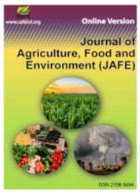
Vol 2 No 2 June 2021 Pages 24-29 e-ISSN 2708-5694

Journal of Agriculture, Food and Environment (JAFE)

Journal Homepage: http://journal.safebd.org/index.php/jafe

http://doi.org/10.47440/JAFE.2021.2205



Original Article

Growth and yield performance of chickpea varieties (*Cicer arietinum* L.) under rainfed and irrigated conditions

S. Rezia[1], A. K. Hasan[1], M. R. Uddin[1], S. G. Azam[2], R. Nasrin[3], F.M.M. Hossain[4] and U. K. Sarker[1]

[1]Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]Momenshahi Educational and Training Institute, Mymensingh
[3]Department of Agricultural Extension, Nakla, Sherpur
[4]Ministry of Expatriates Welfare & Overseas Employment, Dhaka

A B S T R A C T

Water scarcity is the most common abiotic stress limiting chickpea production which is usually grown under the residual soil moisture. Considering this point, the present study was undertaken to determine the effect of irrigation levels on growth and yield of chickpea varieties. The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh from November 2016 to March 2017. The experiment comprised of four varieties such as BARI Chola-5, BARI Chola-9, BINA Chola-4 and BINA Chola-7 and three irrigation levels viz. one irrigation at pre-flowering stage, two irrigations at pre-flowering and pod formation stages and rainfed condition. The results revealed that irrigation treatments had significant effect on growth parameters (plant height, nodule number and dry matter production). Among the yield and yield contributing characters, the highest number of pods plant^{-1} (48.67), number of seeds pod^{-1} (1.44), seed yield (1.25 t ha^{-1}) and stover yield (2.85 t ha^{-1}) were found from BARI Chola-9. Accordingly, highest number of pods plant^{-1} (49.75), number of seeds pod^{-1} (1.53), seed yield (1.32 t ha^{-1}) and stover yield (2.94 t ha^{-1}) were found from two irrigations (pre-flowering and pod formation stages). The lowest seed yield (0.63 t ha^{-1}) and stover yield (1.63 t ha^{-1}) were found from BINA Chola-4 with rainfed condition while the highest seed yield (1.59 t ha^{-1}) and stover yield (3.46 t ha^{-1}) were found from BARI Chola-9 with two irrigations (pre-flowering and pod formation stage).Considering the above results, it can be suggested that BARI Chola-9 cultivation with applying supplemental irrigation before flowering and pod formation stages may be useful for yield maximization of chickpea.

Article History

Received: 04 May 2021

Revised: 25 May 2021

Accepted: 30 May 2021

Published online: 30 June 2021

***Corresponding Author**

U. K. Sarker, E-mail: uttam@bau.edu.bd

Keywords

Chickpea varieties, total dry matter, pods plant^{-1},1000-seed weight and harvest index

Introduction

Pulses play an important role in the food and farming economy of Bangladesh. The major pulses grown are grasspea, lentil, chickpea, black gram, green gram, cowpea, etc. which contribute more than 95% of total pulses production in the country. Among them Chickpea (*Cicer arietinum* L.) has special importance in intensive crop production. The production of chickpea lessened from 61,485 tons (1997) to 6,237 tons (2017) in the last two decades even though yield soared from 0.73 to 1.05 t ha^{-1} over the period (DAE, 2019). In order to meet the consumption demand, Bangladesh imported 190322 tons chickpea in 2017 that was 96% of the total chickpea supply in the market in that year (BBS, 2019). Alternately, worldwide chickpea production in 2014 was 13 million tons, whereas it was only 7 million tons in 1971 (FAO, 2019).

