Response of Chickpea Genotypes to Drought

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***Abstract*—**Water is the main component of biological processes. Water management is important to obtain higher productivity. In this study, some of the yield components were investigated together with different drought levels. Four chickpea genotypes (CDC Frontier, CDC Luna, Sawyer and Sierra) were grown in pots with 3 different irrigation levels (a dose of 17.5 ml, 35 ml and 70 ml for each pot per day) after three weeks from sowing. In the research, flowering, pod set, pod per plant, fertile pod, double seed/pod, stem diameter, plant weight, seed per plant, 1000 seed weight, seed diameter, vegetation length and weekly plant height were measured. Consequently, significant differences were observed on all the investigated characteristics owing to genotypes (except double seed/pod and stem diameter), water levels (except first pod, seed weight and height on 3rd week) and genotype x water level interaction (except first pod, double seed/pod, seed weight and height).

***Keywords*—**Agronomical characteristics, *Cicer arietinum*, water levels.

I. Introduction

DEMAND for food has been increasing worldwide as populations continue to increase. Scientists search for solutions to agriculture production systems in an effort to meet rising food needs. The solutions should be environmentally friendly for sustainable agriculture [1]. Increased yield can be realized through plant breeding and improved crop management [2]. Water is an important resource and plays a vital role in agricultural activities [3]. Research efforts are unable to change ecological situations; however, it is possible to change some plant characteristics and develop new varieties and regulate or eliminate some of the harmful effects of environment on plant quality parameters. Knowledge of the effects of ecological conditions on plants will allow improvement of plant quality and productivity parameters [4].

Drought is a widely distributed ecological problem worldwide where water resources are limiting. Water requirements may be supplied by precipitation, irrigation or both. Crop water requirement is driven by evaporative demand and may be quantified by pan-evaporation during the growing season. Water is needed mainly to meet the demands of evaporation (E), transpiration (T) and the metabolic need of the plant, which are together termed consumptive use. Consumptive water use of the crop is less than its water requirement. Water requirement includes losses during the application of irrigation water in the field (percolation, seepage and runoff) and water required for special operations such as land preparation, transplantation and leaching. Crop water requirement depends on various factors including genotype, growth stage, crop duration, plant density, growing season, soil factors (i.e. texture, structure, depth and topography) and climatic factors (rainfall, temperature, relative humidity and wind velocity), as well as crop management practices such as tillage and weeding [5].

Pulse crops are rich sources of plant proteins [6]. Chickpea is traditionally a low-input crop and is grown extensively in moisture stressed environments. The global chickpea production has increased only marginally, unlike the many fold increase in cereal production over the last 40 years. There are many constraints to production from diseases, insects, pests, soil problems, environmental stresses and non-adoption of modern management techniques [7].

Research focused on drought is needed to develop strategies to manage drought. The results of previous research will be useful to understand the response of the plants to drought. The objective of this study was to investigate and identify the yield components in different chickpea genotypes in terms of the plant response to different levels of water shortage.

II. Materials And Methods

The experiment was carried out to investigate the effects of drought on chickpea grown under different water irrigation conditions. The plants were grown under greenhouse conditions on the campus of North Dakota State University, Fargo, ND, USA. The experimental design was 3x4 factorial with four replications. Plant materials comprised four chickpea genotypes, CDC Frontier, CDC Luna, Sawyer and Sierra. Two seeds were sown in each 15cm pot on 16 December 2011. which contains the soil type LC1. Each pot was filled with 335 g of LC1 potting media (SunGro Horticulture, Canada). Slow release fertilizer was applied after sowing immediately with a rate of ½ tea spoon of 3-month fertilizer type. Water was applied at the rate of 120 ml per pot from sowing to 21st day. The plants were thinned to one in each pot. Application of three different water levels (17.5 ml, 35 ml and 70 ml to each pot/daily) was started from 22nd day to harvest.

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Each plant was harvested by hand at maturity. Appropriate pesticides were appliedduring the growth period to control insects.

Flowering date, pod set date were calculated as day from sowing date; pod per plant, fertile pod, double seed/pod and seed per plant were determined by counting; stem diameter and seed diameter were measured using a micrometer caliper device (mm); plant weight (air dried plants were cut from soil level and then; leaves+stems+pods were weighed together) at harvest and 1000 seed weight were measured using a weigh scale (g); plant height (from soil level to highest terminal point) was measured weekly using a ruler (cm).

