INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–4–590–593
http://www.fspublishers.org

Response of Chickpea Genotypes to Irrigated and Rain-fed Conditions

AHMAD BAKHSH, SHAHID RIAZ MALIK[1], MOHAMMAD ASLAM†, UMER IQBAL† AND A.M. HAQQANI
Pulses Program, National Agricultural Research Center, Islamabad, Pakistan
†*Arid Zone Research Institute, Bhakkar, Pakistan*
[1]Corresponding author's e-mail: shahriz5@yahoo.com

ABSTRACT

A field study was undertaken to evaluate newly developed chickpea genotypes under water application and rain-fed management system. Highly significant differences were observed between genotypes and between two management practices for all the traits except primary branches per plant, which were non-significantly different between two managements. The interaction between genotypes and managements (G x M) was non-significant for number of primary branches and number of secondary branches. The yield and most of the yield components were improved with the application of irrigation. On average basis 48% increase in number of pods per plant, 36% in total dry weight and 17% in grain yield was recorded due to irrigation. On the contrary, the grain size was reduced by 16% and the number of primary and secondary branches remained un-affected due to irrigation. The genotype 93A086 with grain yield of 14.37 g per plant was better under irrigation while 92A207 with grain yield of 12.60 g per plant performed better under rain-fed planting. It may be inferred from the present study that any genotype that responds positively to irrigation with respect to seed size coupled with increase in number of pods per plant will be most suitable for irrigated areas.

Key Words: Chickpea; *Cicer arietinum;* Grain yield; yield components; Irrigation; Rain-fed; Management system

INTRODUCTION

Chickpea is the third most important food legume after peas and soybean in the world. Due to high protein content, it has become an important component of human diet in developing world. Pakistan is one of the major chickpea producing countries, where it is annually cultivated on about one million ha. "Thal" that is comprised of parts of district Mianwali, Khushab, Bhakkar, Jhang, Layyah, Lucky Marwat and Karak is the major chickpea-producing tract, where the soils are predominantly sandy and the crop is planted under rain-fed management system. Under rain fed condition the chickpea crop usually faces moisture stress due to low rainfall and responds favorably to supplemental irrigation (Singh, 1980; Raghu & Choubey, 1983). The study of genetic parameters of chickpea under irrigated and rain-fed management conditions revealed significantly positive effect of irrigation on all the parameters including yield (Nawaz *et al*., 1994; Shinde *et al.,* 1996; Jagganath *et al.*, 1999; Anwer *et al*., 2003). Yet, it has been observed that with the introduction of canal or tube well irrigation, the farmers tend to grow major crops and consequently the area of pulses and specifically that of chickpea is reduced. Although, recently, the low water requiring crops like chickpea are becoming a popular option in irrigated areas due to frequent droughts caused by lower availability of water in rivers, the chickpea area under canal command in Pakistan could not substantially increase. To make chickpea a competitive crop for irrigated regions the information on its water requirement and identification of genotypes responsive to water application is vital.

Recently, the Government of Pakistan has initiated a project aimed at providing irrigation facility for the "Thal" area, where chickpea is traditionally grown as rain-fed. It is very likely that the chickpea area will sharply decline with the introduction of irrigation in Thal. Under such situation it would be important to develop high input responsive chickpea cultivars that could compete with other cash crops in irrigated areas. Present study was an effort to evaluate and identify new genotypes suitable for irrigated and rain fed conditions. The information obtained from this study will go a long way to maintain chickpea area and improve its production.