The cropping system in Bangladesh is mainly rice based and chickpea is grown after the harvest of *aman* rice. There is an increasing focus on chickpea production in Bangladesh for (i) meeting the domestic demand and (ii) diversification of rice-based cropping system with legumes, which can help in improving soil fertility and system productivity. Introduction of chickpea in a cereal based rotation can break the disease and pest cycle and increase the productivity of the entire rotation. It plays an important role in sustaining soil fertility by improving its physical, chemical and biological properties and trapping atmospheric nitrogen in their root nodules (Ali and Kumar, 2005). A good crop of chickpea could fix up to 141 kg N ha^{-1}which economizes nitrogen application for succeeding cereals to the tune of 56-58 kg N ha^{-1} (Ahlawat *et al.*, 1981). But the yield of chickpea in Bangladesh is miserably low (761 kg ha^{-1}) as compared to that of other countries like India (833 kg ha^{-1}), Myanmar (1,106 kg ha^{-1}), Mexico (1,600 kg ha^{-1}) and China (6,000 kg ha^{-1}) (FAO 2012). The acreage of chickpea cultivation in Bangladesh is decreasing due to less return as compared to other crops and also due to increase in area under *boro* rice, maize and potato cultivation. In such low yield of chickpea however is not an indication of low yielding potentiality of this crop, but may be attributed to unavailability of quality seeds of high yielding varieties and improper or limited irrigation facilities which causes flower and pod droppings with negative effects on production.

Legumes are highly sensitive to water deficit stress (Labidi *et al.*, 2009). In Bangladesh, farmers grow chickpea mainly in the *rabi* season when moisture level is very limited in the soil and obtain very low yield. In general for pulse crop, the most sensitive growth stage to drought occurs at flower initiation, flowering, pollination, fertilization and pod filling. Chickpea seed yield decreased by 50% when stressed during pod formation and 44% when stressed during flowering (Gan *et al.*, 2004). Most studies on grain legumes confirmed that pod development and seed filling stages were the most drought sensitive stages (Al-Hamadany, 2005). Irrigation can increase the reproductive period of chickpea and produce higher total biomass and more pods plant^{-1}. So chickpea varieties tolerant to drought stress with highest yield potential have to be identified and developed to increase national average yield of chickpea. Therefore the present work was undertaken to study the effect of irrigation on growth and yield of chickpea varieties under field condition.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh during the period from November 2018 to March 2019 to study the effect of irrigation levels on the growth and yield performance of different chickpea varieties. Geographically the experimental field is located at 24°75´ N latitude and 90°50´ E longitude at an elevation of 18 m above the sea level. The region occupies a large area of Brahmaputra sediments which are laid down before the river shifted into its present Jamuna channel about 200 years ago (UNDP and FAO, 1988).The area was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during *kharif* season (April to September) and low rainfall associated with moderately low temperature during *rabi* season (October to March). The winter climate condition of Bangladesh (*rabi* season) is favorable for chickpea cultivation. The treatments of the experiment composed four varieties of chickpea namely BARI Chola-5, BARI Chola-9, BINA Chola-4 , BINA Chola-7 and three levels of irrigations viz. one irrigation at pre-flowering stage, two irrigations at pre-flowering and pod formation stages and rainfed condition. The experiment was laid out in a split plot design with three replications assigning irrigation in the main plot and variety in the sub plot. Each unit plot was uniformly fertilized with urea, triple superphosphate, and muriate of potash in a quantity of 50, 90 and 40 kg ha^{-1}, respectively. All fertilizers were applied at the time of final land preparation and mixed thoroughly with soil. Seeds were sown on 21 November 2016 in rows at 2-3 cm depth maintaining row to row distance 50 cm and seed to seed distance 15 cm using seed rate of 50 kg ha^{-1}. After sowing, the seeds were covered with soil to conserve soil moisture. Irrigation was applied as per treatment specification. Three plants in each plot were randomly selected to record the data on nodulation and different growth parameters (plant height and dry weight) at 15, 30, 45, 60, 75 DAE (days after emergence) and at harvest (120 DAE). The shoot and leaf materials were oven dried until constant weight was achieved to record their respective dry weights. After harvesting, crop of each plot was dried separately. Sample plants were processed in a similar way. The collected data were compiled and analyzed statistically using the analysis of variance technique and the differences among treatment means were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Growth parameters