Analysis of variance was performed using "JUMP" computerized statistical program.

III. Results and Discussion

Results of statistical analysis are presented in Table I, II and III, respectively. Summary of genotypes x water level interactions are given below.

The shortest time (42 days) from sowing to starting of flowering was obtained from *"G1 X W3" [Genotype 1 (Sierra) X Water level 3 (17.5 ml/day)]* while "G3 X W3 and G4 X W1" had the longest time to flowering (58.75 days). Ganjeali, Porsa and Bagheri [8] reported that, days to first flower in chickpea genotypes ranged from 42.7-53.1 days under stress conditions, and ranged from 45.3 to 52.1 under non-stress conditions.

Furthermore, "G1 X W3" had the shortest time (61 days) in terms of pod set and "G3 X W3" had the longest time (67.25) to pod set. It was reported that days to flowering varies between 60 and 101 days in chickpea [9].

Number of total pods per plant ranged from 2 (G1 X W3 and G4 X W2) to 34 (G1 X W1). It was reported that number of pods per plant varies between 3 and 46 per plant [10].

There were differences for. The overall mean number of fertile pods per plant across genotypes and water level ranged from 0.5 to 24. The results of the research were in accordance with previously reported results [11].

Water level had significant effects on number of pods with two seeds for all the genotypes except the genotype 4 (Sierra). The highest value (1.75) was recorded for the "G3 X W1" treatment. Liu, Gan, Warkentin and McDonald [12] determined that more than 96 % of the chickpea pods contained one seed.

Significant differences were not detected among genotypes for stem diameter. The highest value was 0.49 mm on "G4 X W1" while the lowest value was 0.33 cm and 0.34 cm and was observed for the 17.5 ml water treatment. Previous research revealed that stem diameter varied from 0.451 to 0.584 cm in chickpea [13].

Genotype X water level interaction had a significant effect on plant weight during harvest and varied widely among the genotypes and also water levels. The highest value (19.5 g) was obtained from "G3 X W1" while "G4 X W3" had the lowest value (5.6 g) for plant weight. McPhee, Spaeth and Muehlbauer [14] reported that differences (i.e. water availability) in the upper and lower slope positions were important for seed and residue production.

There were large differences for number of seeds per plant. The highest yield (25) was recorded for the "G1 X W1"treatment. The interaction of "G4 X W2" had 0.25 seed per plant. It was previously reported that the number of seeds ranged from 15 to 40 per plant in different chickpea genotypes [15].

The interaction of genotype X water level for 1000 seed weight was not significant. Mean 1000 seed weight ranged from 110 g (G1 X W2) to 533 g (G2 X W1). A previous study reported that the weight of 1000 seeds ranged from 167 to 289 g in several genotypes of chickpea [8]. Another study showed that, the weight of 1000 seeds ranged from 167 to 485 g in several genotypes of chickpea [16].

Mean seed diameter was greatest (9.1 mm) for the "G4 X W1" treatment and lowest (2.3 mm) for the "G4 X W2" treatment. Means were significantly different at the 1% level of probability. Cubero [17] reported that seed diameter changed from 4 mm to 8 mm in chickpea.

Days to maturity varied widely from 97 days (G3 X W3) to 112 days. A previous study revealed that days to maturity ranged from 103.0 to 132.6 days in chickpea genotypes [18].

Plant height was lowest for the "G2 X W3" treatment while "G4 X W1" had the greatest value. Plant height at harvest ranged from 38.7 cm to 64.8 cm in terms of genotype x water level interaction. Upadhyaya [18] reported that the height of chickpea varies from 18.4 cm to 103.8 cm in chickpea genotypes.

Appendix

The results of variance analysis were given in Table 1, 2 and three, respectively.

