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Comparative Evaluation of Water Deficit Tolerance Capacity of Extra-early and Early Maize Genotypes under Controlled Conditions

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Abstract

Maize is an important staple food crop in Tropical Africa including Nigeria. However, the production of the crop is constrained by inadequate soil moisture resulting from erratic rainfall distribution. There is therefore the need to breed and select for drought tolerant genotypes for production especially in the southern Guinea savannah ecology responsible for over 60% of maize production in Nigeria. Controlled experiments using potted plants were therefore conducted during the dry periods between November 2007 and April 2008. The study evaluated moisture deficit tolerance capacity of two maize maturity groups, consisting of 15 extra-early and 12 early genotypes along with two local checks, subjected to two moisture levels 25% (stressed) and 100% (unstressed) soil available moisture) determined gravimetrically. Crop establishment parameters (% germination and mean germination time (MGT), morphological growth parameters (number and area of leaves, plant height, flowering characteristics), physiological growth indices (leaf area index, crop growth rate, relative growth rate, net assimilation rate and leaf area ratio) were measured during growth. Yield components (harvest index, shelling percentage and number of kernels per cob) and grain yield were determined at harvest. The data were analyzed using the general model of ANOVA and significant means were separated by the Least Significance Difference (LSD) at 5% probability level. The results showed that there were no appreciable differences between the two maturity groups for most measured parameters. However, across the two groups, crop establishment parameters, morpho-physiological growth parameters, yield components and grain yield were significantly reduced by soil moisture deficit, while flowering characteristics were significantly delayed by soil moisture stress with significant variable genotypic responses. Grain yield reduction due to water stress was significantly related to drought susceptibility index (DSI) of the genotypes in the two maturity groups. Conclusively, whereas extra-early genotypes showed good yield potentials but poor drought tolerance which suggested poor yield stability and therefore may not be suitable for the southern Guinea savanna (SGS) ecology in the event of severe stress. However, early genotypes, though showed lower yield potential, had good yield stability and hence are promising genotypes for the SGS ecology.

Keywords: Maize maturity group, Genotypes, Water deficit tolerance, Grain yield potential and stability, Drought susceptibility index

1. Introduction

Maize (*Zea mays* L) is a staple food for a vast number of people around the world. Although the crop has its origin in a semi-arid area, is not a reliable crop for cultivation under dry land conditions with limited or erratic rainfall (Arnon, 1972). Maize is the third most important cereal crop after wheat (*Triticum aestivum* L) and rice (*Oryza sativa* L) in terms of production in the world (IITA, 2009). Many studies have shown that maize has low drought tolerance capacity due to its high transpiration surface and poor root system. In Nigeria, notwithstanding the efforts of breeders and agronomists to develop high yielding cultivars (Fakorede, et al, 2001; Olakojo and Iken, 2001; Olaoye, et al, 2009) as well as improved production packages (Abayomi, 2004), the yield of maize in farmers' fields throughout the production regions, most especially the savannah ecologies of Nigeria is generally low averaging < 1.5 t ha^{-1}. This low productivity has been attributed to low soil fertility and drought stress. Drought stress is a major abiotic factor that limits agricultural production (Nemeth, et al 2002; Chaves and Oliveria, 2004; Jaleel, et al, 2009; Golbashy, 2010), more importantly in the rain-fed areas of the world (Nikus, et al., 2004). This is probably due to inhibited cell expansion and reduced biomass production (Ashraf & Mehmood, 1990). Frequent drought stress in the largely rain-fed agricultural system is therefore a major constraint limiting maize production in Nigeria.

One strategy to reduce the effect of water stress on crop yield is to use drought tolerant species and cultivars (Carrow, et al, 1990). This assertion was later supported by Siddique, et al. (2000), who reported that for the purpose of crop production, yield improvement and yield stability under water stress conditions, development of drought tolerant varieties is the best option. Crop plants are usually under stress at one time or another and the plant species able to withstand such stresses have great economic potential (Bibi, et al., 2010). Previous reports on drought tolerance in crops in literature show that variability in genotypic responses to water stress do occur in crops, for example in wheat (Moinuddin, et al. 2005), peanut (Upodhyaya, 2005), barley (Rizza, et al. 2004), soybean (Hufsteler, et al, 2007) and cowpea (Abayomi and Abidoye, 2009). These studies revealed that varieties/ genotypes in each species differed from each other in their responses to water stress conditions, suggesting that drought tolerance in such species may be improved through breeding.

When a large number of genotypes is available for screening against any stress condition, availability of a technique, which could rapidly and efficiently identify the varieties is important (Iqbal, et al, 2010). Although maize is susceptible to water deficit, there is a marked genotypic variations in root density, morphological and physiological characteristics in the crop, while Farhad, et al (2011) also reported that plant adaptation to drought involves both morphological and physiological alterations. It has been observed that water resources for agriculture are decreasing due to increase in demand for irrigation and other non-agricultural water uses (Bacon, 2004). As maize crop requires about 400 to 600 mm of water during its life cycle (Singh, 1991), water availability therefore imposes strong and recurring demand for screening maize genotypes for drought tolerance (Bohnert, et al., 1995). In their continual effort to improve maize production in the West and Central African sub-regions, the International Institute of Tropical Agriculture (IITA) and the West and Central Africa Maize Collaborative Research Network (WECAMAN) under the drought tolerant maize (DTMA) programme released some drought tolerant (DT) genotypes of different maturity groups for evaluation under rain-fed conditions. It was therefore the objective of the present study to screen some extra-early and early maize DT genotypes for moisture deficit tolerance under controlled conditions in a southern Guinea savannah ecology of Nigeria.

2. Materials and Methods

2.1 Experimental Location, Design and Treatment Application

The study was conducted during the dry periods between November 2007 and April 2008 at the crop pavilion of the Department of Agronomy, Faculty of Agriculture, University of Ilorin (8^o 39' N, 4^o 35'E) in the southern Guinea savannah ecology of Nigeria using potted plants. The study designed as a factorial experiment, evaluated the responses of two maize maturity groups (consisting of 15 extra-early (60-75 days) 12 early (75-90 days) genotypes) obtained from the IITA, Ibadan and two local checks, Afo and DMR-STR-Y (Table 1) to two soil water levels (25% (stressed) and 100% (unstressed) soil available moisture determined gravimetrically (Kramer, 1983). The factorial combinations of the two factors were replicated three times. Ten litre capacity plastic pots perforated at the bottom were filled with 10 kg top soil and thereafter laid out according to the randomization plans. Prior to planting, each pot was moistened with enough water to achieve the desired soil moisture content (25 or 100 % soil available moisture) following the randomization plans. Ten seeds of each genotype, treated with a fungicide, Apron Plus 50 DS (10% Metalaxy, 6% Carboxin and 14% Ferothiocarp) were planted in each pot at a depth of 2.5 cm. The resultant seedlings were later thinned to four per pot at two weeks after planting (WAP). Two of the seedlings were tagged for the collection of non-destructive data (plant height, number of

leaves per plant, flowering traits), while the other two plants were harvested at 4 and 6 WAP for the collection of dry matter. Inorganic fertilizer (NPK 15-15-15) was applied at a rate equivalent to 80 kg N/ha in two split applications at 2 and 6 WAP. Weed control inside and around the pots were done by regular hand pulling of emerging weeds.