Statistically significant variation was recorded in terms of plant height among the four varieties at different stages of growth i.e. 15, 30, 45, 60 and 75 days after emergence. At 15 DAE, BARI Chola-9 produced the tallest plant (14.55 cm) among the varieties and the shortest plant was produced from BARI Chola-5 (11.90 cm). At 30, 45, 60 and 75 DAE, BARI Chola-9 produced the tallest plant (19.70 cm, 30.03 cm, 40.89 cm and 52.99 cm, respectively) and the shortest plant was produced from BINA Chola-4 (17.26 cm, 24.40 cm, 33.91 cm and 46.42 cm, respectively) (Figure 1). Different varieties produced different plant height on the basis of their varietal characters. Golldani and Moghaddam (2006) reported various plant heights for different chickpea varieties. In case of irrigation, the highest plant height was observed by two irrigations at pre-flowering and pod formation stages at 15, 30, 45, 60 and 75 DAE (13.63, 18.85, 30.08, 38.81 and 53.68 cm, respectively) (Figure 2). The lowest plant height was observed in rainfed or non-irrigated condition at all growth stages except 15 DAE. Supplementary irrigation ensured favorable condition for chickpea plant with longest plant. Number of nodules was significantly influenced by the interaction between variety and irrigation levels at all the sampling dates (Table 1). The lowest number of nodules was produced at 15 DAE in BINA Chola-7 with two irrigations at pre-flowering and pod formation stages (7.00). AT 60 DAE, BINA Chola-4 with rainfed condition (13.44) produced the lowest number of nodules plant^{-1} which was statistically identical to BARI Chola-5 with rainfed condition (14.44) and at 75 DAE, BINA Chola-4 with rainfed condition (14.22) produced the lowest number of nodules plant^{-1} (Table 1).The effect of variety on total dry matter production was significant for at all sampling dates (Table 2). Total dry matter production showed an increasing trend on extended sampling dates and attained the peak at 75 DAE for BARI Chola-5 (4.70 g), BARI Chola-9 (7.04 g), BINA Chola-4 (4.79 g) and BINA Chola-7 (6.13 g) (Table 2). The increasing dry weight of plant over time mainly depends on leaf dry weight. Irrigation has significant effects on total dry matter production for all the varieties at all sampling dates except 15 and 30 DAE (Table 3). Total dry matter production showed an increasing trend based on extended sampling dates and attained the peak for two irrigations at pre-flowering and pod formation stage (6.71 g) at 75 DAE). This is might be due to optimum water at flowering and pod formation stage.

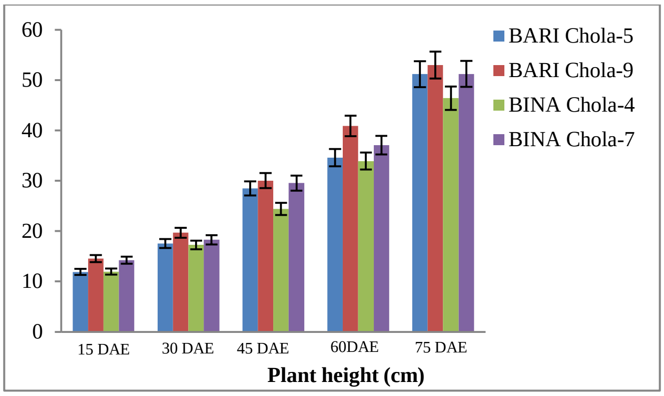


Figure 1. Effect of variety on plant height at different days after emergence (DAE) of chickpea varieties.

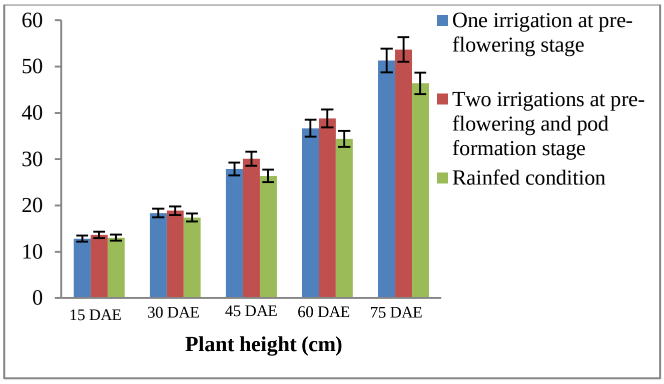


Figure 2. Effect of irrigation levels on plant height at different days after emergence (DAE) of chickpea varieties.

Table 1. Interaction effects of variety and irrigation levels on number of nodules plant^{-1} at different days after emergence of chickpea varieties.

