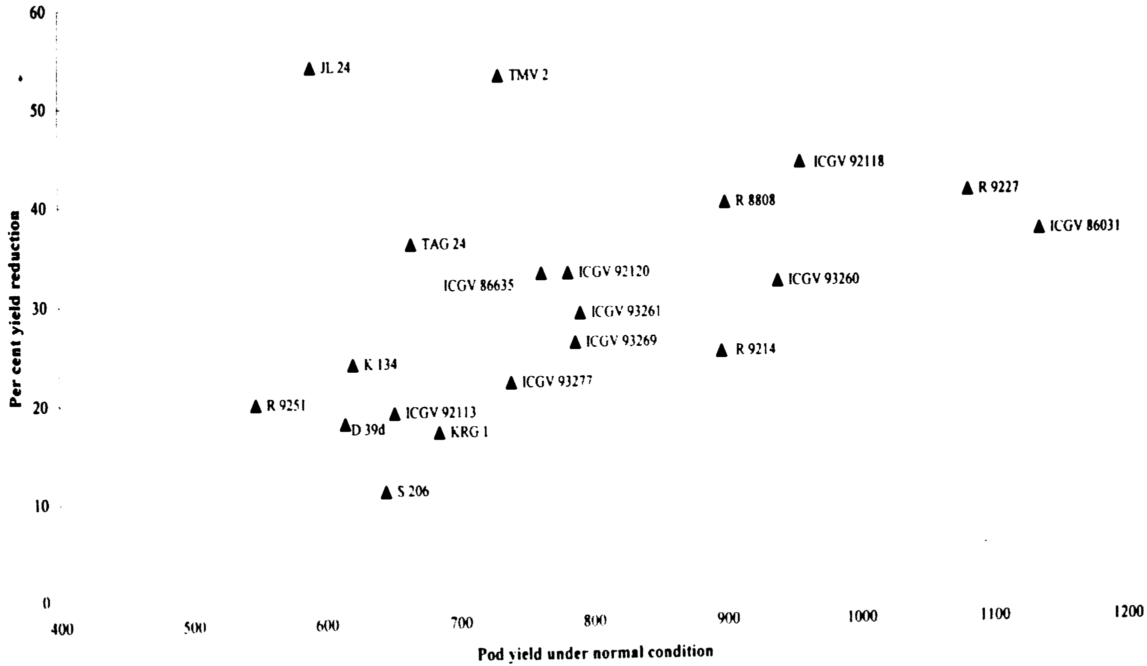


Fig. 5 Percent reduction in pod yield under ESD and pod yield potential under normal condition