MATERIALS AND METHODS

A field experiment was conducted at Arid Zone Research Institute, Bhakkar, Pakistan, during Rabi (winter) season of 2002 - 03 on a sandy loam soil. The experimental treatments consisted of eight new chickpea genotypes *viz*. CM-98, 92A048, 93A111, 92A207, 93A086, 92A217, 92A186 and PC 2000 and two management practices (irrigated & rain-fed). The experiment was laid out in a split plot design with management practices in main plots and genotypes in subplots. The treatments were replicated three times. Each genotype was planted in a 4 m long, 6-row plot. Row to row and plant - plant distance was maintained at 30 cm and 10 cm, respectively. The seed was sown with a single row drill and 30 days old seedlings were thinned to establish the plant - plant distance. Before sowing, a soaking

dose of water was applied to the whole experimental area to obtain uniform germination. The first post planting irrigation to the main plots with irrigated management was applied 45 days after germination and second irrigation was applied 105 days after germination when 50% flowering had occurred. No post planting irrigation was applied to the plots with rain-fed management. The weather data during the experimental period are presented in Table III. Data on days to 50% flowering was recorded on plot basis, whereas data on grain yield and other yield parameters was recorded on 10 randomly selected plants from each treatment. This data were subjected to Analysis of variance (Steel & Torrie, 1980) to determine the significance of difference between treatments. Least significant difference (LSD) test was applied for comparison of means of individual genotypes.

RESULTS

Results of Analysis of variance presented in Table I revealed significant differences between genotypes for all the traits. Similarly the two management practices differed significantly for all parameters except primary and secondary branches per plant. The interaction between genotypes and managements (G X M) was non-significant for plant height, primary branches per plant and secondary branches per plant (Table I), whereas this interaction had significant effect on the rest of the characters studied. The genotypic means for various traits over the two managements revealed that number of primary branches and number of secondary branches per plant varied from 2.63 to 3.60 and from 5.97 to 8.45, respectively. Maximum number of primary branches and maximum number of secondary branches were recorded in the genotype 92A207 (Table II a & b). The genotypic variation for number of pods per plant, total dry weight per plant (g), 100 grain weight (g) and grain yield per plant (g), respectively was in the range of 30.96 to 42.97, 27.43 to 37.75, 20.94 to 25.75 and 8.76 to 11.95. The comparison of means of two management practices for various traits over the genotypes expressed a substantial increase due to irrigation in all the traits except primary and secondary branches per plant. The increase in number of pods per plant, dry weight per plant and grain yield per plant due to irrigation was 47.42%, 36.09% and 17.03%, respectively (Table II a & b). The 100-grain weight was reduced by 15.93% due to irrigation. Maximum pods per plant (53.83), maximum 100 grain weight (25.04 g) and maximum grain yield per plant (14.37 g) under irrigation practice were obtained from the same genotype (93A086). On the other hand under rain-fed condition maximum number of pods (32.20), maximum 100 grain weight (24.41 g) and maximum grain yield per plant (12.30) were obtained from another genotype 92A207.