Variety x Irrigation levels	Number of nodules plant^{-1}				
	15 DAE	30 DAE	45 DAE	60 DAE	75 DAE
V_1xI_1	9.45 bc	10.78 d	13.11 fg	15.55 d	18.00 de
V_1xI_2	9.44 bc	10.44 d	15.89 c	18.11 bc	19.67 c
V_1xI_3	9.23 bc	10.90 d	12.44 g	14.44 de	12.56 h
V_2xI_1	12.33 a	15.75 b	15.00 cd	17.44 c	19.56 cd
V_2xI_2	12.22 a	17.76 a	20.00 a	22.48 a	24.89 a
V_2xI_3	12.24 a	15.70 b	14.22 de	15.67 d	17.44 ef
V_3xI_1	8.11 d	14.67 bc	15.00 cd	17.44 c	16.33 f
V_3xI_2	9.00 c	14.44 c	15.67 c	18.44 bc	18.89 cde
V_3xI_3	7.89 d	14.29 c	13.78 ef	13.44 e	14.22 g
V_4xI_1	7.89 d	14.44 c	15.56 c	19.11 b	18.11 cde
V_4xI_2	7.00 e	15.18 bc	17.11 b	22.00 a	22.22 b
V_4xI_3	9.85 b	14.59 bc	13.44 ef	15.06 d	16.44 f
Level of sig.	**	*	**	**	**
CV (%)	4.45	4.61	3.36	4.98	4.60

Here, In a column, means followed by same letters are not significantly different at 1% probability level by Duncan's Multiple Range Test (DMRT), ** =Significant at 1% level of probability, * =Significant at 5% level of probability, V_1 = BARI Chola-5,V_2 = BARI Chola-9,V_3 = BINA Chola-4,V_4 = BINA Chola-7, I_1 = One irrigation at pre-flowering stage, I_2 = Two irrigations at pre-flowering and pod formation stage, I_3 = Rainfed condition

Table 2. Effect of variety on total dry matter at different days after emergence of chickpea varieties.

Variety	Total dry matter (g)				
	15 DAE	30 DAE	45 DAE	60 DAE	75 DAE
BARI Chola-5	0.16 c	0.50 a	1.34 b	2.84 b	4.70 c
BARI Chola-9	0.20 a	0.55 a	1.78 a	3.61 a	7.04 a
BINA Chola-4	0.14 d	0.40 b	1.22 b	2.36 c	4.79 c
BINA Chola-7	0.18 b	0.51 a	1.68 a	3.13 b	6.13 b
Level of sig.	**	**	**	**	**
CV (%)	5.81	11.13	10.28	13.02	11.36

Here, In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT), ** = Significant at 1% level of probability

Yield and yield attributes

Variety exerted significant effect on total number of branches plant^{-1} (Table 4). Among the four varieties, the highest number of branches was recorded in BARI Chola-9 (27.42) while the lowest number of branches plant^{-1} recorded in BARI Chola-5 (24.13). Islam *et al.* (2008) reported that high yielding varieties of chickpea, in general, produced higher number of secondary branches plant^{-1}. It means that yield is positively correlated with secondary branches. Ali *et al.* (1999) indicated the importance of secondary branches plant^{-1} and pods plant^{-1} in determining the yield of chickpea. High variability in the number of secondary branches of chickpea varieties was also reported by Ahmad *et al.* (2003). The highest number of branches was recorded in two irrigations at pre-flowering and pod formation stages (27.91) while the lowest number of branches recorded in rainfed condition (23.30) (Table5).Total number of pods plant^{-1} was significantly affected by different varieties of chickpea and irrigation level (Table 4). The number of pods ranged from 31.80 to 48.67. The highest pod number (48.67) was obtained from BARI Chola-9 followed by BARI Chola-5 (42.98) and BINA Chola-7 (38.31) (Table 4). The highest pod number (49.75) was recorded in two irrigations at pre-flowering and pod formation stages while the lowest pod number(28.87) in plant recorded in rainfed condition (Table 5). Shaktawat and Sharma (1986) reported that irrigation increased pods plant^{-1}in chickpeas. Bicer *et al.* (2004) reported that number of pods plant^{-1}was higher under irrigated than rainfed condition. Different chickpea varieties showed significant variations in respect of total number of seeds pod^{-1} (Table 4). The highest number of seeds in pod was recorded in the variety BARI Chola-9 (1.44) and the lowest number of seeds pod^{-1}(1.16) was found in BINA Chola-4 (Table 4). Significant variability in seeds pod^{-1} in chickpea was also observed by Ahmad *et al.* (2003). The highest number of seeds pod^{-1}was recorded in two irrigations at pre-flowering and pod formation stage (1.53) while the lowest number of seeds pod^{-1} recorded in rainfed condition (1.06) (Table 5). Bicer *et al.* (2004) reported that number of seeds pod^{-1} was higher under irrigated than rainfed conditions. Significant variation was found in 1000 seed weight due to the interaction between variety and irrigation levels (Table 6).