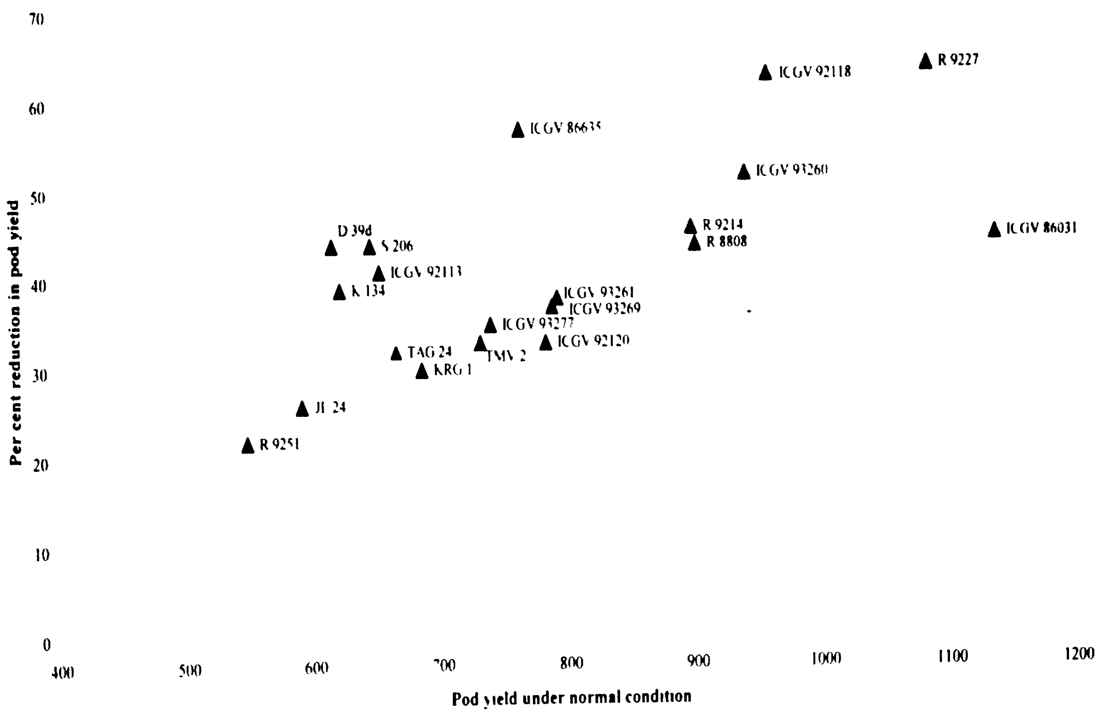


**Table 33: Genotypes which performed superior for yield and the characters which are atrributed for high yield**

| Genotype | Under both MSD and ESD | MSD | ESD |
|---|---|---|---|
| KRG 1 | LI,PDM,RPD,RKD,<br>NMP,Shelling % | RWC at harvest<br>SMK % | |
| R 9251 | RWC,PDM,RPD,RKD,<br>NMP,Shelling % | SMK % | LI, RPA, RMT,NIMP |
| ICGV 93261 | RWC,PDM,RKD,NMP | NIMP | Shelling %, RMT<br>RWC at harvest |
| ICGV 93269 | RWC,PDM,RPD,RKD,<br>NMP,Shelling%,100<br>kernel Weight,SMK%<br>oil% | NIMP | Shelling %, RMT<br>RWC at harvest |
| ICGV 93277 | RWC, PGR, PDM, RPD,<br>RMT, NMP | | SMK %, RKD |
| ICGV 92120 | RWC, RPD, RKD, NMP,<br>SMK%, Oil % | LI at 90 DAS | PDM |
| ICGV 92113 | RWC, LI, PDM, RKD,<br>SMK%, Oil % | CGR, RPD | |
| ICGV 86031 | RWC, PDM, RPD, RKD,<br>NMP,CGR,PGR,100 Ker<br>nel weight SMK %,<br>SLA, LI | | SMK% |
| R 9214 | PDM, RPD, LI,NIMP | | CGR, NMP |
| S 206 | NIMP, SMK %,<br>Shelling % | RPD, LI at 90<br>DAS, RWC, Oil% | RKD,RPA, NMP |

TABLE 34: Individual characters for which some genotypes showed superiority under MSD and ESD

| Characters | MSD | ESD |
|---|---|---|
| RWC | JL 24 | R 8808 |
| SLN | R 8808, R 9227 | TAG 24 |
| SLA | | R 9227 |
| LI | R 9227 | ICGV 92118, R 8808 |
| CGR | | TMV 2, R 9227 |
| PGR | | TAG 24, R 9227,TMV 2. |
| PDM | D 39d, TAG 24 | TAG 24 |
| RPD | | R 9227, TAG 24,TMV 2 |
| RPA | TAG 24 | TAG 24, TMV 2 |
| RKD | TAG 24 | R 9227, TAG 24 |
| RMT | TAG 24, TMV 2 | TAG 24, TMV 2 |
| NMP | K 134, TAG 24 | TAG 24 |
| Shelling % | D 39d | D 39d, K 134, R 8808 |
| 100 kernel weight | R 9227, TAG 24 | |
| SMK % | R 8808 | JL 24 |
| Oil % | D 39d | D 39d |

## Future line of work

(1) Genotypes which were identified as superior for drought tolerance should be tested again under different drought patterns to know their stability of high yield.

(2) Genotypes which exhibited superiority for individual characters can be used in breeding programme to incorporate these characters based on association of these with yield under moisture stress conditions.