DISCUSSION

Chickpea is an important pulse crop throughout the world. Due to its ability to survive and perform well under moisture stress conditions this crop is an important component of rain-fed agriculture in Pakistan. The greater Thal that is comprised of districts of Mianwali, Khushab, Bhakkar, Jhang and Layyah in Punjab province and Karak and Lucky Marwat from NWFP is traditionally rain-fed area of chickpea in Pakistan. Recently, the Government of Pakistan has launched a project to establish canal irrigation system in Thal. It has been observed that on having irrigation facility the farmers tend to switch over to cash crops other than pulses. Therefore, it is quite likely the area of chickpea in Thal will reduce drastically on availability of canal irrigation if suitable genotypes and related technology that enables chickpea to compete with cash crops like wheat, cotton, etc., is not developed. The Present study was an attempt to identify genotypes suitable for irrigated and rain-fed agriculture. The results of this study reveled highly significant differences between genotypes, showing the genetic variability in the experimental material. The difference between two management systems was also highly significant. The application of irrigation improved all the major traits by increasing 17.03% grain yield, 36% dry weight and 48% pods per plant on overall basis. Ali *et al.* (1995) and Giunta and Motzo (2003) reported increase in total dry weight under irrigation. Nawaz (1994) and Shinde *et al.* (1996) found the pods per plant to be the most affected trait by the irrigation. Similarly the delay in days to 50% flowering suggested that irrigation prolongs the vegetative period. As indicated by highly significant genotype x management interaction, the response of genotypes for flowering time to the management was quite variable. Kanouni (2001) have reported delay in flowering due to irrigation. However, irrigation invariably caused reduction in grain size of all the genotypes. This reduction may be attributed to the reduced availability of assimilate and increase in number of pods. Malik and Anwar (1994) and Katare *et al.* (1984) reported no change in grain size due to irrigation. As already found by Malhotra *et al.* (1997) and Ammannuallah (1999), the present study showed an increase in plant height due to irrigation, though the genotype x management interaction was non-significant for this trait showing similarity in response by all the genotypes to irrigation. Generally, our results get support from the findings of Shinde *et al.* (1996), Khan *et al.* (1995) and Rahman *et al.* (1983). The non-significant difference between genotypes, between managements and non-significant genotypes x management interaction for primary branches indicated the stability of this character across changes in production conditions. Malhotra *et al.* (1997) and Ammanullah *et al.* (1999) have already reported similar findings. The extent of negative effect of irrigation on grain size was different in different genotypes. Despite reduction in grain size grain yield was increased as its negative effect was compensated by the increase in pods/plant, invariably in all the genotypes. Rather, the grain yield in all the genotypes was increased under irrigated condition. Increase in grain

Table I. Results of analysis of variance for the significance of difference between genotypes and managements for yield and yield components in chickpea

SOV Source of variation	Degree of freedom	Mean squares						
		Days to 50% flowering	Plant height	Primary branches	Secondary branches	Pods/ plant	Dry weight	100-seed weight
Genotypes (A)	7	34.81**	11.21**	0.525**	5.31**	87.10**	68.56**	17.76**
Error I	14	1.56	3.64	0.166	0.094	2.01	1.65	1.33
Management Practice (B)	1	841.68**	1092.0**	0.067NS	0.047NS	4224.37**	997.36**	150.70**
Error II	2	3.25	3.03	0.162	0.004	0.758	1.53	0.11
(AxB)	7	14.88**	7.016NS	0.067NS	0.040NS	11.29**	144.26**	7.50**
Error III	14	2.58	3.24	0.034	0.031	1.51	2.08	0.771
CV %age		1.56	3.35	6.27	2.54	3.38	4.85	3.66

Table IIa. Performance of chickpea genotypes for yield and important yield components under rain-fed and irrigated conditions

Genotypes	Days to 50% Flowering			Plant Height (Cm)			Primary Branches/Plant			Secondary Branches/Plant		
	Rain fed	Irrigated	Average	Rain fed	Irrigated	Average	Rain fed	Irrigated	Average	Rain fed	Irrigated	Average
CM-98	99.00	108.0	103.5	36.53	66.17	51.35	2.833	2.900	2.867	6.800	6.933	6.867
92A048	97.33	107.3	102.33	40.73	69.77	55.25	2.867	2.900	2.883	6.833	6.733	6.783
93A111	98.33	108.0	103.17	39.80	66.60	53.20	2.967	2.967	2.967	7.067	7.167	7.117
92A207	98.33	108.0	103.17	40.17	66.63	53.40	3.667	3.533	3.600	8.500	8.400	8.450
93A086	91.67	104.3	98.00	40.67	70.87	55.77	2.700	3.200	2.950	8.300	8.133	8.217
92A217	100.7	107.3	104.00	37.43	69.47	53.45	2.500	2.767	2.633	5.833	6.100	5.967
92A186	105.7	107.7	106.67	39.70	66.33	53.02	2.733	2.633	2.683	5.967	6.200	6.083
PC2000	100.0	107.3	103.67	38.27	69.47	53.87	2.867	2.833	2.850	6.133	6.267	6.200
Mean	98.88	107.24	-	39.16	68.16	-	2.89	2.84	-	6.93	6.99	-
%increase or decrease by irrigation	-	8.44	-	-	74.05	-	1.76	-	-		0.86	
LSD VALUE	3.033	1.504	2.335	2.734	3.689	3.079	0.4499	0.6410	0.5378	0.4732	0.3993	0.4050