2.2 Data Collection

Data collection included crop establishment obtained as seedling emergence counts from 3 to 9 days after planting (DAP) which were used to estimate percent germination and speed of germination as mean germination time (MGT in days) as described by Abayomi and Wright (1999). Morphological growth parameters (plant height, number of leaves and leaf area, tassel and silk appearances and pollen shed), physiological growth indices (crop growth rate, CGR; relative growth rate, RGR; net assimilation rate, NAR; leaf area ratio, LAR and leaf area index, LAI) were determined according to Hunts (1978) using leaf area and dry matter data collected at 4(t_1) and 6 (t_2) WAP as follows:

$NAR = (W_2-W_1)\ (\ln A_2- \ln A_1)/\ (A_2-A_1)(t_2-t_1)$; $CGR = (W_2-W_1)/\ (t_2-t_1)$;

$LAR = (A_2-A_1)(\ln W_2-\ln W_1)/(W_2-W_1)(\ln A_2-\ln A_1)$; RGR = NAR X LAR; LAI= leaf area/ ground area;

W_1 and W_2 = DM weights at t_1 and t_2, while A_1 and A_2 are the respective leaf area.

Yield components (harvest index (HI) = grain yield/biological yield; shelling percentage (SP) = grain weight/cob weight x 100 and number of kernels per cob) and grain yield were determined at harvest. To assess the drought tolerance of genotypes, percent yield reduction (PRED) was calculated as PRED = (Yp – Ys) /Yp x 100, while drought susceptibility index (DSI) was estimated using the expression (1 – Ys/Yp)/SI, where Ys = grain yield under stress; Yp = yield at normal soil moisture; SI = stress intensity = 1- mean yield of all genotypes under stress/mean yield of all genotypes at normal soil moisture, as described by Golabadi, et al (2006).

2.3 Statistical Analysis

All data were analyzed using the general model of the Analysis of Variance (ANOVA) with Genstat Discovery 3 and significant means were separated by the Least Significant Difference (LSD) at 5% probability level.

3. Results

3.1 Effects Genotypes and Moisture Deficit on Crop Establishment and Morphological Growth Parameters

The effect of maturity group was significant for percent germination under moisture deficit in favour of the extra-early genotypes, while there was no significantly difference in the percent germination of the two groups under normal soil moisture. However, MGT was similar for the two maturity groups under both soil moisture conditions (Table 2). Germination percent was higher with the extra-early genotypes, while MGT was lower with the group. Across the genotypes of the two groups, the effect of soil moisture levels was not significant for the two crop establishment parameters. There were significant variations among genotypes of each maturity group for crop establishment parameters. Among the extra-early genotypes, percent germination was highest with G11 and least with G2, while the highest and the lowest germination percent were obtained with G17 and G26 respectively among the early genotypes. Overall, germination was faster but slightly higher under normal soil moisture condition than under soil moisture deficit. Significant genotype x moisture level observed for the percent germination revealed that while moisture level had no significant effect on germination percent of most genotypes across the two maturity groups, the parameter was significantly reduced in G27 and increased in G28 by soil moisture deficit.

Results in Table 3 show that the effect of maturity group was significant for the morphological growth parameters. The number of leaves per plant and leaf area were higher with the extra-early genotypes, while the plant height was higher with the early genotypes. The effect of soil moisture deficit was significant for the plant height and leaf area, but not for the number of leaves per plant. The number of leaves per plant and consequently leaf area were significantly higher in the extra-early than in the early genotypes. However, the extra-early genotypes were significantly shorter than the early genotypes. The number of leaves was not significantly different between the well-watered and the stressed plants, even though the leaf area was significantly higher in the well-watered plants. Plant height was also significantly higher in the well-watered plants than in the stressed plants. The interactive effects of maturity group x soil moisture deficit was significant for the number of leaves per plant and leaf area, but not significant for the plant height. Results in Table 3 also show that the plant height and leaf area were higher with the well-watered than in the stressed plants.

The number of leaves and plant height were not significantly different among genotypes, while the LA varied significantly among them. Leaf area was significantly highest (3232 cm^2) with an extra-early genotype, G5, and

lowest (1241 cm^2) with G24, an early genotype, which value was however not significantly lower than the values obtained for G17, G18, G20, G22 and G25 (Table 3).

Both the tassel and silk emergences were not significantly influenced by the maturity group, but the anthesis and ASI differed significantly between the two groups (Table 4). While the anthesis was significantly earlier in the extra-early group, ASI was significantly smaller with the early group. Table 4 also shows that all flowering traits were significantly delayed by soil moisture deficit. The genotypes in the two groups varied significantly for most flowering traits, except ASI which values were not significantly different among genotypes of the two groups. Significant maturity group x moisture deficit effect observed for anthesis, silk appearance and ASI revealed that anthesis date was significantly longer with the early than the extra-early genotypes in well-watered plants, while there were no appreciable differences between the groups in stressed plants. Silk appearance was significantly delayed by soil moisture deficit in the extra-early genotypes, while the treatment has no significant effect on silk appearance of the early genotypes. Consequently, ASI was significantly increased by moisture deficit in extra-early genotypes, while there were no significant differences between the well-watered and stressed early maize genotypes. Significant moisture level x genotype effect obtained for the LA revealed that while LA was not significantly influenced in 5 genotypes, G10 (extra-early), G18, G22, G23 and G24 (early), the parameter was significantly reduced by soil moisture deficit in all other genotypes (Table 4).

3.2 Effects of Maize Genotype and Soil Moisture Deficit on Physiological Growth Indices

The two maturity groups were not significantly different for all physiological growth traits (Table 5), with the exception of LAI which was significantly higher in the extra-early than in the early genotypes (Table 6). However, all indices varied significantly ($p<0.001$) among genotypes and were significantly ($p<0.01$) reduced by soil moisture deficit, except RGR which values were similar for all genotypes and was not significantly ($p>0.05$) influenced by soil moisture (Table 5) and LAR which was significantly increased by moisture deficit (Table 6). Significant maturity group x moisture deficit for CGR showed that while the extra-early had significantly higher CGR value than the early genotypes in well watered condition, the earlier group showed significantly lower CGR than the later under moisture deficit condition (Table 5). Significant moisture level x genotype effect for CGR showed that moisture deficit significantly reduced CGR in most genotypes of the two maturity groups, except in 2 extra-early (G4, G10) and 7 early (G18, G19, G21, G22, G23, G25 and G26) genotypes which were not significantly influenced by soil moisture deficit (Table 5). Similar significant moisture level x genotype effect for LAR revealed that while LAR was significantly increased by soil moisture deficit in 5 extra-early (G2, G3, G5, G9 and G15) genotypes and 3 early (G18, G20 and G28), the parameter was not significantly influenced by soil moisture level in other genotypes (Table 6).