# SUMMARY

# VI SUMMARY

The present investigation on 20 genotypes of groundnut was undertaken to evaluate their performance with respect to drought tolerance by evaluating for physiological parameters and yield components and to assess genetic variability, heritability and genetic advance for all characters under normal and drought conditions.

The experiment was conducted in a strip plot design during post rainy season of 1999-2000 at ICRISAT, Patancheru, Hyderabad. Observation recorded were leaf relative water content, specific leaf area, light interception, specific leaf nitrogen content, growth analysis for computation of various growth parameters, number of mature pods per plant, number of immature pods per plant, pod yield per plot, shelling percentage, hundred kernel weight, sound mature kernel percentage, oil percentage and harvest index, under three drought regimes.

Analysis of variance showed significant differences among genotypes for all the characters except RWC at 90 DAS and LI at 90 DAS. Drought treatments also differed significantly for all the characters except NIMP. Significant genotype X drought interaction existed for CGR, HI, RWC at harvest, LI at harvest, pod yield, shelling percentage and NIMP.

From genetic components studies, it is revealed that the characters, which have potential for improvement of genotypes, are CGR, RPA, HI, and pod yield under both the stress conditions, LI, NMP, shelling percentage under MSD, and NIMP, hundred kernel weight, RWC, SPAD, PDM under ESD, as these characters recorded high GAM under respective drought conditions.

Correlation studies indicated that under normal condition, yield was positively and significantly associated with SLN at harvest, PGR, RPD, RKD, LI at 90 DAS and CGR. It was negatively and significantly correlated with SLA, RPA, and NIMP. But under MSD, yield was negatively and significantly associated with RWC at 90 DAS, SLA at harvest and RPA. Where as under ESD, a strong association of pod yield with SLN at harvest, RKD, RPD, PGR, hundred kernel weight and SMK percentage was observed. Selection based on these characters can help in improvement of yield under respective drought conditions. Of all these parameters, SLN through SPAD chlorophyll meter is easily measured on plants in the field. SPAD meter can be successfully used for rapid screening for high yield under drought conditions.

Most of the characters were significantly affected by drought. When the magnitude of reduction was considered in percentage, among the characters, RKD, NMP, CGR, RPD, and PGR showed more sensitivity to drought stress conditions. Pod yield also reduced more under ESD than MSD.

Based on *per se* performance for yield, the genotypes which were identified as high yielder with low percent yield reduction were ICGV 86031,R 9214, ICGV 93261, 93269, 93277, and 92120, KRG 1, and R 9251 under both the stress conditions, and ICGV 92113 and S 206 only under MSD.

# REFERENCES

# VII REFERENCES


ALI, N., NAWAZ, M.S. AND BASHIR, K., 1996, Genetic variability, heritability and correlation studies in groundnut (*Arachis hypogaea* L.). *II International Crop Science Congress*, held at ICAR, New Delhi, 17-24, Nov 1996.

ANDANI GOWDA AND HEGDE, B.R., 1986, Moisture stress and hormonal influence on the flowering behaviour and yield of groundnut (*Arachis hypogaea* L). *Madras Agricultural Journal*, **73**: 82-86.

ARAUS, J.L., BORT, J., CACCARELI, S. AND GRANDO, S., 1997, Relationship between leaf structure and carbon isotope discrimination in field grown barley. *Plant Physiology and Biochemistry*, **35**: 533-541.

BADWAL, S.S. AND SINGH HARBANS, 1973, Effects of growth habits on correlations and path coefficients in groundnut. *Indian Journal of Genetics and Plant Breeding*, **33**: 101-111.

BANDHOPADHYAYA, A.A., GHOSH, P.K. AND MATHUR, R.K., 2000, Groundnut situation in India, the present scenario and future strategies. *Indian Farming*, **50**: 13-20.

BANSAL, U.K., SATIJA, D.R., AND GUPTA, V.P., 1992, Variability and Genotype x Environment interaction in relation to growth habit in groundnut. *Crop Improvement*, **19**: 42-47.

BASHIR, K., NAAZAR AND ALI MALIK, S.N., 1998, Estimation of variability and heritability for quantitative traits in groundnut. *Sarhad Jouranal of Agriculture*, **14**: 575-579.