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References

[1] Kahraman, A., Önder, M. and Ceyhan, E., 2011. Biodiversity and biosecurity in Turkey. Biology, Environment and Chemistry (ICBEC 2011), Volume 24, Page 33-37, December 28-30, Dubai, UAE.
[2] McPhee, K. E. and Muehlbauer, F. J., 2001. Biomass production and related characters in the core collection of Pisum germplasm. Genetic Resources and Crop Evaluation, 48: 195-203.
[3] Önder, M., Ceyhan, E. and Kahraman, A., 2011. Effects of agricultural practices on environment. Biology, Environment and Chemistry (ICBEC 2011), Volume 24, Page 28-32, December 28-30, Dubai, UAE.
[4] Ceyhan, E., Kahraman, A. and Önder, M., 2012. The effects of environment on plant products. International Journal of Bioscience, Biochemistry and Bioinformatics, Volume 2, no 1, Page 48-51.
[5] Sekhon, H. S. and Singh, G., 2007. Irrigation management in chickpea. Chickpea Breeding and Management. Edited by S. S. Yadav, R. Redden, W. Chen and B. Sharma. Cab International. Cambridge, MA, USA.
[6] Önder, M. and Kahraman, A., 2009. Antinutritional factors in food grain legumes. 1st International Syposium on Sustainable Development, volume 3, page 40-44, June 8-10, Sarajevo.

[7] Yadav, S.S., Redden, R., Chen, V. and Sharma, B., 2007. Chickpea breeding and management. cab international. Cambridge, MA, USA.
[8] Ganjeali, A., Porsa, H. and Bagheri, A., 2011. Assessment of Iranian chickpea (*Cicer arietinum* L.) germplasms for drought. Agricultural Water Management, 98: 1477-1484.
[9] Anonymous, 2012. dspace.icrisat.ac.in/bitstream/.../PMD53.pdf. Cold - tolerant chickpea varieties. ICRISAT. Plant material descriptipn no 53.
[10] Eser, D., Geçit, H.H., Emekliler, H.Y and Kavuncu, O., 1989. Nohut gen materyalinin zenginleştirilmesi ve değerlendirilmesi. Turk J. Agric., 13(2):246-254.
[11] L. Leport, N.C. Turner, S.L. Davies and K.H.M. Siddique, "Variation in pod production and abortion among chickpea cultivars under terminal drought", Europ. J. Agronomy, 24: 236–246, 2006.
[12] Liu, P. H., Gan, Y., Warkentin, T. and McDonlad, C., 2003. Morphological plasticity of chickpea in a semiarid environment. Crop Sci., 43: 426-429.
[13] Cokkizgin, A., 2012. Botanical characteristics of chickpea genotypes (Cicer arietinum L.) under different plant densities in organic farming. Scientific Research and Essays. Vol. 7 (4), pp. 498-503.
[14] McPhee, K. E., Spaeth, S. C. and Muehlbauer, F. C., 1997. Seed yield and residue production of lentil cultivars grown at different slope positions. J. Prod. Ag. 10: 602-607.
[15] Wang, J., Gan, Y. T., Clarke, F. and McDonald, C. L., 2006. Response of chickpea yield to high temperature stress during reproductive development. Crop. Sci., 46: 2171-2178.
[16] Cinsoy, A.S., Açıkgöz, N., Yaman, M., Kıtıkı, A. 1997. Ege bölgesinden toplanan nohut (*Cicer arietinum* L.) genetik kaynakları materyalinin karakterizasyonu kantitatif karakterler. Anadolu, J of AARI, 7 (1), 1-14.
[17] Cubero, J.I.,1987. Morphology Chickpea. The Chickpea C.A.B. International ICARDA. (Eds. M.C. Saxena and K.B. Singh), Aleppo, Syria.
[18] Upadhyaya, H. D., 2003. Geographical patterns of variation for morphological and agronomic characteristics in the chickpea germplasm collection. Euphytica 132: 343–352.

TABLE I
ANALYSIS OF VARIANCE FOR THE INVESTIGATED CHARACTERISTICS

Characteristic	**P**		
	Genotype	*Water level*	*Interaction*
Flower (day)	<0.01	<0.01	<0.01
Flower-Pod (day)	<0.01	ns	<0.01
Pod set (day)	<0.01	ns	ns
Total pod/Plant (number)	<0.01	<0.01	<0.01
Fertile pod (number)	<0.01	<0.01	<0.01
Double seed/Pod (number)	ns	<0.01	ns
Stem diameter (mm)	ns	<0.01	<0.01
Plant weight (g)	<0.01	<0.01	<0.01
Seed/Plant (number)	<0.01	<0.01	<0.05
1000 seed weight (g)	<0.01	ns	ns
Seed diameter (mm)	<0.01	<0.05	<0.05
Vegetation (day)	<0.01	<0.01	<0.01
Height (3rd week) (cm)	<0.01	ns	ns
Height (4th week) (cm)	<0.01	<0.01	ns
Height (5th week) (cm)	<0.01	<0.01	ns
Height (6th week) (cm)	<0.01	<0.01	ns
Height (7th week) (cm)	<0.01	<0.01	ns
Height (8th week) (cm)	<0.01	<0.01	ns
Height (9th week) (cm)	<0.01	<0.01	ns
Height (10th week) (cm)	<0.01	<0.01	ns
Height (11th week) (cm)	<0.01	<0.01	ns
Height (12th week) (cm)	<0.01	<0.01	ns
Height (13th week) (cm)	<0.01	<0.01	ns
Height (14th week) (cm)	<0.01	<0.01	ns
Height (15th week) (cm)	<0.01	<0.01	ns