3.3 Effects Genotype and Soil Moisture Deficit on Yield Components and Grain Yield

The yield components of genotypes under normal and moisture deficit conditions are presented in Table 7, while grain yields under both moisture conditions, yield reduction due to moisture deficit and drought susceptibility index of genotypes are presented in Table 8. The harvest index was significantly ($p<0.05$) higher in the extra-early than in the early genotypes, while the shelling percent and number of kernels per cob were not significantly different for the two maturity groups (Table 7). All yield components were significantly reduced by soil moisture deficit across the genotypes of the two maturity groups. The values of HI and SP significantly varied among the genotypes of each maturity group, which however showed similar values for the number of kernels per cob (Table 7). Significant moisture level x genotype effect showed that HI was significantly reduced by moisture deficit in 7 extra-early (G8, G12, G13, 14, G15 and check 1, G16) and 2 early (G20 and check 2, G29) genotypes, while the parameter was not significantly affected by moisture level in other genotypes. Grain yield across moisture levels was insignificantly higher in the extra-early than in the early genotypes (Table 8). Table 8 also shows that grain yield was highest with G10 and lowest with G1 under moisture deficit. However, with adequate soil moisture, grain yield was highest with G8 and still lowest with G1. Significant maturity group x moisture deficit effect obtained for grain yield showed that grain yield was significantly higher in the extra-early than in the early genotypes when plants were well-watered, while there were no significant difference in grain yield of the two groups under soil moisture deficit (Table 8). Among the genotypes, percent grain yield reduction was highest with an extra-early (G8) and lowest with G22, an early genotype (Table 8). The results on percent grain yield reduction were similar to those of drought susceptibility index (DSI) which showed that DSI was higher with extra-early genotypes than in the early genotypes, and highest and lowest with G8 and G22 respectively, hence a significant positive relationships between the two parameters and / or negative relationships between grain yield under stress and drought tolerance index (Figure 1).

4. Discussion

Speed and quantum of germination are important prerequisites for the success of stand establishment in crop plants. Proper germination of planted seeds, the rate and degree of the subsequent seedling establishment are of great importance in determining both yield and time of maturity (Brigg and Aytenfisu, 1979). However, soil moisture deficit affects seed germination (Abayomi and Wright, 1999; Etejere, 2004), while the effects of moisture stress on seed germination had been shown to be crop species and genotype dependent (Abayomi, 1992). The results of the present study showed that germination percent and speed of germination (MGT) were significantly reduced under moisture deficit condition in all maize genotypes belonging to the two maturity groups evaluated. Significant maturity group x moisture deficit effect showed no significant differences in germination percent of the two maturity groups when adequately watered, while the extra-early genotypes germinated significantly better than the early genotypes when they were water-stressed. These results are in line with the early reports (Smith and Hoveland, 1986; Abayomi and Saliu, 1997; Abayomi and Wright, 1999) which showed that water stress affected germination by delaying its onset, slowing its rate and by decreasing the final germination percentage. The results also showed significant differences in germination between the two maturity groups and within the genotypes in consonance with the reports of Ashraf and Abu-Shakra (1978) who showed that the ability of seeds to germinate at low soil moisture was dependent on crop species and genotypes. The speed of germination was also significantly reduced (high MGT) by soil moisture deficit in the present study. This was similar to the reports of earlier workers (Abayomi and Mobolaji, 1995; Abayomi and Saliu, 1997; Abayomi and Wright, 1999; Smith, et al., 1989) who showed significant increase in MGT due to low available soil moisture. The decrease in germination rate as shown by high MGT with soil moisture deficit observed in the present study may be due to reduced water uptake by the germinating seeds (Abayomi, 1992). The overall results of germination tolerance of soil moisture stress show that crop establishment was better with extra-early than the early genotypes. Among the genotypes, G11 (extra-early) showed the best establishment, while G29 (local check 2) show the least in terms of germination percentage and speed of germination (MGT).

Morphological growth characters of number of leaves per plant, leaf area and plant height were significantly reduced by soil moisture deficit. The reduction in leaf area as a result of water deficit is attributable to decreased rate of leaf initiation and expansion / and or increased rate of leaf senescence and leaf shedding (Legg, et al., 1979). Nesmith and Rochie (1992) and Fortis and Edward (1995) have reported that water deficit reduced leaf development and decreased leaf area expansion. The importance of the number of leaves to grain yield has been shown by Benti and Ranson (1993) who reported that grain yield is directly proportional to the number of leaves removed. The decrease in plant height by soil moisture deficit as observed in the study was in line with the report of Gavloski, et al. (1992) who observed that there was a decrease in maize plant height following the withdrawal of water from one or more section of the root system. The importance of plant height as a yield predictor has been shown by Abayomi (1992) and Hadjichristodoulou (1987) had earlier suggested that variations in plant height may become one of the causes of variation in crop yield. This suggests that genotype that can maintain good plant height under stress are likely to give good grain yield in line with the results of this study which showed that when water stress reduced plant height by 37.4%, grain yield was reduced by 59.28% in the extra-early genotypes. However, in the early genotypes, a reduction of 24.06% in plant height by moisture deficit resulted in a decrease of only 39.46% grain yield. Among the genotypes, two early genotypes (G21 and G24) showed good heights and hence good grain yields under stress.

The results of the effect of water stress on flowering traits showed that inadequate soil moisture significantly delayed tassel and silk appearance, anthesis and hence increased ASI. Flowering traits in maize have been shown to be significantly delayed under severe drought (Edmeades, et al., 1997). Similarly, Herrero and Johnson (1981) also reported that water stress during the reproductive period can increase the interval from silking to pollen shed which shortened the grain filling period. The results of this study were also in line with the observation of Mckenzie (2006) who reported that water stress during flowering causes several changes in plant development including delay in silk emergence and pollen shed, resulting in synchronous pollination, decreased kernel weight, delay in physiological maturity and a decrease in final yield. Edmeades, et al. (2000) also reported that water stress slows ear growth in relation to tassel growth resulting in an increase in anthesis to silking interval (ASI).