BENNETT, J.M., BOOTE, K.J. AND HAMMOND, I.C., 1981, Alterations in the components of peanut leaf water potential during desiccation. *Journal of Experimental Botany*, **32**: 1035-43.

BENNETT, J.M., BOOTE, K.J. AND HAMMOND, I.C., 1984, Relationships among water potential components relative water content and stomatal resistance of field grown peanut leaves. *Peanut Science*, **11**: 31-35.

BHAGSARI, A.S., BROWN, R.H. AND SCHEPER, J.S., 1976, Effect of moisture stress on photosynthesis and some related physiological characteristics in peanut. *Crop Science*, **16**: 712-715.

BOOTE, K.J., STANSELL, J.R., SCHUBERT, A.M. AND STONE, J.F., 1982, Irrigation, water use and water relations in peanut science and technology. *American Peanut Research and Education Association*, Texas, pp. 164-205.

CHAUDHARY, S.K., 1993, Variability, heritability and genetic advance in groundnut under mid altitude condition. *Indian Journal of Hill Farming*, **6**: 171-174.

CHAVAN, A.A. AND DHOBLE, M.V., 1994, Studies on genetic variation in (*Arachis hypogaea* L.) under water stress and natural conditions. *Journal of Oilseeds Research*, **11**: 9-14.

CHAVAN, A.A., DHOBLE, M.V. AND KHATING, E.A., 1992, Effect of artificial water stress on different genotypes of groundnut (*Arachis hypogaea* L.) in dryland. *Indian Journal of Agricultural Sciences*, **62**: 376-381.

CHHONKAR, A.K. AND ARVIND KUMAR, 1987, Correlation and regression studies between different physiological attributes and pod yield in groundnut. *Journal of Oilseeds Research*, **4**: 132-135.

COLLINSON, S.T., AZAM ALI, S.N., CHAVULA, K.M. AND HODSON, D.A., 1996, Growth, development and yield of bambara groundnut (*Vigna subterranea*) in response to soil moisture. *Journal of Agricultural Science*, **126**: 307-318.

CRISWELL, J.G. AND SHIBLES, R.M., 1971, Physiological basis for genotypic variations in net photosynthesis of oat leaves. *Crop Science*, **11**: 550-553.

DEL ROSARIO, D.A. AND FAJARDO, F.F., 1988, Morphophysiological responses of ten peanuts (*Arachis hypogaea*. L) varieties to drought-stress. *The Philippine Agriculturist*, **71**: 447-459.

DESHMUKH, S.N., BASU, M.S. AND REDDY, P.S., 1986, Genetic variability, character association and path coefficient of quantitative traits in Virginia bunch varieties of groundnut. *Indian Journal of Agricultural Sciences*, **56**: 816-821.

DESHMUKH, S.N., BASU, M.S. AND REDDY, P.S., 1987, Influence of various vegetative and reproductive attributes on yield of Virginia runner groundnut. *Journal of Oilseeds Research*, **4**: 215-219.

DHOPTE, A.M. AND RAMTEKE, S.D., 1994, Relative variation in dry matter partitioning of peanut genotypes under moisture stress conditions. *Annals of Plant Physiology*, **8**: 174-178.

DIXIT, P.K., BHARGAVA. P.D., SAXENA, D. K. AND BHATIA, L. K., 1970, Estimates of genotypic variability of some quantitative characters in groundnut (*Arachis hypogaea* L.). *Indian Journal of Agricultural Sciences*, **40**: 197-202.

DONALD, C.M., 1962, In search of yield. *Journal of Australian Institute of Agricultural Science*, **28**: 171-178.

DORNHOFF, G.M. AND SHIBLES, R.M., 1976, Leaf morphology and anatomy in relation to $CO_2$ exchange rate of soybean leaves. *Crop Science*, **16**: 377-381.

DUNCAN, W.G., MC CLOUD, D.E., MC GRAW, R.L. AND BOOTE, K.J., 1978, Physiological aspects of peanut yield improvement. *Crop Science*, **18**: 1015-1020.