Significant variation was found in seed yield due to different varieties. The highest seed yield (1.25 t ha^{-1}) was obtained in the variety BARI Chola-9 followed by BARI Chola-5 and

BINA Chola-7 (Figure 3). The lowest seed yield (0.85 t ha^{-1}) was recorded from the variety BINA Chola-4. Islam *et al.* (2008) reported that low yielding varieties produced lower number of secondary branches $plant^{-1}$. Although BINA Chola-4 and BINA Chola-7 were recorded with more number of secondary branches $plant^{-1}$, but less number of pods $plant^{-1}$, these two varieties produced low yield. It might be due to the lowest seed size and lowest number of pods $plant^{-1}$ of these varieties or the inherent quality of varieties. Similar findings have been reported by Islam *et al.* (2008). The variation in yield components and seed yield among the chickpea varieties were also reported by Chandra and Yadav (1997). Mukherjee and Singh (2005) reported that chickpea genotypes differed significantly with respect to seed yield. For irrigation, the highest seed yield was recorded in two irrigations at pre-flowering and pod formation stages (1.33 t ha^{-1}) while the lowest seed yield was recorded in rainfed condition (0.76 t ha^{-1}) (Figure 4). This variation was due to lack of supply of water in rainfed condition. Similarly significantly lower values of seed yield were also recorded under non-irrigated condition by many researchers. Hamdi *et al.* (1992) indicated 20% increase in seed yield $plant^{-1}$ in two supplemental irrigations (50 mm each) in Syrian growth conditions. After conducting a four years experiment, Oweis *et al.* (2004) reported that supplemental irrigation (SI) increased the lentil grain and biomass yield by raising its values from 1.04 t ha^{-1} and 4.27 t ha^{-1} (under rainfed conditions) to 1.81 t ha^{-1} and 6.2 t ha^{-1} (under full SI conditions), respectively. Leport *et al.* (1999) have also reported that 50-80% reduction was found in chickpea varieties exposed to terminal drought. Mohammadi *et al.* (2006) reported that among phenological stages of chickpea, pod formation was the most sensitive to water deficit and that under water limitation conditions chickpea yield could be improved by irrigation at this stage. Interaction between variety and irrigation levels showed significant variation in seed yield (Table 6). Highest seed yield (1.59 t ha^{-1}) was recorded in BARI Chola-9 with two irrigations at pre-flowering and pod formation stage. Lowest seed yield (0.72 t ha^{-1}) was recorded from the combination of BINA Chola-7 with rainfed condition followed by BARI Chola-5 with rainfed condition (0.75) (Table 6). Grain yield variations for varieties were significantly and highly related (R^2=0.68) to total dry matter (Figure 6).Omar and Singh (1997) reported that increased biomass yield in chickpea can contribute to higher seed yield. Singh *et al.* (2004) also noted that seed yield was directly and positively correlated with the biomass yield in chickpea. However, in the present study high seed yielding varieties produce the highest value of biomass yield under irrigated condition.