Table IIb. Performance of chickpea genotypes for yield and important yield components under rain-fed and irrigated conditions

Genotypes	Number of pods/plant			Total dry weight (g)			100-grain weight (g)			Grain yield/plant (g)		
	Rainfed	Irrigated	Average	Rainfed	Irrigated	Average	Rain fed	Irrigated	Average	Rain fed	Irrigated	Average
CM-98	23.50	38.43	30.967	20.80	37.23	29.02	26.19	19.67	22.93	6.733	10.80	8.767
92A048	26.30	46.27	36.283	20.03	41.17	30.60	27.67	24.67	26.17	9.167	12.00	10.583
93A111	27.67	43.40	35.533	24.83	31.83	28.33	26.90	24.80	25.85	8.800	13.60	11.200
92A207	32.20	49.20	40.700	43.63	31.87	37.75	24.41	21.39	22.90	12.30	8.900	10.600
93A086	32.07	53.83	42.95	22.90	32.83	27.87	24.61	25.04	24.83	9.53	14.37	11.950
92A217	24.27	44.00	34.13	21.83	33.03	27.43	23.39	18.49	20.94	9.133	10.37	9.750
92A186	25.00	43.43	34.22	24.97	30.63	27.80	27.42	21.47	24.44	10.50	9.567	10.033
PC2000	24.93	47.47	36.20	22.93	36.27	29.60	25.48	22.19	23.84	10.90	10.57	10.733
Mean	26.99	39.80	-	25.24	34.36		25.76	22.22	-	9.63	11.27	-
%increase or decrease due to irrigation		48.12			36.09	-	15.93		-		17.03	
LSD VALUE	1.650	2.842	2.170	2.076	2.670	2.264	1.531	2.023	1.565	1.172	1.398	1.192

yield of chickpea under irrigation has been reported by many workers (Chavan *et al.*, 1993; Krishnamurthy *et al.*, 1999; Jagannath *et al.*, 1999; Anwar *et al.*, 2003).

The comparison between individual genotypes revealed that under irrigated condition 93A086 and under rain-fed condition 92A207 gave maximum grain yield. The grain size remained stable in 93A086, whereas it was reduced in 92A207 on application of irrigation. Nagative effect of irrigation on grain size in chickpea has been reported by Malik and Anwar (1994). Katare *et al.* (1984) however, reported no change in grain weight due to irrigation. The partial differences between results of various studies may be due to different genotype used in difference studies. The scanning of literature on the effect of irrigation on grain yield and yield components showed that grain yield is increased by the application of supplementary irrigation especially in water stress condition (Chavan *et al.*, 1993; Jagannath *et al.*, 1999; Krishnamurthy *et al.*, 1999; Anwar *et al.*, 2003). From the present study it was obvious that

Table III. Monthly rainfall (mm) at Arid Zone Research Institute (AZRI) Bhakkar from July 2002 to April 2003

Month	Rainfall (mm)	Remarks
July-02	-	Moon soon rains are received in the months of July and August.
August-02	-	
September-02	40.5	6 rains each of 8.5mm, 2mm, 8mm, 15mm,3mm and 4mm
October-02	19.0	2 rains each of 12mm and 7mm
November-02	01.0	Single rain
December-02	09.5	Single rain
January-03	06.5	3 rains each of 0.5mm, 1.0mm and 5.0mm
February-03	30.0	4 rains each of 4mm, 10mm, 6mm and 10mm.
March-03	30.0	3 rains each of 10mm, 5mm and 15mm
Total	136.5	

number of pods per plant was the most important character that responded positively to irrigation and hence contributed significantly to yield increase. On the contrary, the reduction in grain size contributed negatively to yield under irrigation.