EDNA ANTONY, DODDAMANI, M.B., MUMMIGATTI, U.V. AND CHETTI, M.B., 2000, Correlation studies in groundnut (*Arachis hypogaea* L.) genotypes. *Crop Research*, **19**: 535-537.

FLOWER, D.J. AND LUDLOW, M.M., 1986, Contribution of osmotic adjustment to the dehydration tolerance of water stressed pigeonpea (*Cajanus cajan L.*Millsp.) leaves. *Plant Cell and Environment*, **9**: 33-40.

GAJJAR, R.B., SHEKH, A.M. AND PATEL, N.M., 1994, Response of groundnut genotypes to photosynthetically active radiation. *Annals of Arid Zone*, **33**: 223-227.

GIBBONS. R.W., 1980, The ICRISAT groundnut program. *Proceedings of International Workshop on Groundnut* Patancheru India 13-17 oct International Crops Research Institute for the Semi-arid Tropics, Andra Pradesh, India. pp. 12-16.

GOLAKIYA, B.A. AND PATEL, M.S., 1992, Growth dynamics and reproductive efficiency of groundnut under water stress at different phenophase. *Indian Journal of Agricultural Research*, **26**: 179-186.

GOLAKIYA, B.A., 1993, Drought response of groundnut VII. Identification of the critical growth stages most susceptible to water stress. *Advances in Plant Sciences*, **6**: 20-27.

GREENBERG, D.C. AND NDUNGURU, B.J., 1989, Groundnut drought-simulation studies at ICRISAT Sahelian center. *International Arachis Newsletter*, **6**:10-12.

GREENBERG, D.C., WILLIAMS, J.H. AND NDUNGURU, B.J. 1992, Differences in yield determining processes of groundnut (*Arachis hypogaea* L.) genotypes in varied drought environments. *Annals of Applied Biology*, **120**: 557-566.

GUPTA, S.K., BHATIA, V.S., SINGH, D.N. AND GANGULY, S.B., 1989, Genotypic variation and relationship of specific leaf weight with photosynthesis in Chickpea (*Cicer arietinum* L.). *Indian Journal of Plant Physiology*, **32**: 224-227.

HARRIS, D., MATTHEWS, R.B., NAGESWARA RAO, R.C. AND WILLIAMS J.H., 1988, The physiological basis for yield differences between four genotypes of groundnut (*Arachis hypogaea*) in response to drought. III. Developmental processes. *Experimental Agriculture*, **24**: 215-226.

HOQUE, M.S., MIA, F.U., NESSA, D. AND AZIMUDDIN, M., 1993, Correlation and path analysis in groundnut. *Bangladesh Journal of Agricultural Research*, **18**: 131-136.

HOSSAIN, K.G. AND ISLAM, M.S., 1989, Genetic variation and character association in groundnut (*Arachis hypogaea* L). *Bangladesh Journal of Plant Breeding and Genetics*, **2**: 27-30.

HUBICK, K.T., FARQUHAR, G.D. AND SHORTER, R., 1986, Correlation between water use efficiency and carbon isotope discrimination in diverse peanut (*Arachis*) germplasm. *Australian Journal of Plant Physiology*, **13**: 803-816.

JAGANNATH, N.H., NAGARAJA SETTY, M.V., BYRE GOWDA, M., BASAVARAJAIAH, D AND CHANDRAPRAKASH, J., 1999, Stability of genetic parameters under irrigated and stressful conditions for yield and its components in chickpea. *Crop Research*, **17** 367-370.

JAYALAKSHMI, V., RAJAREDDY, C., REDDY, P.V. AND NAGESWARA RAO, R.C., 1999 Genetic analysis of carbon isotope discrimination and specific leaf area in groundnut *Journal of Oilseeds Research*, **16**: 1-5.

JOHNSON, H.W., ROBINSON, H.F. AND COMSTOCK, R.E., 1955, Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*, **47**: 314-318.

JOSHI, Y.C., NAUTIYAL, P.C., RAVINDRA, V. AND SNETIC DWIVEDI, R., 1988, Water relations of two cultivars of groundnut (*Arachis hypogaea* L.) under soil water deficit *Tropical Agriculture (Trinidad)*, **65**: 82-184.