Significant variation was found in stover yield due to the interaction between variety and irrigation levels (Table 6). The highest stover yield (3.46 t ha^{-1}) was recorded in BARI Chola-9 with two irrigations at pre-flowering and pod formation stages. The lowest stover yield was recorded from the combination of BINA Chola-7 with rainfed condition(1.76 t ha^{-1})followed by BARI Chola-5 with rainfed condition(1.90 t ha^{-1}) (Table 6).Singh and Smita (2006) reported that irrigation proved better in terms of straw yield. Harvest index was significantly influenced by the effect of irrigation levels only. The highest harvest index of plants was found in two irrigations at pre-flowering and pod formation stage (31.09%) while the lowest harvest index was recorded in rainfed condition (28.65%) (Figure 5). Harvest index which is as an important criterion for improvement in yield, strongly influenced by environment (Kumar *et al.*, 2001). However, in the present study high seed yielding varieties produce the highest value of harvest index under irrigated condition. Significant and positive relation was found between dry matter and yield at 75 after emergence.

Table 3. Effect of irrigation levels on total dry matter production at different days after emergence of chickpea varieties.

Irrigation levels	Total dry matter (g)				
	15 DAE	30 DAE	45 DAE	60 DAE	75 DAE
One irrigation at pre-flowering stage	0.17	0.50	1.49 b	2.95 b	5.49 b
Two irrigations at pre-flowering and pod formation stage	0.17	0.50	1.65 a	3.44 a	6.71 a
Rainfed condition	0.17	0.48	1.38 b	2.56 c	4.79 b
Level of significance	NS	NS	**	**	**
CV (%)	5.81	9.09	8.90	10.80	14.60

Here, In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT). ** =Significant at 1% level of probability, NS = Not significant

Table 4. Effect of variety on yield contributing characters of chickpea.

Variety	Number of branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}
BARI Chola-5	24.13 c	42.98 b	1.29 b
BARI Chola-9	27.42 a	48.67 a	1.44 a
BINA Chola-4	25.65 b	31.80 d	1.16 b
BINA Chola-7	25.04 bc	38.31 c	1.24 b
Level of significance	**	**	**
CV (%)	3.12	9.12	9.22

Here, In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT).** =Significant at 1% level of probability,

Table 5. Effect of irrigation levels on yield contributing characters of chickpea varieties.

Irrigation levels	Number of branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}
One irrigation at pre-flowering stage	25.48 b	42.70 b	1.25 b
Two irrigations at pre-flowering and pod formation stage	27.91 a	49.75 a	1.53 a
Rainfed condition	23.30 c	28.87 c	1.07 c
Level of significance	**	**	**
CV (%)	4.68	12.46	8.89

Here, In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT).** =Significant at 1% level of probability

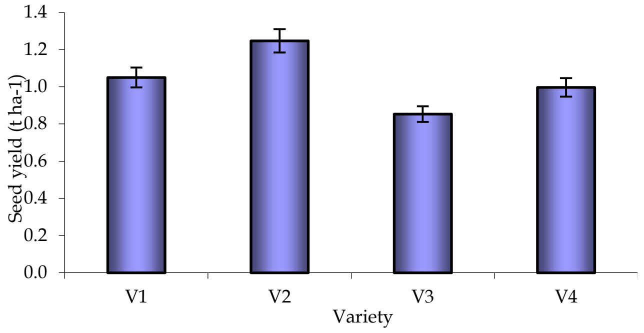


Figure 3. Effect of variety on seed yield (t ha^{-1}) of chickpea.

Here, V_1 = BARI Chola-5, V_2 = BARI Chola-9, V_3 = BINA Chola-4, V_4 = BINA Chola-7

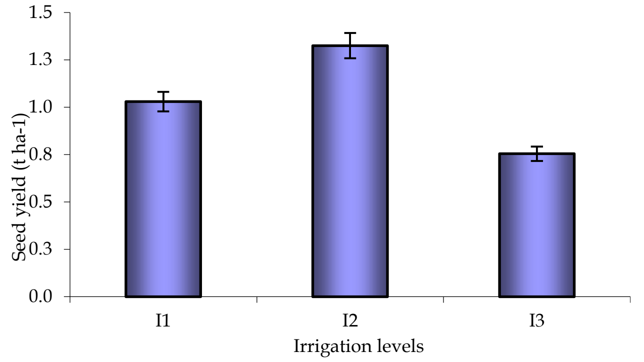


Figure 4. Effect of irrigation levels on seed yield (t ha^{-1}) of chickpea.

Here, I_1 = One irrigation at pre-flowering stage, I_2 = Two irrigations at pre-flowering and pod formation stage, I_3 = Rainfed condition.