The results of the present study also show that most physiological growth indices measured were significantly reduced by inadequate soil moisture content across the genotypes. The reduction in net assimilation rate (NAR) was in agreement with the report of Boyle, et al (1991) who showed that low seed yield at low water potential can be accounted for by lack of assimilate supply at flowering. The results also showed that soil moisture stress reduced leaf area index (LAI), suggesting reduction in photosynthesis. It has been observed that photosynthesis can be reduced by water stress through reduction in leaf area, stomatal closure and decrease in the efficiency of

carbon fixation process (Ludlow, 1975). Soil moisture deficit reduced all yield components and grain yield in maize genotypes across the two maturity groups. Girma, et al (2005) have reported reduction in HI as a result of moisture stress. Other workers have also reported reduction in yield components and grain yield due to water stress. O'Neil, et al (2004) reported that water stress during grain fill period caused decrease in kernel weight, earlier physiological maturity and decrease in final yield. Percent grain yield reduction due to soil moisture deficit was observed to be positively related to drought susceptibility index (Figure 1) in line with the report of Rizza, et al. (2004) who showed significant negative relationship between grain yield and water stress index of barley (*Hordeum vulgare*, L) genotypes. A lower grain yield reduction under stress suggests a higher yield stability which is more important than breeding and selection for absolute high yield under stress.

According to Roland (1993), drought resistant genotypes are known for their higher yields under conditions of limited and uncertain rainfall. The results of the present study show that genotypes G2, G9, G10, G21 and G25 had higher grain yields under stress condition, suggesting that they are more water stress tolerant than the other genotypes. The focus of varietal response evaluation to environmental stress is to identify superior genotypes that perform relatively well under stress and could be used to replace the existing genotypes and / or as sources of genes for the production of inbred lines aimed at the development of stress tolerant genotypes (Olaoye, 2009). The above identified genotypes are therefore promising for the southern Guinea savannah and could replace the two local checks, Afo (G2, G9, and G10) and DMR-SRT-Y (G21 and G25), as well as being sources of genes for breeding programme for drought tolerant maize cultivars in the zone. However, it has been suggested that in an environment prone to severe drought conditions like the Guinea savannah ecology (SGS), the most suitable genotypes should maintain high yield under both favourable and stress conditions (Rizza, et al., 2004). Considering the results of the 29 genotypes evaluated in the present study, an extra-early genotype, G10, ranked best under stress and no stress conditions and may therefore be the best genotype for the SGS ecology. Although reduced with inadequate soil moisture, its yield was superior under both conditions. The results further show that five genotypes (G8, G11, G3 and G5, all extra-early genotypes), had higher yield potentials under favourable soil moisture condition, but were highly susceptible to drought stress. There is some agreement that a high yield potential is advantageous under moderate stress, while high drought tolerance may be more useful under severe stress (Voltas, et al, 1999; Panthywan, et al, 2002)., thereby suggesting that these five genotypes may not be suitable for the SGS ecology in the event of severe stress. However, three early genotypes (G22, G23 and G19), with lower yield potentials under favourable moisture condition, showed lower yield reductions under stress (Table 8), thereby suggesting good yield stabilities and are therefore promising candidates for the ecology. An extra-early genotype, G1, showed poor yield potential with adequate soil moisture and dismally low drought tolerance, is neither good for cultivation nor as a source of genes for drought tolerance improvement programme for the ecology.

Conclusively, two extra-early genotypes (G2 and G10) and two early genotypes (G21 and G25), which showed both high yield potentials under favourable moisture condition and good drought tolerance under moisture deficit, are promising as DT genotypes for the SGS ecology and can therefore replace Afo and DMR-SRT-Y (local checks), and as well serve as sources of genes for the improvement of three extra-early genotypes (G8, G11 and G16) with high yield potentials under favourable moisture condition, but low stability under moisture deficit; and three early genotypes (G19, G22 and G23) which look promising as DT genotypes, but showed low yield potentials under favourable moisture condition. Hybridization of these identified ten genotypes may result in the production of better DT genotypes well suited to the SGS ecology.

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Table 1. The evaluated extra-early, early and local maize genotypes for responses to soil moisture deficit at Ilorin, southern Guinea savanna, Nigeria

Code Number	Genotype
Exra-early genotypes	
G1	TZEE-W POP STR C_4
G2	TZEE-Y POP STR C_4
G3	2000 Syn EE-W QPM C_0
G4	TZEE-W POP SYR C_0 S_6 Inb x 9071
G5	TZEE-W POP STR QPM C_0
G6	TZEE-YSR BC_1 X 9450 STR S_6 Inb 10B X 4000
G7	2000 Syn EE-W
G8	TZEE-Y POP STR QPM C_0
G9	99 TZEF-Y STR QPM C_0
G10	EV 99 QPM
G11	TZEE-W POP x LD S_6 (Set A1)
G12	TZEE-W POP x LD S_6 (Set A2)
G13	99 TZEE-Y STR C_0
G14	2004 TZEE-Y POP STR C_4
G15	2004 TZEE-W POP STR C_4
G16	Afo (Check 1)
Early Genotypes	
G17	EV DT-W 99 STR C_0
G18	EV DT-97 STR C_1
G19	EV DT-W 99 STR QPM C_0
G20	TZE-Y DT STR C_4
G21	TZE-Y DT STR QRM C_0
G22	TZE-W DT STR C_4
G23	AC 90 Pool 16 DT STR
G24	TZE Comp 3 DT C_1F_2
G25	TZE Comp 3 DT C_2F_2
G26	EV DT-Y 2000 STR QPM C_0
G27	EV DT-Y 2000 STR C_0
G28	Pool 18-SR/AK94-DMRESR-Y
G29	DMR-SRT-Y (Check 2)

Table 2. Crop establishment of some maize genotypes under moisture deficit and irrigated conditions

Treatment	Percent Germination (%)			Mean Germination Time (MGT) (days)		
Genotype	Stressed	Unstressed	Mean	Stressed	Unstressed	Mean
Extra-early						
G1	90.0	96.7	93.3ab	4.5	4.3	4.4def
G2	16.7	43.3	30.0mno	8.8	7.0	7.9a
G3	53.3	73.3	63.3d-h	5.6	4.1	4.8c-f
G4	50	60	55.0f-k	6.5	5.0	5.7bc
G5	36.7	46.7	41.7i-n	4.4	4.5	4.5c-f
G6	46.7	70	58.3e-j	5.8	4.7	5.3bcd
G7	43.3	70	56.7f-k	5.3	4.2	4.7c-f
G8	46.7	66.7	56.7f-k	5.1	3.8	4.5c-f
G9	43.3	60	51.7g-l	5.5	4.4	5.0cde
G10	80	83.3	81.7a-d	4.3	3.7	4.0ef
G11	93.3	100	96.7a	4.4	3.6	4.0ef
G12	70	86.7	78.3a-e	3.9	3.5	3.7f
G13	86.7	90	88.3abc	3.8	3.6	3.7f
G14	83.3	96.7	90.0abc	4.4	3.6	4.0ef
G15	83	90	86.7abc	5	3.5	4.3def
G16 (check 1)	23.3	40	31.7l-o	4.7	4.4	4.6c-f
Group Mean	70.8A	61.5A		5.1A	4.5A	
Early						
G17	73.3	73.3	73.3b-f	5	4.3	4.7c-f
G18	46.7	70	58.3e-j	5.4	3.7	4.5c-f
G19	46.7	70	58.3e-j	4.5	4.0	4.3def
G20	63.3	76.7	70.0c-g	5.7	3.7	4.7c-f
G21	30	43.3	36.7k-o	5.5	4	4.8c-f
G22	50	70	60.0e-j	5.3	4.4	4.9c-f
G23	36.7	56.7	46.7h-m	4.7	4.6	4.6c-f
G24	23.3	40	31.7l-o	6.5	6	6.3b
G25	23.3	56.7	40.0j-n	6	4.8	5.4bcd
G26	16.7	23.3	20.0no	6.7	4.8	5.7bc
G27	43.3	80	61.7d-l	5.1	4.2	4.6c-f
G28	26.7	63.3	45.0h-m	5.6	4.8	5.2b-e
G29 (check 2)	16.7	20	18.0o	5.7	4.8	5.2b-e
Group Mean	42.1B	53.3A		5.3A	4.6A	
s.e.d	14.25		10.54	0.77		0.62
l.s.d(0.05)	28.24			1.54		
CV(%)	28.7			16.5		

