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Evaluation of Various Double Haploid Maize Hybrids Under Water Deficit Condition

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ABSTRACT

The present study was conducted for evaluation of double haploid maize hybrids under water deficit condition. Total nine maize hybrids having eight double haploid maize hybrids and one commercial maize hybrid check have sown in autumn season 2019 with two treatments by using randomized complete block design under factorial by two replications. For evaluating maize hybrids under water deficient condition, 100% and 50% irrigation was given in Treatment-I and treatment-II. At several maize growth stages data was collected regarding morphological and physiological traits. Data was analyzed by using analysis of variance, path analysis and correlation analysis. The results showed that all the double haploid maize hybrids under evaluation was significant in analysis of variance. Path coefficient analysis of field research showed, days to 50% tasseling, plant height, leaf area, leaf temperature, cob diameter, kernel rows per cob and grain yield positive direct effect on total biomass of plant. The traits such as days to 50% tasseling, tasseling to silking interval, ear height, cob length and harvest index indicated negative direct effect on total biomass of plant. Grain yield showed highest positive direct effect on other side the lowest positive direct effect of kernel rows per cob on total biomass of plant. Correlation coefficient indicated that maximum significant positive genotypic correlation was present between days to 50% silking and days to 50% tasseling, it was also significant positive correlation present among grain yield per plant and total biomass of plant under normal but under water deficit condition maximum positive correlation was observed among kernel rows per cob and cob diameter.

Key words: Maize, double haploid, drought

INTRODUCTION

Maize (*Zea mays* L.) is a prime cereal plant and is one of the high yielding and nutritive cereal crop grown around the world (Ahmad *et al*., 2016). According to global farming system maize is placed third among major cereal crops after wheat and rice in Pakistan. In some regions of Khyber Pakhtunkhwa, maize is categorized as a second position in terms of its importance and utility. Maize crop is sown during whole year, thus it is also known as "Queen of Cereals" (Baloch *et al*., 2015). The area covered by maize farming in 2014-15 was nearby 178.79 million hectares with a mean production of 5.64 metric tons per hectare in overall maize producing countries. So, the total production of maize was nearly to 1008.68 million metric tons. Corn has high nutritive value both for humans and animals, its nutritive value is well archived because of, 72% starch, 10% protein, 4.8% oil, 3.0% sugar, 1.7% ash and 9.50% fiber. Maize is mainly contributed to 2.1% in agriculture value added products and 0.4% of gross domestic product (Ahmad *et al*., 2017).

Agricultural drought is caused due to constant deficit in precipitation linked with excessive evapo-transpiration need. As it is deficiency of plentiful humidity needed for standard plant growth and enlargement to fulfill the life cycle (Farooq *et al*., 2012). Drought intrudes the growth, nutrient and water relations, and photosynthesis and eventually cause a substantial decrease in crop yields. During severe drought conditions, the traits responsible in increasing the yield of the plant might not act and may eventually cause negative effects (Qayyum *et al*. 2012).

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Both biotic and abiotic factors have effect on maize crop. In plant structure, water plays a critical role to determine plant growth, developmental mechanisms and for proper functioning of crop (Aslam *et al*., 2006). In different regions around the globe including Pakistan, water stressed conditions are the major and important emerging challenge. Water deficit or drought stress is a severe issue for agriculture where 33% of world's credible arable land is opposing water shortage and resultantly low yield (Mustafa *et al*., 2015). C_4 plants such as maize hybrids require prosperity of water while under water deficient condition the completion of growth cycle is more susceptible.

The sensitivity of maize towards drought can be seen at flowering period. About 15-20% yield loss may be experienced annually as maize cannot tolerate water and heat stresses. Water stress can affect seed setting and grain size with 20-50% yield losses two weeks before or during silking stage (Khan *et al*., 2016) as water deficient effects anatomical, physiological, morphological, and biochemical processes occurring in maize. During severe water stress at tasseling and silking stages, yield reduction is more than 90% while under mild stress conditions reduction in grain yield was 70%.

MATERIAL AND METHODS

The experiment was conducted in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during autumn season in 2019. The Experimental material was comprised of eight double haploid maize hybrids with one commercial used as check hybrid, two regimes (100% normal and 50% water deficit) irrigations as followed:

Hybrids:

1. DH-3B×DH-100G
2. DH-6D×DH-8B
3. DH-1613×DH-100E
4. DH-6B×DH-100A
5. DH-100×DH-1D
6. DH-14D×DH-4
7. DH-1C×DH-54
8. DH-100L×DH-14C
9. FH-1046

The experiment was carried in a Randomized Complete Block Design, under Factorial, with eight rows per hybrid were sown, to evaluate the performance of double haploid maize hybrids. Plant-to-plant and row-to-row distances will be maintained at 7″ and 30″, respectively. Standard agronomic and cultural practices were also given to the experimental area throughout the crop season. Under control treatment, recommended irrigation was applied while under water deficit treatment, half of recommended irrigation was applied. The following parameters of double haploid maize hybrids were recorded at different growth stages.

