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Response of Chickpea Varieties to Different Irrigation Regimes

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Chickpea is an important pulse crop in Bangladesh. The study was conducted at BINA sub-station Magura, to evaluate the yield potential of new cultivars of chickpea under different irrigation regimes. The experimental design was RCBD (with split-plot) having irrigation treatments in the main plots and chickpea varieties in the sub-plots. The irrigation treatments comprised of: control (no irrigation) [T1], irrigation at vegetative stage (25-30 DAS) [T2], irrigation at flowering stage (45-50 DAS) [T3], and irrigation at vegetative stage (25-30 DAS) and flowering stage (45-50 DAS) [T4]. The varieties were: V1 = Binasola-5; V2 = Binasola-6 and V3 = Binasola-4. Irrigation water was applied up to field capacity as per treatment. The results revealed that irrigation treatments had detrimental effect on all yield attributes (plant height, seed per pod, branch per plant) and seed yield. The seed yield gradually reduced when irrigation was applied. The highest seed yield (1.87 t ha^{-1}) was obtained from control treatment which received no irrigation.

The varieties had also significant effect on all yield attributes and seed yield. The cultivar binasola-5 produced the highest yield (1.20 t ha^{-1}). The highest water use efficiency (263.01 kg ha^{-1} cm^{-1}) was also found in control treatment (T1), which received no irrigation. From the results of the study, it is revealed that under the prevailing climatic and soil condition, the chickpea cultivars do not need any irrigation at Magura, rather it reduces yield.

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1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important food legume crop worldwide. It is an important grain legume in many developing countries. Chickpea or Bengal gram or gram (*Cicer arietinum*) is an important pulse crop of the semi-arid tropics, particularly in the rainfed ecology of the Indian subcontinent (Ali and Kumar, [1]). Chickpea seed contains 13% to 33% protein, 40% to 55% carbohydrate, and 4% to 10% oil (Stallknecht et al. [2]). Fatty acid composition varies with chickpea type but is approximately 50% oleic and 40% linoleic (Duke [3]). The daily per capita availability of 14 g chickpea is a source of about 2.3 per cent energy (56 Kcal) and 4.7 percent protein (2.7 g), besides being an important source of Ca and Fe (10-12 percent). Malic and oxalic acids secreted from leaves, stems and pods have medicinal applications for bronchitis, catarrh, catamenia, cholera, constipation, diarrhoea, digestive disorders, snakebite, sunstroke and warts. These acids are known to lower blood cholesterol level as well. Chickpea is used for human consumption as well as for feeding the animals. Chickpea flour is used in the preparation of various types of sweets. Chickpea also plays an important role in sustaining soil productivity by improving its physical, chemical and biological properties and trapping atmospheric nitrogen in their root nodules [1]. 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. [4]).

There are two groups of chickpea, depending on seed size, shape, and color. The large-seeded chickpeas (in excess of 26 g/100 seeds) are called Kabuli and the smaller ones are called Desi. Desi types are traditionally grown in India, other parts of Asia, and in Ethiopia and account for more than 80% of the world production of chickpea (Muehlbauer et al. [5]). Important strategies to enhance production and productivity of chickpea include: high yielding varieties, appropriate sowing time, irrigation, bio-fertilizer, integrated management of pest and diseases, etc. (Sohu et al. [6], Patel et al. [7], Kadam et al. [8], Moemeni et al. [9]).

Most of the chickpea crop in the world is produced on residual moisture but supplemental irrigation can enhance production. Irrigation during the pre-flowering period and at early pod fill resulted in increased yield at several locations in India (Saxena [10]). Irrigation prolonged the reproductive period of chickpea and produced higher total biomass and more pods per plant. Conversely, 100-seed weight and harvest index were reduced (ICRISAT [11]). Amin et al. [12] reported that under residual moisture conditions, extra short-duration chickpeas had a 30% yield advantage over commonly grown long-duration cultivars. Local and improved cultivars produced similar yields when irrigated, but improved management provided a 19% yield advantage when compared to traditional cultivation practices. Ulla et al. [13] concluded that the irrigation of chickpea cultivars had positive effects on phosphate solubilizing micro-organisms activity and the crop yields.

Ilhe et al. [14] conducted field experiment to determine water production function for chickpea under sprinkler method of irrigation, at Ahmednagar, India. The treatments were 1.2 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method (T1), 1.68 mm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method (T2), 2.24 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method (T3), 3.12 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method (T4), 3.44 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method (T5), 4.56 cm depth of irrigation at 37.5 mm CPE through sprinkler irrigation method (T6) and 6 cm depth of irrigation at 75 mm CPE through surface irrigation method. They concluded that growing of chickpea under sprinkler irrigation method resulted in the more seed yield (25.90 q ha^{-1}) and maximum benefit: cost ratio (2.57) as compared to the surface irrigation method.

Patel et al. [7] conducted a study in Bansagar command area of Madhya Pradesh (India), to improve chickpea production and to enhance water productivity. They imposed four water management treatments consisting two farmers practices treatments i.e. two irrigation by flooding method and two improved practices i.e. two irrigation at flowering and pod formation stage with border strip method. Under improved practices, water was applied twice each of 4 cm depth at flowering and pod formation stages by boarder strip method. They found that improved irrigation management practices gave significantly higher number of nodules and seed yield of chickpea. An increase of 11.32%

chickpea yield was noticed as compared to farmers practices. Water expenses efficiency (water productivity) was also found better in improved practice as compared to farmers practices as total 15 cm irrigation water was applied.