Table 3. Morphological growth characters of some maize genotypes under moisture deficit and well watered conditions

	Number of leaves (no)			Plant Height (cm)			Leaf Area (cm^2)		
Genotype	Stressed	Unstressed	Mean	Stressed	Unstressed	Mean	Stressed	Unstressed	Mean
Extra-early									
G1	12	11.3	11.7a-d	97	124.2	110.6f-l	1488	3006	2247bcd
G2	13.3	10.3	11.8a-d	79.3	120.3	99.8j-m	1796	2917	2357bcd
G3	12	11.3	11.7a-d	87.6	121.3	104.4h-m	1391	2730	2060cd
G4	12	11	11.5a-e	59	118.5	88.8klm	1757	2688	2223bcd
G5	12.7	13.7	13.2a	59.8	126.8	93.3j-m	2541	3925	3232a
G6	10.3	12	11.2b-f	70.8	123.2	97.0j-m	1732	2937	2334b-e
G7	12.3	11	11.7a-d	66.2	126.1	96.1j-m	931	2978	1955d-g
G8	12	11	11.5a-e	68.2	132.9	100.6i-m	1237	2757	1997c-f
G9	10.7	11.7	11.2b-f	87.3	135.5	111.4f-k	1686	2891	2288b-f
G10	12	10.3	11.2b-f	90.4	122.7	106.6g-m	2412	2869	2640b
G11	11.3	10.3	10.8c-g	92.5	118.3	105h-m	1896	2837	2367bcd
G12	13.3	11.7	12.5abc	51.3	122.4	86.9m	1220	2656	1938d-g
G13	10.3	9.7	10.0d-g	92	107.7	99.8j-m	1479	2707	2093c-f
G14	12	11.7	11.8a-d	82.3	137.4	109.9f-m	2140	2931	2535bc
G15	13	11.3	12.2abc	55.8	119.5	87.7lm	1417	2909	2163b-f
G16 (check 1)	13	13	13.0ab	67.1	110.5	88.8klm	2158	4547	3353a
Group Mean	11.9A	11.3A		77.0B	123.1A		1659A	2915A	
Early									
G17	10.3	9.3	9.8e-l	111.8	146	128.9c-g	1037	2474	1755f-j
G18	10	9.7	9.8e-l	119.8	151.3	135.6b-e	1088	1526	1307hij
G19	7.7	10	8.8hi	115.3	137.7	126.5c-h	1179	2461	1820d-i
G20	9.7	10.3	10.0d-g	121.8	164.8	143.3a-d	1031	1557	1294ij
G21	9.3	11	10.2d-h	127.7	177.3	152.5ab	1432	2657	2044c-g
G22	8	8	8.0i	116.5	161.5	139.0a-d	1277	1302	1290ij
G23	10	9	9.5f-l	93	134.2	113.6e-j	1235	1577	1406g-j
G24	9	9.7	9.3ghi	107.8	152.7	130b-f	878	1603	1241j
G25	8.3	10.3	9.3ghi	133.3	185	159.2a	115.9	2387	1773e-j
G26	8.7	10.7	9.7e-l	143.7	175	159.3a	1455	2259	1857d-h
G27	9.3	9.0	9.2ghi	105.3	141.5	123.4d-l	1588	2929	2259b-f
G28	9.7	9.3	9.5f-l	146	149.5	147.8abc	1476	2313	1894d-g
G29 (check 2)	9	9.3	9.2ghi	113	170.3	141.7a-d	1206	2886	2046c-f
Group Mean	9.2A	9.7A		119.6B	157.0A		1234B	2149A	
s.e.d	1.09		0.90	14.72		11.66	379.9		280.1
l.s.d(0.05)	ns			29.18			752.9		
CV(%)	10.0			13.30			21.6A		
s.e.d									

Table 4. Tassel and silk appearances, anthesis and anthesis-silking interval (ASI) of maize genotypes under moisture deficit (STR) and well-watered (WWT) conditions