1) Plant height (cm)
2) Ear height (cm)
3) Leaf Area (cm^2)
4) Days to 50 % tasseling
5) Days to 50 % silking
6) Tasseling to silking interval
7) Leaf temperature (^0C)
8) Cob length (cm)
9) Cob diameter (mm)
10) Kernel rows per cob
11) Total biomass of plant (g)
12) Grain yield per plant (g)
13) Harvest Index (%)

The data on the above-mentioned parameters were recorded as follows:

Plant Height (cm)

After the growth of maize plant and completion of flowering stage, Plant height was measured by meter-rod measuring height in (centimeters) from the ground level to the base of tassel. The average of ten random plants was used for the statical analysis.

Ear height (cm)

After the completion of maize flowering, the further growth of plants is stopped and ear height was measured by measuring the height in (centimeters) from the ground level to the base of upper most cob using an inchitape (Panday *et al.,* 2000). Also, selected the average of ten random plants for analysis.

Leaf Area (cm^2)

After the completion of plant growth the fifth leaf is selected from upper to lower, leaf area was measured in (cm^2) by measuring length and width of a leaf at two different positions. The leaf area was calculated by multiplying the leaf length and leaf width by using the following formula and average leaf area was calculated for ten selected plants. Leaf area = Leaf Length (cm) × leaf width (cm) × 0.75 (Montgomery, 1911).

Days to 50% Tasseling

Days to 50% tasseling were measured by counting the number of days right from date of sowing to till 50% of the plants in eight rows emerged tassels.

Days to 50% Silking

Days to silking were measured by counting the number of days right from sowing till 50% of the plants in eight rows showed silk emergence on their cobs.

Tasseling to silking interval

The tasseling to silking interval is calculating by the difference between tasseling to silking in days.

Leaf temperature (C^0)

Ten plants from eight accession were selected randomly and temperature of a leaf of each plant was recorded by using infrared thermometer (Raytec-PM Pluse England) and average was calculated.

Cob Length (Cm)

Ten cobs of selected plants per hybrid were harvested and their length was measured by a graded scale in (centimeters), and then the average was calculated.

Cob Diameter (mm)

Ten cobs per hybrid were harvested and then diameter was measured by using vernier calipers and average was calculated.

Kernel Rows per cobs

Ten cobs per hybrid were harvested and their kernel rows per cob was counted and the average was calculated.

Total Biomass of Plant (g)

Ten plants from each hybrid were selected and their total biomass was calculated in (grams) by using digital electric balance and their average was calculated.

Grain yield per plant (g)

Ten cobs from each of nine hybrids were selected and at maturity the cobs were harvested. After that, each cob was threshed by hands and the grains weight of per cob was calculated in (grams) by using digital electric balance. At the end, the average was calculated for the statical analysis.

Harvest Index (%)

Harvest index of each hybrid was calculated by using the formula (grain yield/total biomass×100) which includes the value of total biomass of plant and grains yield per plant and the average was calculated.

Statical Analysis

The following statical analysis (given below) were used to analyze the recorded data.

Analysis of Variance

Analysis of Variance was done for all the parameters which is given by (Steel *et al.*, 1997) using Statistix 8.1 software.

Mean Matrix

To determine the most and less responding genotype for every characteristic, R software was used.

RESULTS AND DISCUSSION

The detailed description of the results acquired and the discussion of similarity and differences with the findings of the other researchers are given as follows:

Days taken to 50% Tasseling

Analysis of variance indicated that there was significant difference among the genotypes, treatments and their interaction under consideration shown in Table 1. Among these maize hybrid FH-1046 was the maximum mean value and the double haploid maize hybrid DH-6D×DH-8B showed minimum value in Table 2.

Days taken to 50% Silking

The results of analysis of variance concluded that there was significant difference among the genotypes, treatments and their interaction under consideration shown in Table 1. Double haploid maize hybrids DH-6D×DH-8B showed lowest value but the hybrid FH-1046 showed highest value for days to silking.

Tasseling to silking Interval

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. For tasseling to silking interval FH-1046 maize hybrid was indicated highest value but DH-14D×DH-4 double haploid maize hybrid shown lowest value (Table 2).