ns: non-significant

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TABLE II
MEANS OF THE INVESTIGATED CHARACTERISTICS AND DUNCAN GROUPS

Characteristic	Means of Water Levels			Means of Genotypes			
	70 ml (W1)	35 ml (W2)	17.5 ml (W3)	Frontier (G1)	Luna (G2)	Sawyer (G3)	Sierra (G4)
Flower (day)	48.56a	46.38b	47.63a	47.17b	45.50c	48.33ab	49.08a
Flower-Pod (day)	14.88b	16.75a	15.38ab	15.25b	17.67a	17.00ab	12.75c
Pod set (day)	63.44	63.13	63.00	62.42b	63.17b	65.33a	61.83b
Total pod/Plant (number)	21.44a	5.38b	3.13b	14.58a	6.50b	12.17a	6.67b
Fertile pod (number)	16.5a	3.44b	2.69b	10.17a	5.75b	8.92a	5.33b
Double seed/Pod (number)	1.19a	0.44b	0.00b	0.83	0.58	0.75	0.00
Stem diameter (mm)	0.468a	0.379b	0.334c	0.394	0.398	0.382	0.400
Plant weight (g)	18.25a	9.31b	5.97c	10.58b	9.75b	13.83a	10.54b
Seed/Plant (number)	17.56a	3.81b	2.31b	11.00a	6.33b	9.67a	4.58b
1000 seed weight (g)	391.42	322.45	353.80	144.34c	503.17a	442.42ab	333.64b
Seed diameter (mm)	8.46a	6.57b	7.62ab	7.13ab	8.64a	8.54a	5.88b
Vegetation (day)	108.38a	106.63b	102.00c	108.50a	104.75c	102.25d	107.17b
Height (3rd week) (cm)	32.32	32.63	32.06	28.23c	26.22d	35.94b	38.96a
Height (4th week) (cm)	44.24a	42.49ab	40.63b	34.94b	35.31b	49.50a	50.07a
Height (5th week) (cm)	50.60a	47.04b	43.94c	38.98b	42.16b	54.01a	53.62a
Height (6th week) (cm)	53.07a	48.48b	45.33c	40.60b	43.55b	55.87a	55.81a
Height (7th week) (cm)	55.14a	49.13b	45.65c	42.15b	44.84b	56.50a	56.40a
Height (8th week) (cm)	56.10a	49.79b	45.91c	43.01b	45.46b	57.06a	56.88a
Height (9th week) (cm)	57.19a	50.29b	46.43c	44.54b	45.77b	57.55a	57.35a
Height (10th week) (cm)	57.81a	50.58b	46.58c	45.06b	45.96b	57.84a	57.76a
Height (11th week) (cm)	58.13a	50.84b	46.65c	45.66b	46.08b	57.88a	57.87a
Height (12th week) (cm)	58.40a	51.13b	46.76c	46.27b	46.12b	58.01a	58.00a
Height (13th week) (cm)	58.68a	51.23b	46.81c	46.68b	46.12b	58.13a	58.02a
Height (14th week) (cm)	59.16a	51.41b	46.83c	47.48b	46.12b	58.18a	58.09a
Height (15th week) (cm)	59.51a	51.50b	46.83c	47.83b	46.20b	58.27a	58.15a