KALE, O.V. AND DHOBLE, M.V., 1988, Genetic variability and character association in groundnut varieties. *Journal of Maharastra Agricultural Universities*, **13**: 239-240.

KATARIA, V.P., RAO, S.K. AND KUSHWAHA, J.S., 1984, Yield components in bunch type of groundnut. *Mysore Journal of Agricultural Sciences*, **18**: 13-16.

KETRING, D.L., 1986, Physiological response to groundnut to temperature and water deficits-breeding implications. Agrometeorology of groundnut *Proceedings of an International Symposium*. pp. 135-145.

KIMANI, P.M., BENZIONI, A. AND VENTURA, M., 1994, Genetic variation in pigeonpea (*Cajanus Cajan* (L) Mill Sp.) in response to successive cycles of water stress. *Plant and Soil*, **158**: 192-201.

KRAMER, P.J., 1969, *Plant and soil water relationships: a modern synthesis*, Mc Graw Hill, New York, pp.25.

KUDUPLEY, S.D., 1977, Variability in physiological parameters and seed aminoacid contents of seventeen cultivars of groundnut and its correlation with yield. *M Sc.(Agri) thesis*, Punjabra Krishi Vidyapetha, Akola.

LAKSHMAIAH, B., 1978, Studies on the relationship between yield and its components in groundnut (*Arachis hypogaea* L.). *M.Sc.(Agri) Thesis*, Andhra Pradesh University, Hyderabad.

LUDLOW, M.M. AND MUCHOW, R.C., 1988, Critical evaluation of the possibilities of modifying crops for high production per unit of precipitation. *In Drought Research Priorities For The Dryland Tropics For The Dryland Tropics*, Ed. Bidinger F.R.and Johansen, Wiley and Sons, New York, pp. 179-211.

MA, B.L. AND DWYER, L.M. 1977, Determination of nitrogen status in maize senescing leaves. *Journal of Plant Nutrition*, **20**: 1-8.

MACKOWN, C.T. AND SUTTON, T.G., 1998, Using early-season leaf traits to predict nitrogen sufficiency of burley tobacco. *Agronomy Journal*, **80**: 21-27.

MANOHARAN, V. AND RAMALINGAM, R.S., 1993, Genetic parameters of quantitative traits in Virginia groundnuts. *Madras Agricultural Journal*, **80**: 716-718.

MANOHARAN, V., RAMALINGAM, R.S. AND KALAIMANI, S., 1990, Genetic advance and path analysis in the $F_2$ generation of an intrasubspecific cross in groundnut. *Indian Journal of Genetics and Plant Breeding*, **50**: 244-247.

MANOHARAN, V., RAMALINGAM, R.S. AND THAGAVELU, S., 1993, Heritability and genetic advance of some quantitative traits in Spanish bunch groundnuts. *Madras Agricultural Journal*, **80**: 37-39.

MATTHEWS, R.B., HARRIS, D., NAGESARA RAO, R.C., WILLIAMS, J.H. AND WADIA, K.D.R., 1988, The physiological basis for yield differences between four genotypes of groundnut (*Arachis hypogaea*) in response to drought. I. Dry matter production and water use. *Experimental Agriculture*, **24**: 191-202.

MISHRA, L.K. AND YADAV, R.K., 1992, Genetic variability and correlation studies in summer groundnut. *Advances in Plant Sciences*, **5**: 106-110.

NADAF, H.L. AND HABIB, A.F., 1987, Studies on genetic variability in bunch groundnut (*Arachis hypogaea*). *Mysore Journal of Agricultural Sciences*. **21**: 297-301.