Table 6. Interaction effects of variety and irrigation levels on yield and yield contributing characters of chickpea varieties.

Variety x Irrigation levels	1000 seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
V_1xI_1	116.4 h	1.03 de	2.49 d
V_1xI_2	123.3 gh	1.37 b	3.05 b
V_1xI_3	102.8 i	0.75 h	1.90 fg
V_2xI_1	210.4 b	1.23 c	2.86 c
V_2xI_2	224.5 a	1.59 a	3.46 a
V_2xI_3	174.6 d	0.92 f	2.23 e
V_3xI_1	131.2 g	0.85 g	1.98 f
V_3xI_2	140.9 f	1.08 d	2.42 d
V_3xI_3	117.5 h	0.63 i	1.63 h
V_4xI_1	172.0 d	1.01 e	2.35 de
V_4xI_2	190.6 c	1.26 c	2.82 c
V_4xI_3	160.9 e	0.72 h	1.76 gh
Level of significance	**	**	**
CV (%)	3.03	3.05	3.47

Here, In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT).** =Significant at 1% level of probability, V_1= BARI Chola-5, V_2 = BARI Chola-9, V_3 = BINA Chola-4, V_4 = BINA Chola-7, I_1 = One irrigation at pre-flowering stage, I_2 = Two irrigations at pre-flowering and pod formation stages, I_3 = Rainfed condition

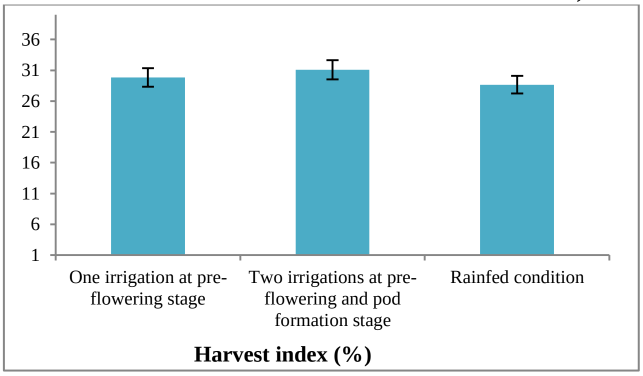


Figure 5. Effect of irrigation levels on harvest index (%) of chickpea varieties.

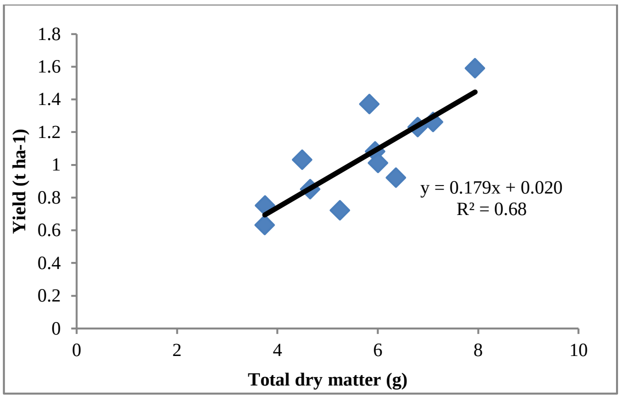


Figure 6. Relationship between grain yield and total dry matter at 75 days after emergence (DAE).

References

Ahlawat JPS, Singh A, Saraf CS (1981). Effects of winter legumes on the nitrogen economy and productivity of succeeding cereals. Experimental Agriculture17: 55-62.

Ahmad B, Wahid MA, Bugti RA, Zahid MA, Shaukal A (2003).Evaluation of chickpea germplasm for semi-arid zones of Balochistan. International Journal of Agricultural Biology5: 113-116.

Al-Hamadany SH (2005). The effects of supplemental Irrigation and Abscisic acid (ABA) spraying on growth and yield of some faba bean (*Viciafaba* L.) cultivars. PhD Thesis, Mosul University, Mosul, Iraq.pp. 23.

Ali M, Kumar S (2005). Chickpea (*Cicerarietinum*) research in India: Accomplishment and future strategies. Indian Journal of Agricultural Science75: 125-133.