TABLE III
MEANS OF GENOTYPE X WATER LEVEL AND DUNCAN GROUPS

Characteristic	Least Squares Means of Genotype X Water level											
	G*1XW*1	G1XW2	G1XW3	G2XW1	G2XW2	G2XW3	G3XW1	G3XW2	G3XW3	G4XW1	G4XW2	G4XW3
Flower (day)	50b	49.75b	41.75e	43.50cde	47.75b	45.25c	42de	44.25cd	58.75a	58.75a	43.75cde	44.75c
Flower-Pod (day)	12.5e	14de	19.25abc	21ab	15.25de	16.75cd	22.25a	20.25abc	8.5f	3.75g	17.5bcd	17cd
Pod set (day)	62.5bcd	63.75bcd	61d	64.5ab	63bcd	62bcd	64.25abc	64.5ab	67.25a	62.5bcd	61.25c	61.75bcd
Total pod/Plant (number)	33.75a	7.75de	2.25e	12.75cd	3.75e	3e	24.5b	8de	4e	14.75c	2e	3.25e
Fertile pod (number)	23.75a	5de	1.75de	11.25c	3de	3de	18.25b	5.25d	3.25de	12.75c	0.5e	2.75de
Double seed/Pod (number)	1.5ab	1abc	0c	1.5ab	0.25bc	0c	1.75a	0.5bc	0c	0c	0c	0c
Stem diameter (mm)	0.48a	0.38c	0.33d	0.48a	0.38c	0.34d	0.43b	0.38c	0.34d	0.49a	0.38c	0.33d
Plant weight (g)	19.3a	6.8d	5.8d	16bc	7.5d	5.8d	19.5a	15.3c	6.8d	18.3ab	7.8d	5.6d
Seed/Plant (number)	25.3a	6c	1.75cd	12.75b	3.25cd	3cd	20a	5.75c	3.25cd	12.25b	0.25d	1.25cd
1000 seed weight (g)	169bc	110c	154c	533a	528a	449a	407a	471a	450a	458a	182bc	362ab
Seed diameter (mm)	7.30ab	6.68ab	7.43ab	8.92ab	8.61ab	8.40ab	8.57ab	8.69ab	8.35ab	9.06a	2.30c	6.29b
Vegetation (day)	112a	112a	101.5c	112a	104.5b	97.75d	112a	98d	96.75d	97.5d	112a	112a
Height (3rd week) (cm)	27.98de	29.68d	27.03de	27.05de	25.65e	25.95e	35.55bc	35.25c	37.03abc	38.7ab	39.93a	38.25abc
Height (4th week) (cm)	35.15cd	36.13cd	33.55cd	37.1c	36.1cd	32.73d	52.58a	48.7ab	47.23b	52.15a	49.03ab	49.03ab
Height (5th week) (cm)	39.5fg	40.63efg	36.83g	46de	43ef	37.48fg	59.15a	52.63bc	50.28cd	57.75ab	51.9c	51.2cd
Height (6th week) (cm)	41.78ef	41.8ef	38.23f	48.25cd	44.13de	38.28f	61.58a	53.98bc	52.05bc	60.68a	54b	52.75bc
Height (7th week) (cm)	44.9c	42.65cd	38.9d	51.35b	44.7c	38.48d	62.53a	54.9b	52.08b	61.78a	54.28b	53.15b
Height (8th week) (cm)	46.28c	43.58cd	39.18d	52.48b	45.33c	38.58d	62.93a	55.65b	52.6b	62.73a	54.63b	53.28b
Height (9th week) (cm)	48.88cd	44.25def	40.5ef	53.1bc	45.63de	38.58f	63.63a	56.13b	52.9bc	63.15a	55.15b	53.75bc
Height (10th week) (cm)	49.8cd	44.5def	40.88ef	53.48bc	45.75de	38.65f	63.93a	56.6b	53bc	64.03a	55.45bc	53.8bc
Height (11th week) (cm)	50.55bc	45.5cd	40.93de	53.78b	45.75cd	38.73e	63.98a	56.6b	53.08b	64.23a	55.5b	53.88b
Height (12th week) (cm)	51.4bc	46.13cd	41.28de	53.85b	45.78cd	38.73e	63.98a	56.88b	53.18b	64.38a	55.75b	53.88b
Height (13th week) (cm)	52.25bc	46.5cd	41.23de	53.85b	45.78d	38.73e	64.18a	56.88b	53.35b	64.43a	55.75b	53.88b
Height (14th week) (cm)	53.78b	47.38cd	41.28de	53.98b	45.65d	38.73e	64.25a	56.88b	53.43bc	64.65a	55.75b	53.88b
Height (15th week) (cm)	54.48b	47.73cd	41.28ef	54.23b	45.65de	38.73f	64.5a	56.88b	53.43bc	64.83a	55.75b	53.88bc

G*= Genotype W*= Water level X= Interaction