NAGABHUSHANAM, G.V S , 1981, Studies on estimation of genotypic, phenotypic variability and analysis of character association in certain Spanish and Valencia genotypes of groundnut (*Arachis hypogaea* L ) *M.Sc.(Agri) Thesis,* APAU, Hyderabad

NAGESWARA RAO, R C , SARDAR SINGH, SIVAKUMAR, M V K , SRIVASTAVA, K L AND WILLIAMS, J H , 1985, Effect of water deficit at different growth phases of peanut I Yield responses *Agronomy Journal,* 77 782-786

NAGESWARA RAO, R C , UDAYKUMAR, M , FARQUHAR, G D , TALWAR, H S AND PRASAD T G , 1995, Variation in carbon isotope discrimination and its relationship to specific leaf area and ribulose-1,5, biphosphate carboxylase content in groundnut genotypes *Australian Journal of Plant Physiology,* **22** 545-551

NAGESWARA RAO, R C , WILLIAMS, J H AND MURARI SINGH, 1989, Genotypic sensitivity to drought and yield potential of peanut *Agronomy Journal,* **81** 887-893

NAGESWARA RAO, R C, WILLIAMS, J H, WADIA, K D R, HUBICK, K T AND FARQUHAR, G D , 1993, Crop growth, water use efficiency and carbon isotope discrimination in groundnut (Arachis *hypogaea* L ) genotypes under end-of-season drought conditions *Annals of Applied Biology,* **122** 357-367

NAGESWARA RAO AND WRIGHT, 1994, Stability of the relationship between specific leaf area and carbon isotope discrimination across environments in peanut *Crop Science,* **34** 98-103

NAM, N H , SUBBARAO, G V , CHAUHAN, Y S AND JOHANSEN, C , 1998, Importance of canopy attributes in determining dry matter accumulation of pigeonpea under contrasting moisture regimes *Crop Science*, **38** 955-961

ONG, 1986, Agroclimatological factors affecting phenology of groundnut *Proceeding of International Symposium*, ICRISAT, Patancheru, Andhra pradesh India, pp 115-126

PADMA AND SUBBARAO, 1992, Influence of irrigation on the composition and quality of groundnut genotypes *Journal of Oilseeds Research* **9** 159-163

PALLAS, J E , STANSELL, J R AND KOSKE, T J , 1979, Effects of drought on florunner peanuts *Agronomy Journal*, **71** 853-857

PARMAR, J V , PATEL, C L AND POLARA, K B , 1989, Influence of soil moisture stress at different stages of growth on yield response and nutrients in groundnut *Annals of Arid Zone*, **28** 267-270

PATEL, M S AND GOLAKIYA, B A , 1988, Effect of water stress on yield attributes and yield of groundnut *Indian Journal of Agricultural Sciences*, **58** 701-703

PATEL, M S AND GOLAKIYA, B A , 1991, Effect of water stress on yield attributes of groundnut (*Arachis hypogaea* L ) *Madras Agricultural Journal*, **78** 178-181

PATHAK, S R , PATEL, M S , QURESHI, A U AND GHODASARA, G V , 1988, Effect of water stress on yield and diurnal changes of biophysical parameters of groundnut *Legume Research*, **11** 193-195

PATIL, P S AND BHAPKAR, 1987, Estimates of genetic and phenotypic variability in groundnut *Journal of Maharastra Agricultural Universities*, **12** 319-321

PEARCE, R B , CARLSON, G E , BARNES, D K , HART, R H AND HANSON, C H , 1989, Specific leaf weight and photosynthesis in alfa alfa *Crop Science* **19** 16-23

POLARA, K B , PATEL, C L AND PATHAK, S R , 1984 Pattern of N, P and K accumulation in groundnut varieties as influenced by soil moisture stress at different stages of growth *Legume Research*, 7 95-100

PRABOWO, A , PRASTOWO, B AND WRIGHT, G C , 1990, Growth, yield and soil water extraction of irrigated and dry land peanuts in South Sulawesi, Indonesia *Irrigation Science*, **11** 63-8

RAO, T S , 1978, Heritable variation and inter-relationships of economic characters in groundnut *Genetica Iberica*, **30** 257-260

RAVINDRA, V , NAUTIYAL, P C AND JOSHI, Y C , 1990, Physiological analysis of drought resistance and yield in groundnut (*Arachis hypogaea* L ) *Tropical Agriculture (Trinidad and Tobago)*, **67** 290-296

RAZI, H AND ASSAD, M T , 1999, Comparison of selection criteria in normal and limited irrigation in sunflower *Euphytica*, **82** 83-90

REDDI, M V , REDDY, K R , REDDY, K H P AND RAO, J A , 1991, Heritability, genetic advance and character association in groundnut over three environments *Journal of Maharashtra Agiricultuaral Universities*, **16** 383-385

REDDI, M.V., SUBRAMANYAM, D., KRISHNAMURTHY, B., REDDY, J.R., REDDI, N.S. AND RAJ, A.D., 1986, Variability, heritability and genetic advance in Virginia cultivars of groundnut (*Arachis hypogaea* L.), *Indian Journal of Genetics and Plant Breeding*, **46**: 355-359.