Plant Height (cm)

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under examination shown in Table 1. For plant height maximum value showed by double haploid maize hybrid DH-6D×DH-8B and minimum mean value for plant height by DH-1C×DH-54 maize hybrid indicated in Table 2.

Ear Height (cm)

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. Ear height highest value concluded after mean matrix was presented the FH-1046 maize hybrid and lowest mean value showed by DH-100L×DH-14C double haploid maize hybrid (Table 2).

Leaf Area (cm2)

The analysis of variance revealed significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. The DH (double haploid) maize hybrid such as DH-1C×DH-54 indicated minimum value and DH maize hybrid DH-100×DH-1D and FH-1046 showed highest value for leaf area under shown in Table 2.

Leaf Temperature

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. In leaf temperature the highest mean value showed by DH-3B×DH-100G DH maize hybrid and the other side DH-100L×DH-14C DH maize hybrid showed lowest mean value for leaf temperature in Table 2.

Cob Length

The results demonstrated that the analysis of variance was significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. Cob length was shown the maximum mean value for maize hybrid FH-1046, DH-3B×DH-100G and it was shown minimum value by DH-100×DH-1D DH maize hybrid in Table 2.

Cob Diameter

The analysis of variance was presented significant differences among the treatment, genotypes and their interaction under study shown in Table 1. The results of mean matrix indicated that DH maize hybrid DH-3B×DH-100G was observed maximum value but the DH maize hybrid such as DH-6B×DH-100A was concluded the minimum mean value for cod diameter shown in Table 2.

Kernel Rows per cob

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. The results indicated that the mean value for kernel rows per cob was highest by DH-100L×DH-14C maize DH hybrid and the lowest mean value showed by DH-6B×DH-100A hybrid in a Table 2.

Total Biomass of plant

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. Mean matrix evaluated that the DH maize hybrid DH-3B×DH-100G, FH-1046 was shown maximum value but the maize hybrid DH-1C×DH-54 indicated minimum value in a Table 2.

Grain yield per plant

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under observation shown in Table 1. Grain yield per plant showed the maximum mean value for DH-3B×DH-100G and minimum mean value showed by DH-6B×DH-100A maize DH hybrid shown in Table 2.

Harvest Index

The results showed analysis of variance have significant differences among the treatment, genotypes and their interaction under examination shown in Table 1. The harvest index concluded under mean matrix highest value by DH-1C×DH-54 DH maize hybrid and lowest mean value for harvest index showed by DH-6B×DH-100A double haploid maize hybrid in Table 2.

Ahmad *et al*. (2015) conducted an experiment to evaluate the maize hybrids with role of potassium nutrition in improving productivity under water deficit conditions. Maize hybrids such as (NK-8441 and P-32B33) were used to check the productivity at stem elongation and tasseling stage under 50% field capacity. Results showed that both hybrids under water deficit condition reduced the yield due to decrease in yield related traits. Carrol *et al*. (2015) conducted a replicated study by growing maize genotypes in glasshouse conditions under normal and water limited conditions and normal and deficit nitrogen levels. Leaf area and chlorophyll content was recorded for these stress conditions. Canopy temperature was recorded by remote sensing. At limited irrigation leaf temperature was recorded 31.9 C as compared to 30.0 C under normal conditions. Barutcular *et al.* (2016) noticed that yield contributing characters (ear height, number of grains per row, biomass yield and harvest index) were influenced by water stress and reduced the yield except plant height and number of rows/cob). The correlation results indicated that during water stressed condition number of rows/cob and ear height negatively corelated with grain yield.