	Tassel Emergence (DAP)			Anthesis (DAP)			Silk Emergence (DAP)			ASI (days)		
	STR	WWT	Mean	STR	WWT	Mean	STR	WWT	Mean	STR	WWT	Mean
Extra-early genotype												
G1	48	51	49.5e-h	56	54	55.0f-j	62.7	59	61.0b-e	6.7	5.3	6.0a-e
G2	56.8	52.3	54.6a-d	64	51	57.5b-h	69	54	61.5bcd	5	3	4.0cde
G3	46.3	48.7	47.5gh	56	51.7	53.8g-j	64.7	57.3	61.0b-e	9	5.7	7.3ab
G4	58.3	49.3	53.8a-f	62	52.3	57.2b-i	66.3	57	61.7bc	4.3	4.7	4.5b-e
G5	54.7	52	53.3a-f	59.7	55	57.3b-h	68.7	58.7	63.7abc	9	3.7	6.3a-d
G6	52	50	51.0d-h	58.2	53.7	55.9d-l	68.7	56.7	62.7bc	10	3.0	6.5abc
G7	50.3	50	50.2d-h	56.7	54.3	55.5e-j	62	58.3	60.2cde	5.3	4	4.7b-e
G8	60.8	52.3	56.6ab	64.5	55	59.8a-e	71.7	58.7	65.2ab	7.2	3.7	5.4b-f
G9	53	50	51.5c-h	57.3	53.3	55.3e-j	68	59	63.5abc	10.7	5.7	8.2a
G10	50	48.3	49.2fgh	55.7	51	53.3hij	65	54.3	59.7cd	9.3	3.3	6.3a-d
G11	50	45.5	47.8gh	57.3	47.8	52.6ij	60.7	51.7	56.2de	3.3	3	3.2ef
G12	61.7	52.3	57.0ab	64	55.7	59.8a-e	68.7	60.7	64.7ab	4.7	5	4.8b-f
G13	45.3	48	46.7h	51.3	50.3	50.8j	55.7	55.7	55.7e	4.3	5.3	4.8b-f
G14	55	54	54.5a-f	59.3	56.7	58.0a-g	63	59.7	61.3b	3.7	3	3.3def
G15	56.7	52.7	54.7a-d	59.7	54.7	57.2b-l	67.8	58.3	63.0ab	8	3.7	5.8a-e
G16	59.8	56.3	58.1a	63.7	58.7	61.2ab	67.3	60.3	63.8ab	3.7	1.7	2.71f
GM	52.9A	50.0A		58.7A	52.7B		65.5A	57B		6.8A	4.3B	
Early genotype												
G17	54.7	52.2	53.4a-f	57.7	56.7	57.2b-g	63	60	61.5bcd	5.3	3.7	4.5b-f
G18	57.7	54	55.8abc	61.7	59.3	60.5abc	64.7	62.7	63.7abc	3.3	3.3	3.3def
G19	51.7	52.3	52.0b-g	55.3	57.7	56.5c-l	59.7	61.7	60.7b-e	4.3	4	4.2c-f
G20	59	55	57.0ab	62	60	61.0ab	66.3	61.3	63.8abc	4.3	4.7	4.5b-f
G21	57	51.7	54.3a-e	61.7	56.3	59.0a-f	67	59	63.0abc	5.3	2.7	4.0c-f
G22	57.7	55.7	56.7ab	61.3	59.3	60.3a-d	67.8	63.3	65.6ab	5.3	4	4.7b-f
G23	58.3	56.8	57.6a	61.7	60.2	60.9ab	64.3	64.3	64.3abc	3	4.5	3.8c-f
G24	58.3	56.4	57.3a	63.6	60.7	62.2a	69.6	66.7	68.2a	4.7	5.7	5.2a-f
G25	47.5	59.5	53.5a-f	50.1	62	56.1c-l	58.7	67.6	63.2abc	4	5.7	4.8b-f
G26	54.9	56.9	55.9abc	59	60.2	59.6abc	63.9	65.1	64.5abc	3	4	3.5c-f
G27	57.3	55.3	56.3abc	61	59.7	60.3a-d	67	64	65.5ab	6	4.3	5.2a-f
G28	58.3	55.5	57.1ab	62	59.5	60.8ab	66.7	62.7	64.7abc	4.7	3.7	4.2c-f
G29	57.8	55.8	56.8ab	60.7	57.3	59.0a-f	64.6	59.3	61.9bc	4	2.7	3.3def
GM	55.7A	55.4A		59.2A	59.3A		63.9A	63.1A		4.4A	4.1A	
s.e.d	**3.65**		2.50	3.23		2.28	3.56		2.67	2.04		1.54
l.s.d	**7.25**			**6.41**			**7.07**			**4.05**		
CV(%)	8.5			6.9			6.5			18.5		

Table 5. Net assimilation rate, crop growth rate and relative growth rate of maize genotype under moisture deficit (STR) and well-watered (WWT) conditions

	Net assimilation rate ($g\ m^{-2}d^{-1}$)			Crop growth rate ($g\ g^{-1}d^{-1}$)			Relative growth rate		
	STR	WWT	Mean	STR	WWT	Mean	STR	WWT	Mean
Extra-early genotype									
G1	10.9	8	9.5cde	0.27	1.75	1.01a	0.077	0.136	0.107
G2	14	51.4	32.7a	0.43	1.08	0.76a-e	0.179	0.194	0.186
G3	3.9	36.6	20.2a-d	0.39	1.62	1.01a	0.010	0.128	0.069
G4	8.3	6.5	7.4de	0.23	0.69	0.46cde	0.104	0.076	0.090
G5	5.4	16	10.7cde	0.37	1.17	0.77a-d	0.135	0.128	0.131
G6	5.8	11.6	8.7cde	0.07	1.36	0.64a-e	0.091	0.174	0.133
G7	7.5	9.4	8.5cde	0.09	1.07	0.58a-e	0.065	0.145	0.105
G8	14.3	8.7	11.5cde	0.17	0.83	0.50cde	0.139	0.103	0.121
G9	12.5	8.5	10.5cde	0.17	1.02	0.60a-e	0.076	0.106	0.091
G10	17.6	41	29.3ab	0.50	0.96	0.73a-d	0.125	0.128	0.126
G11	12.1	8.5	10.3cd-e	0.23	1.35	0.79a-d	0.075	0.124	0.099
G12	5.9	8.7	7.3de	0.23	0.99	0.61a-e	0.348	0.124	0.236
G13	4.9	27.8	16.3b-e	0.51	1.34	0.93ab	0.087	0.150	0.119
G14	9.9	11.2	10.5cde	0.31	1.42	0.86abc	0.09	0.142	0.110
G15	3.3	9.3	6.3e	0.12	1.39	0.75a-d	0.057	0.113	0.085
G16	11.9	28.4	20.1a-d	0.41	1.32	0.87abc	0.178	0.89	0.184
GM	9.3A	18.2A		0.27B	1.17A		0.116A	0.132A	
Early genotype									
G17	16.6	12.7	14.7bcd	0.51	1.47	0.99ab	0.123	0.162	0.142
G18	12.1	8.7	10.4cd	0.56	0.34	0.45cd	0.129	0.124	0.126
G19	10.4	7.7	9.1cd	0.55	0.96	0.75a-d	0.140	0.110	0.125
G20	5.2	9.7	7.4d	0.23	0.93	0.58a–e	0.327	0.020	0.173
G21	5.8	9.7	7.7d	0.36	0.39	0.37de	0.107	0.127	0.117
G22	9.5	13.6	11.6c	0.58	0.92	0.75a-d	0.125	0.103	0.114
G23	8.8	8.8	8.8cde	0.49	0.47	0.48cde	0.126	0.075	0.101
G24	13	7.3	10.1cde	0.10	1.02	0.56b-e	0.137	0.127	0.132
G25	32	11	21.5abc	0.34	0.11	0.23e	0.122	0.184	0.153
G26	15.7	26.7	21.2abc	0.68	1.22	0.95ab	0.140	0.152	0.146
G27	7.8	9.8	8.8cde	0.47	1.42	0.94ab	0.130	0.132	0.131
G28	8.3	7.5	7.9de	0.52	1.23	0.88abc	0.131	0.125	0.128
G29	7.2	11.9	9.5cde	0.49	1.21	0.85abc	0.123	0.124	0.123
GM	11.7A	11.2A		0.49B	0.89A		0.141A	0.118A	
s.e.d	10.17		6.57	0.311		0.218	0.0742		0.0542
l.s.d	20.19			0.619			ns		
CV(%)	63.4			54.1			68.6		

Table 6. Leaf area ratio and leaf area index of maize genotype under moisture deficit (STR) and well-watered (WWT) conditions