REDDY, K.H.P., 1994, Variation in Spanish groundnut collection *Journal of Maharastra Agricultural Universities*, **19**: 452.

REDDY, K.R. AND GUPTA, R.V.S., 1992, Variability and inter relationship of yield and its component characters in groundnut. *Journal of Maharashtra Agricultural Universities*, **17**: 224-226.

REDDY, Y.M., REDDI, M.V., REDDY, J.T., REDDY, K.R. AND REDDY, D.R., 1987, Heritability and genetic advance in groundnut. *Journal of Research, APAU*, **15** 102-107

REDDY, G.L.K., REDDY, M.S.S., AND REDDY, P.R., 1995, Heritability estimates (narrow sense) utilizing F3, F4 and F5 progeny means of groundnut crosses. *Journal of Research APAU*, **23**: 1-2.

SHARMA, V.K. AND VARSHNEY, S.K., 1995, Analysis of harvest index in groundnut. *Journal of Oilseeds Research*, **12**: 171-175.

SIMPSON, G.M., 1981, *Water stress on Plants*, New York, USA, pp. 1-33.

SINCLAIR, T.R. AND LUDLOW, M.M., 1985, Who taught plants thermodynamics The unfulfilled potential of plant water potential. *Australian Journal of Plant Physiology*, **12**: 213-217.

SINGH, D N , 1998, Shift in heritability and character association within M₁ population of groundnut (*Arachis hypogaea*) *Annals of Agricultural Research*, **19** 98-99

SINGH, R K AND CHAUDHARY, B D , 1977, *Biometrical Methods in Quantitative Genetic Analysis*, Kalyani publishers, New Delhi, pp 20-22

SRINIVASAN, P S , SATHASIVAM, R , ARJUNAN, A , SETHUPATHI RAMLINGAM, R AND VAMAN BHAT, M , 1987, Effect of water stress on partitioning of dry matter and crop growth rate in relation to productivity in groundnut cultivars *Journal of Oilseeds Research*, **4** 89-96

TURNER, N C , 1986, Crop water deficits a decade of progress *Advances in Agronomy*, **39** 1-51

VANANGAMUDI, SUNDARAM, K M , MALLIKA VANANGAMUDI, BALAKRISHNAN AND NATARAJARATHAM, 1987, Influence of moisture stress at critical stages of crop growth on seed quality of groundnut cultivars *Journal of Oilseeds Research* **4** 9-12

VARISAI MOHAMMAD, S , RAMACHANDRAN, M ANO MOHAN BABU, G , 1973 Variation in kernel weight and shelling out-turn in *Arachis hypogaea* L *Madras Agricultural Journal*, **60** 1394-1398

WRIGHT, G C , HUBICK, K T AND FARQUHAR, G D , 1988, Discrimination in carbon isotopes of leaves correlates with water use efficiency of field grown peanut cultivars *Australian Journal of Plant Physiology*, **17** 815-825

WRIGHT, G.C., NAGESHWARA RAO, R.C. AND FARQUHAR, G.D., 1994, Water use efficiency and carbon isotope discrimination in peanut under water deficit conditions. *Crop Science,* **34**: 92-97.

YADAVA, T.P., KUMAR, P. AND THAKRAL, S.K., 1984, Association of pod yield with some quantitative traits in bunch group of groundnut (*Arachis hypogaea* L.). *Journal of Research, Haryana Agricultural University*, **14**: 85-88.

YAO, J.P., LUO, Y.N. AND YANG, X.D., 1982, Preliminary report on the effects of drought and seed development and quality of early groundnut. *Chinese Oil Crops*, **3**:150-52.