It can be inferred from the present study that any genotype that responds positively to irrigation with respect to seed size coupled with increase in number of pods per plant will prove the most suitable for irrigated areas.

REFERENCES

Ali, A., K. Mahmood, M. Tufail and M. Ishaq, 1995. Selection of chickpea varieties for greater dry matter accumulation/partitioning efficiency under irrigated and rain fed conditions. *J. Agric. Res*., 33: 154–8

Ammanullah, M. Hatam and Y. Hayat, 2001. Evaluation of chickpea genotypes under Peshawar valley conditions. *Sarhad J. Agric*., 17

Anwar, M.R., B.A. McKenzie and G.D. Hill, 2003. Water-use efficiency and the effect of water deficits on crop growth and yield of kabuli chickpea in a cool-temperate sub humid climate. *J. Agric. Sci*., 141: 285–301

Chavan, J.K., D.P. Kachare, R.B. deshmukh and S.S. Kadam, 1993. Grain yield, dhal milling and cooking qualities of chickpea cultivars grown under rain-fed and irrigated conditions. *J. Maharashtra Agric. University*, 18: 281–3

Giunta, F. and R. Motzo, 2003. Sowing date, irrigation and nitrogen effects on biomass and grain yield of chickpea (*Cicer arietnium* L.) in a Mediterranean environment. *Agric. Mediterranea*, 133: 130–40

Jagannath, N.H., M.V.N. Setty, M.B. Gowda, D. Basavarijaiah and J. Chandraprakash, 1999. Stability of genetic parameters under irrigated and stressful conditions for yield and its components in chickpea. *Crop Res. Hisar*, 17: 367–70

Kanouni, H., 2001. The yielding ability and adaptability of chickpea cultivars under rain fed conditions of Kurdistan. *Seed Pl.* 17: 1

Katare, R.A., V.M. Bhale and K.S. Mulgir, 1984. Effect of irrigation on gram yield. *J. Maharashtra Agriculture University*, 9: 217

Khan, M.S., M. Rehman and U.K. Shaha, 1995. Yield and water relations in chickpea under various irrigation levels. *J. Agric. Res*., 33: 23–30

Krishnamurthy, L., C. Johasen and S.C. Sethi, 1999. Investigation of factors determining genotypic differences in seed yield of non-irrigated and irrigated chickpea using a physiological model of yield determination. *J. Agron. Crop Sci*., 18: 9–17

Malhotra, R.S., K.B. Singh and M.C. Saxena, 1997. Effect of irrigation on winter sown chickpea in a Mediterranean environment. *J. Agron. Crop Sci*., 178: 237–43

Malik, M.A. and M. Anwar, 1994. Effect of irrigation on growth and seed yield of chickpea. *J. Agric. Res*., 32: 261–5

Nawaz, M., 1994. The response of chickpea to sowing date, plant population and irrigation. *Ph D. Thesis*, Department of Agronomy, University Agriculture Faisalabad, Pakistan

Raghu, J.S. and S.D. Choubey, 1983. Response of gram to irrigation and fertilization. *Indian J. Agron.*, 28: 239–42

Rahman, S.M., M. Alam, M. Shamsul and M. Ahmad, 1983. Water relations and yield of two chickpea cultivars as influenced by different levels of irrigation. *Thai J. Agric. Sci*., 16: 253–65

Shinde, G.C., J.G. Patil, R.B. Deshmukh and R.P. Aher, 1996. Genetic variability in chickpea under rain-fed and irrigated conditions. *J. Maharashtra Agric. University*, 21: 476–7

Singh, R.C., A.S. Faroda and Sharma, 1980. Response of gram to irrigation and fertilization. *Indian J. Agron*., 25: 239–43

Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Procedures of Statistics: A Biometrical Approach*. McGraw Hill Book Co., New York

(Received 04 May 2006; Accepted 15 July 2006)