Treatment	Leaf area ratio (LAR)			Leaf area index (LAI)		
	STR	WWT	Mean	STR	WWT	Mean
Extra-early genotype						
G1	151.2	138.4	144.8cd	2.48	5.01	3.74c-g
G2	208.2	52.4	130.3d	2.99	4.86	3.93cde
G3	245.6	123.7	184.7abc	2.32	4.55	3.44c-g
G4	169.6	165.1	167.4a-d	2.93	4.48	3.71c-g
G5	211.8	143.2	177.5a-d	4.23	6.54	5.39ab
G6	174	162.7	168.4a-d	2.96	4.89	3.93cde
G7	191.7	177.6	184.6abc	1.55	4.97	3.26d-i
G8	176.2	147.8	162.0a-d	2.06	4.60	3.33d-i
G9	234.7	141.1	187.9abc	2.81	4.82	3.82c-f
G10	141.7	156.4	149.1bcd	4.02	4.78	4.40bc
G11	171.6	153.6	162.6a-d	3.16	4.99	4.08cd
G12	189.6	167	178.3a-d	2.03	4.43	3.23e-j
G13	189.8	124.8	157.3bcd	2.47	4.51	3.49c-h
G14	163.5	147.4	155.4bcd	3.57	4.88	4.23cd
G15	213.1	141.1	177.1a-d	2.36	4.85	3.61c-g
G16 (check 1)	186.8	117.3	152.0bcd	3.60	7.58	5.59a
Group Mean	188.9A	142.6A		2.77B	4.88A	
Early genotype						
G17	148.9	161	154.9bcd	1.73	4.03	2.88f-k
G18	182.2	104.6	143.4cd	1.81	2.54	2.18k
G19	146.9	159.2	153.0bcd	1.97	4.10	3.03e-k
G20	248	160.2	204.3ab	1.72	2.68	2.20k
G21	187.5	146.5	167.0a-d	2.39	4.43	3.41c-h
G22	148.2	95.6	121.9d	2.32	2.17	2.24jk
G23	167.6	159.6	163.6a-d	2.06	2.63	2.34ijk
G24	194.7	124.9	159.8a-d	1.28	3.11	2.20k
G25	176.4	252.7	214.5a	1.52	3.87	2.69h-k
G26	182.1	138.5	160.3a-d	2.61	2.96	2.78g-k
G27	170.5	149.3	159.9a-d	2.64	4.88	3.76c-g
G28	192.4	121	156.7bcd	2.46	4.25	3.35e-i
G29 (check 2)	143.8	103.4	123.6d	3.16	5.03	4.10cd
Group Mean	176.7A	143.0A		2.15B	3.5A	
s.e.d	35.81		28.09	0.695		0.495
l.s.d	71.14			1.381		
CV(%)	23.6			24.4		

Table 7. Harvest index, shelling percentage and number of kernels of maize genotypes under moisture deficit (STR) and well-watered (WWT) conditions

	Harvest index			Shelling percentage			Number of kernels/cob		
Genotype	STR	WWT	Mean	STR	WWT	Mean	STR	WWT	Mean
Extra-early									
G1	0.19	0.36	0.28efg	32.3	64.7	48.5ef	117.3	224.0	180.7bcd
G2	0.50	0.48	0.49a	62.0	83.0	72.5a-d	114.6	336.0	225.3a-d
G3	0.23	0.35	0.29d-g	59.0	77.0	68.0a-e	144.0	308.0	226.0a-d
G4	0.29	0.33	0.32d-g	68.3	67.0	67.7a-e	202.7	149.8	176.3bcd
G5	0.22	0.38	0.30d-g	49.3	70.0	59.7c-f	166.0	297.0	231.5abc
G6	0.34	0.47	0.41a-e	54.0	74.0	64.0a-e	191.7	389.3	290.5abc
G7	0.40	0.44	0.42a-d	72.3	82.0	77.2ab	170.3	364.0	267.2abc
G8	0.24	0.53	0.39a-f	58.7	79.7	69.2a-d	122.0	334.3	228.1a-d
G9	0.46	0.46	0.46abc	66.3	78.3	72.3a-d	283.8	255.3	269.6abc
G10	0.35	0.49	0.42a-d	55.0	80.0	67.5a-d	243.7	408.7	326.2a
G11	0.40	0.54	0.47ab	66.0	82.0	74.0a-d	234.0	322.3	278.2abc
G12	0.19	0.53	0.36a-f	51.0	84.3	67.7a-d	146.3	344.3	245.3abc
G13	0.22	0.52	0.37a-f	63.3	81.0	72.2a-d	109.0	282.3	195a-d
G14	0.23	0.48	0.36a-f	44.3	78.3	61.3a-f	207.0	391.7	299.3ab
G15	0.24	0.45	0.34b-g	59.3	78.0	68.7a-d	294.3	283.0	288.7abc
G16 (chk1)	0.16	0.44	0.30d-g	45.0	65.0	55.0c-f	239.3	330.3	282.3abc
Group Mean	0.31B	0.46A		58.3B	77.2A		172.7B	310A	
Early									
G17	0.35	0.40	0.37a-f	68.1	71.8	69.9a-e	162.3	153.3	157.8cd
G18	0.22	0.343	0.28efg	51.6	68.5	60.0b-f	200.0	221.7	210.8a-d
G19	0.34	0.43	0.39a-f	65.0	83.9	74.4abc	162.3	288.7	225.5a-d
G20	0.11	0.31	0.21g	35.0	57.7	46.3f	46.0	147.7	96.8d
G21	0.33	0.28	0.30d-g	66.4	57.2	61.8a-f	201.7	343.0	272.3abc
G22	0.32	0.36	0.34b-g	53.8	76.0	65.2a-f	131.2	243.3	187bcd
G23	0.21	0.37	0.29d-g	72.4	89.8	81.1a	171.7	331.1	251.4abc
G24	0.21	0.32	0.26fg	47.5	70.2	58.9c-f	152.7	381.3	267.0ab
G25	0.32	0.31	0.32d-g	60.3	60.9	60.6b-f	189.3	287.7	238.5ab
G26	0.25	0.28	0.26fg	55.7	55.1	54.4def	159.7	267.7	213.7abc
G27	0.30	0.36	0.33c-g	58.5	77.1	67.8a-e	183.0	233.3	208.2abc
G28	0.39	0.35	0.37a-f	40.2	62.7	51.5ef	158.7	214.7	186.7bc
G29(chk2)	0.12	0.41	0.27fg	31.7	59.2	45.6f	186.0	251.3	221.7abc
Group Mean	0.27B	0.35A		54.3B	68.4A		161.9B	259.3	
s.e.d	0.089		0.068	13.59		9.95	81.81		68.11
l.s.d (0.05)	0.177			26.94			162.37		
CV (%)	29.2			25.0			33.7		

Table 8. Grain yields under soil moisture deficit (Ys), normal soil moisture (Yp), yield reduction percent due to moisture deficit (PRED) and Drought Susceptibility Index (DSI) of maize genotypes of two maturity groups