Ali *et al.* (2016) indicated that variation in F1 hybrids for all examined traits and higher the heritability was established for shoot length, root length, and fresh shoot weight. Khan *et al.* (2016) studied that significant differences were recorded among seedling trait genotypes and variable values of fresh root length, fresh root weight, and dry root weight. Al-Naggar *et al.* (2016) evaluated under three water stress treatments by using split plot design with two replications. The results showed that grain yield of tolerant crosses was higher than sensitive crosses 78.8% and 82.52% under water stress at flowering and grain filling developmental stages. Beyene *et al*. (2017) indicated that ANOVA results showed significant genotypic and genotype by environment interaction (GEI) mean square for grain yield, date of anthesis and plant height. Gazal *et al*. (2017) found the sum of inbred lines CM-129, KDM-1051, KDM-331, KDM-361A KDM-372, KDM-717, KDM-912A, KDM- 402, KDM- 1156, KDM-1236, KDM-343A, KDM-918A, KDM-463, KDM-961 and KDM-932A were drought tolerant under different water deficit levels stress. Shah *et al*. (2008) found that traits such as stomatal frequency, stay green, tassel blasting and green fodder, yield per plant were presented normal probability distribution. But on the other side the relative leaf water content, anthesis to silk interval, leaf area index, leaf senescence, leaf firing, plant bareness, leaf rolling and grain yield per plant are non-normal distribution. El-Sabagh *et al.* (2018) showed that grain weight was severely affected by drought stress and negatively corelated with number of rows/cob and grains/row. Also, the correlation between grain weight and drought tolerant index can be helpful for selecting drought tolerant genotypes. Erdal (2018) explained that 77% and 9% decrease in mean yield due to the water stress and rainfed conditions. Sah *et al*. (2020) observed that the water deficit stress effect the pre-flowering, grain filling stages and the plant performance due to inexact traits function. In maize phenology water deficit stress increased the flowering days, days to maturity, anthesis to silking interval, decreased in number of leaves , abnormal appearance of secondary stress reactive traits, loss of normal root system which leads to decrease in grain yield. The flowering and grain filling stage were highly effected by water deficit condition which leads to significant change in yield specifically in non-drought lines than drought tolerant lines. The yield obtained was fluctuated from 34.28 to 66.15% in (NDT) and 38.48 to 55.95% in (DT) lines due to water stress.

Conclusion

Overall, the best performed double haploid maize hybrid was DH-3B×DH-100G and DH-100L×DH-14C as compare to commercial maize hybrid FH-1046. These hybrids can be released as commercial maize hybrids for growing under changing climatic scenario to meet the shortage of food in Pakistan.

Table 1: ANOVA for all attributes

	DF	DT	S	TSI	PH	EH	LA	LT	CL	CD	KRC	TBP	GYP	HI
Treat	1	1952**	111**	265**	573**	936**	1751**	898**	158*	701**	136*	42.2**	61.5**	23.1**
Geno	8	631**	377**	8.8**	70.8**	16.9**	174**	25.5**	9**	6.76**	3.1*	218**	424**	271**
Treat x Geno	8	22.6**	24.8*	6.0**	24.9**	13.9**	26.4**	14.3**	3.1*	8.4**	1.8*	47.7**	19.3**	19.0**

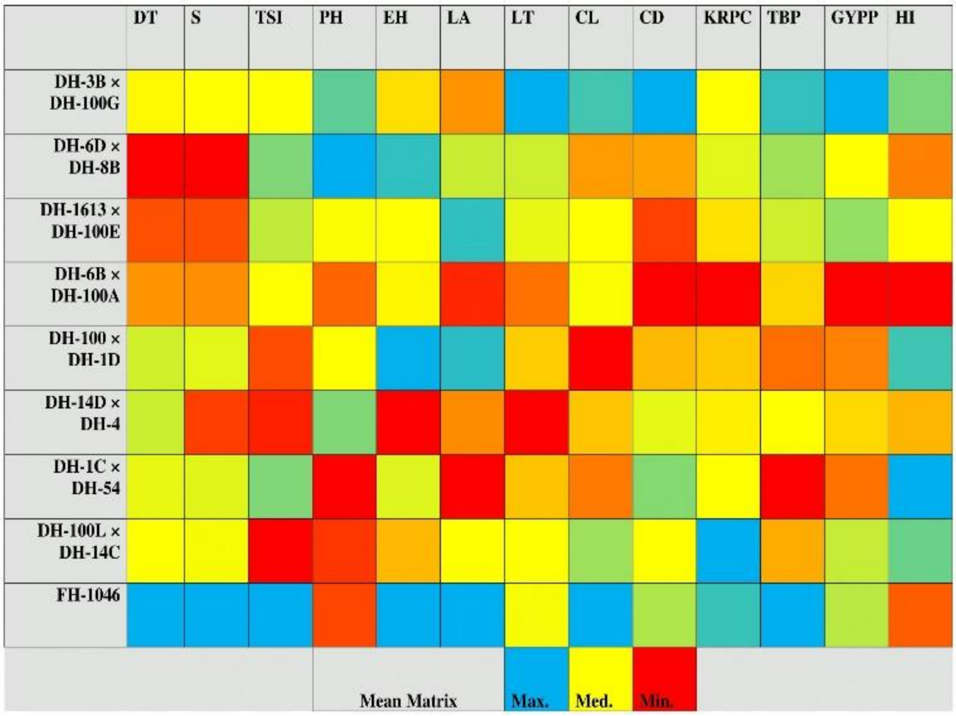

Table 2: Mean Matrix of genotypes for all attributes

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