Ali Y, Haq MA, Tahir GR, Ahmad N (1999). Effect of various morphological traits on chickpea yield under drought and normal field conditions. Pakistani Journal of Biological Science 2(3):1071-1073.

BBS (2019). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka. pp. 101-103.

Bicer BT, Kalender AN, Sakar D (2004). The effect of irrigation on spring-sown chickpea.Journalof Agronomy 3(3): 154-158.

Chandra H, Yadav RS (1997). Physiological basis of seed yield variation in rainfed chickpea (*Cicerarietinum*L.). Indian Journal of Agricultural Research31: 199-204.

DAE (2019). Annual Report. Rajshahi Regional Office, Department of Agricultural Extension, Government of the People's Republic of Bangladesh, Rajshahi, Bangladesh.

FAO (2019). Food and Agriculture Data. Food and Agriculture Organization (FAO), Rome, Italy.

FAO (Food and Agriculture Organization) (2012). Yearly yield of chickpea 20011.FAO Statistics Citation.

Gan Y, Wang J, Angadi SV, Mcdonald CL (2004): Response of chickpea to short periods of high temperature and water stress at different developmental stages. 4th International Crop Science Congress, Brisbane. pp. 75-81.

Golldani A, Moghaddam PR (2006). Effect of different irrigation levels on phenology, physiology characteristics, and yield components of three chickpea (*Cicerarietinum* L.) cultivars in Mashhad. Agricultural Science Technology20(3): 21-32.

Gomez KA, Gomez AA (1984). Statistical procedure for Agricultural Research. A Wiley-Interscience Publication, Toronto, Singapore. pp. 28-192.

Hamdi A, Erskine W, Gates P (1992).Adaption of lentil seed yield to varying moisture supply. Crop Science32(4): 987-990.

Islam MM, Ismail MR, Ashrafuzzaman M, Shamsuzzaman KM (2008). Evaluation of chickpea lines/mutants for growth and yield attributes. International Journal of Agriculture and Biology 10(2): 493-498.

Kumar P, Deshmukh PS, Kushwaha SR, Kumara S (2001). Effect of terminal drought on biomass production its partitioning and yield of chickpea genotypes. Annals of Agricultural Research 22: 408-411.

Labidi N, Mahmoudi H, Dorsaf M, Slama I, Abdelly C (2009).Assessment of intervarietal differences in drought tolerance in chickpea using both nodule and plant traits as indicators. Journal of Plant Breeding and Crop Science 1(2): 80-86.

Leport L, Turner NC, French RJ, Barr MD, Duda R, Davies SL, Tennant D, Siddique KHM (1999). Physiological responses of chickpea genotypes to terminal drought in a Mediterranean type environment. European Journal of Agronomy11: 279-291.

Mohammadi G, Golezani KG, Javanshir A, Moghaddam M (2006).The influence of water limitation on the yield of three chickpea cultivars.Journal of Science and Technology on Agricultural and Natural Resources 10(2):109-120.

Mukherjee D, Singh RK (2005). Influence of weed flora density on yield of chickpea cultivars. Indian Journal of Pulses Research 18(2): 222-223.

Omar M, Singh KB (1997). Increasing seed yield in chickpea by increased biomass yield. International Chickpea and Pigeon pea Newsletter4: 14-15.

Oweis T, Hachum A, Pala M (2004).Lentil production under supplemental irrigation in a Mediterranean environment. Agricultural Water Management68(3): 251-265.

Shaktawat MS, Sharma PK (1986). Response of chickpea varieties to input components.International Chickpea Newsletter 15**:** 24-25.

Singh TK, Ram P, Dwivedi DP, Singh SK, Verma SN (2004). Response of varieties and dates of sowing on growth and yield of chickpea (*Cicerarietinum* L.). Plant Archives 4(2): 471-474.

Singh YP, Smita C (2006). Response of varieties to sources of phosphorus and irrigation schedule on growth, quality, yield, sulphur uptake and water use by chickpea (*Cicerarietinum* L.). Research on Crops7(1): 84-87.

UNDP and FAO (United Nations Development Programme and Food and Agriculture Organization) (1988).*Land Resources Apprraisal of Bangladesh for Agricultural Development*. Agro-ecological Regions of Bangladesh. New Airport Road, Farmgate, Dhaka. pp. 212-221.