	Grain yield (g plant^{-1})				
Genotype	Ys	Yp	Mean	PRED (%)	DSI
Extra-early					
G1	14.0c	43.5d	28.8c	70.4ab	1.41ab
G2	47.1abc	91.2abc	60.7ab	68.5ab	1.37abc
G3	21.0abc	84.4a-d	52.7abc	75.0ab	1.50ab
G4	33.0abc	54.2a-d	43.6abc	39.8b-e	0.79b-e
G5	34.0abc	83.2a-d	58.6abc	65.7abc	1.31a-d
G6	21.5abc	65.5a-d	43.5abc	66.1abc	1.32a-d
G7	35.1abc	76.7a-d	55.9abc	52.7a-d	1.06a-e
G8	12.7abc	91.8a	52.9abc	81.3a	1.63a
G9	44.8abc	64.2a-d	53.0abc	61.0a-d	1.22a-e
G10	52.3a	95.3ab	73.8a	49.0a-e	0.98a-e
G11	33.7abc	90.0abc	61.8ab	62.2a-d	1.24a-d
G12	24.4abc	66.6a-d	45.5abc	65.7abc	1.31a-d
G13	21.3abc	47.4cd	34.3bc	56.5a-d	1.13a-e
G14	29.4abc	75.1a-d	52.3abc	60.8a-d	1.21a-e
G15	32.3abc	66.0a-d	49.1abc	48.7a-e	0.97a-e
G16 (chk1)	18.3abc	80.0abc	48.7abc	79.6ab	1.58ab
Group Mean	29.6C	72.7A	51	62.7	1.15
Early					
G17	36.2abc	42.2d	39.2bc	47.8a-e	1.03a-e
G18	33.7abc	56.4a-d	45.1abc	44.2b-e	0.88b-e
G19	40.1abc	54.3a-d	47.2abc	42.2b-e	0.84b-e
G20	18.4bc	50.4cd	34.4bc	50.2a-d	1.00a-e
G21	47.2abc	78.2a-d	62.7ab	40.0b-e	0.80b-e
G22	40.1abc	51.0cd	45.6abc	20.5e	0.41e
G23	41.8abc	57.5a-d	52.0abc	27.0e	0.54cde
G24	36.0abc	71.6a-d	53.8abc	53.3a-g	1.06a-e
G25	50.8ab	74.8a-d	62.8ab	30.1de	0.60de
G26	35.1abc	62.0a-d	48.6abc	46.9a-e	0.94a-e
G27	35.2abc	52.1bcd	43.7abc	32.0cde	0.64cde
G28	30.7abc	50.0cd	40.4bc	40.5b-e	0.81b-e
G29 (chk2)	21.6abc	64.9a-d	43.3abc	46.9a-e	0.93a-e
Group Mean	35.9C	59.3B	47.6	40.1	0.81
s.e.d	17.29	21.9	15.29	16.9	0.348
CV(%)	61.7	39.8	37.9	40.7	40.4

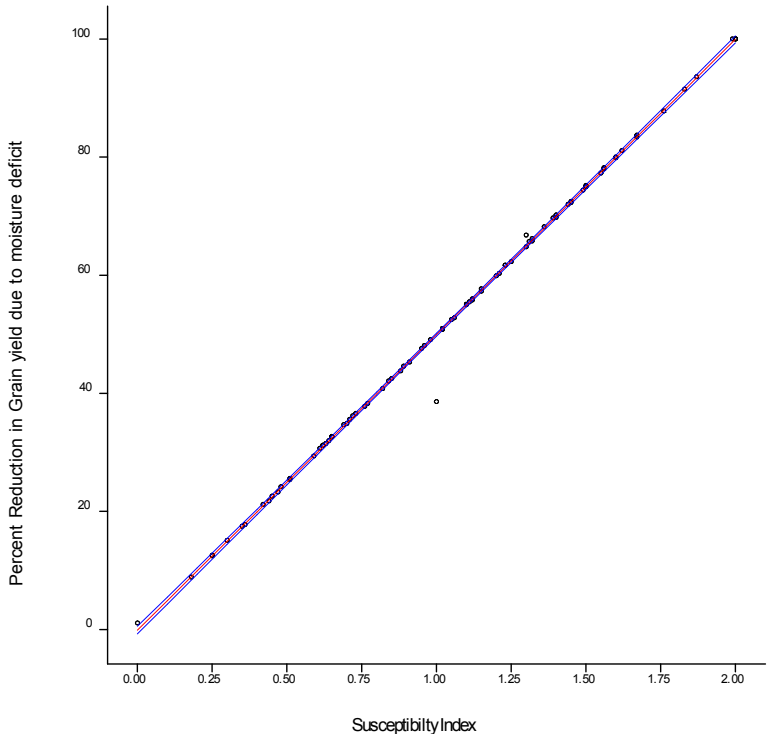

Figure 1a. Relationship between percent reduction in grain yield due to soil moisture deficit and drought susceptibility index in maize

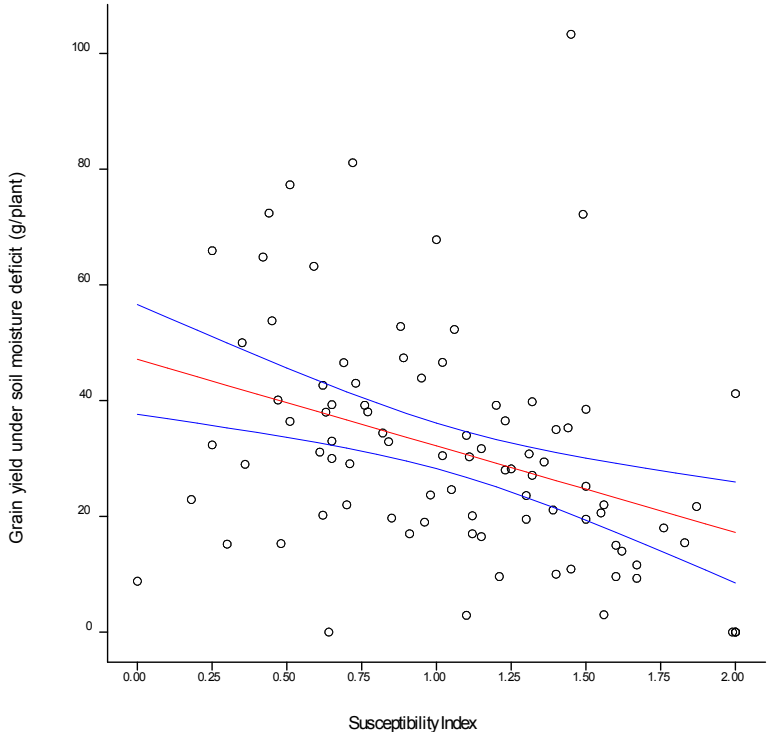

Figure 1b. Relationship between grain yield under stress and drought susceptibility index in maize