A field experiment was conducted by Kadam et al. [8] during rabi season for two consecutive years at Navsari Agricultural University, Navsari to assess the yield potential of chickpea under different irrigation levels with and without combination of fertilizers and biofertilizer. The treatment included four irrigation management levels and three treatment combination of inorganic fertilizers and biofertilizer. Growth and yield attributes of chickpea were influenced significantly by irrigation levels. Irrigating the crop at an IW/CPE ratio of 0.4 through mini sprinkler recorded highest grain (2617 kg/ha) and stover (4188 kg/ha) yield of chickpea. They observed the highest net returns (Rs. 32086 ./ha) with benefit-cost ratio of 1: 3.2, consumptive water expense efficiency 13.08 kg/ha mm and 42% saving of irrigation water over surface method of irrigation under treatment 0.4 IW/CPE ratio. Application of water through mini-sprinkler 0.2 IW/CPE ratio recorded effective consumptive use of water and water saving to the tune of 57.14 per cent. Irrigation level with mini-sprinkler 0.4 IW/CPE ratio gave highest water expense efficiency (13.5 kg/ha mm). The moisture extraction increased with increase in application of irrigation water from upper layers of soil (0-15 and 15-30 cm soil depth), but the reverse trend of moisture extraction was observed at deeper soil layer (30-45 and 45-60 cm soil depth).

Rinaldi et al. [15] found that total plant biomass was related to water availability and radiation interception. But in good conditions of available water, there was a lengthening of the crop cycle, with reduction of pod growth, harvest index and nutrient toward the seeds. Consequently, the best values of water use efficiency were found in the treatment irrigated with 50 mm only at flowering or at pod filling.

From the literature, it is revealed that the response of irrigation to chickpea seed yield depends on the initial soil moisture reserve, atmospheric water demand, and the cultivar. The main objective of the present study was to evaluate the yield potential of new cultivars of chickpea under different soil moisture regimes.

2. MATERIALS AND METHODS

2.1 Experimental Site, Weather and Soil

The experiment was conducted at BINA sub-station, Magura (23°25'44.3"N, 89°26'11.01"E, 10 m above MSL). The climatic parameters during the growing period of chickpea is presented in Table 1. It was observed that no rainfall occurred during the cropping season through November to March. During the growing period of chickpea, maximum and minimum temperature varied from 16.19 to 38.11°C and 7.49 to 27.71°C, respectively. The average relative humidity varied from 60.88 to 73.58%.

The soil at the experimental location was silt-loam, medium in organic matter (~2.0%), having field capacity and wilting point of 44% and 21%, respectively. The soil pH was 6.5 and electrical conductivity was 0.9 dS/m.

2.2 Treatments and Cultural Practices

Chickpea seeds were sown on 30th November 2012. The experimental design was RCBD (with split-plot) having irrigation treatments in the main plots and chickpea varieties in the sub-plots. The irrigation treatment were: T1 = Control (no irrigation), T2 = Irrigation at vegetative stage (25-30 DAS), T3 = Irrigation at flowering stage (45-50 DAS), and T4 = Irrigation at vegetative stage (25-30 DAS) and flowering stage (45-50 DAS). The varieties were: V1 = Binasola-5; V2 = Binasola-6 and V3 = Binasola-4. Here, DAS = days after sowing.

Irrigation water was applied up to field capacity as per treatment. Other cultural practices were followed as and when necessary. The crop was harvested on 28th March, 2013. All agronomic data were collected at harvest time.

2.3 Soil Moisture Measurement and Calculation of Soil Water Depletion

Soil moisture was measured by gravimetric method up to 60 cm for every 15 cm intervals at the time of sowing, before irrigation and at maturity. Profile soil moisture at the sowing time was calculated as:

$$SM_i = \sum_{d=1}^{n} d_i$$

Similarly, soil moisture at the physiological maturity (SM_f) was calculated. Then the soil moisture depletion (SMD) was calculated as:

$$SMD = SM_i - SM_f$$

Table 1. Climatic parameters during the growing days of chickpea (from seeding to harvest)

Growing period (Month)	Days after sowing (DAS)	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Relative humidity (%)		Rainfall (cm)
		Range	Range		Range	Average	
November	0-1	26.93 - 32.44	13.22 -22.55	24.63	54-68	60.88	0
December	2-32	16.19 -29.03	9.35 -19.53	20.34	54-92	73.58	0
January	33-64	17.56 -28.26	7.49 -20.43	19.05	58-78	69.23	0
February	65-93	25.34 -32.66	11.52- 19.70	22.20	63-81	71.19	0
March	94-122	29.52 -38.11	13.93- 27.71	28.03	47-78	61.33	0

3. RESULTS AND DISCUSSION

3.1 Yield Attributes and Seed Yield

The mean effects of irrigation and varieties on yield and yield attributing characters are presented in Table 2. Irrigation treatments had significant effect on all yield attributes (plant height, seed per pod, branch per plant) and seed yield. In case of yield attributes, in most cases, the attributes are statistically similar between treatment T1 and T2, that is, non-irrigated and irrigation at vegetative stage; while different from T3 or T4. The application of irrigation at flowering (T3) and both vegetative and flowering (T4) may cause excessive vegetative growth and ultimately less pod per plant and seed per pod.

The varieties had also significant effect on all yield attributes and seed yield of chickpea. The highest seed yield (1.87 t ha^{-1}) was obtained from T1 treatment which received no irrigation, and Binasola-5 produced the highest yield (1.20 t ha^{-1}). Contrarily, when irrigation was applied, the seed yield gradually reduced.

Most of the chickpea crop in the world is produced on residual moisture but supplemental irrigation can enhance production. The effect of irrigation depends on the initial soil moisture storage throughout the soil profile, solar radiation interception, drying rate (i.e. rate of evapotranspiration), planting date, length of growing period, cultivar type (specially vegetative growth characteristics and tolerant to drought), etc. Chickpea roots deeper than dry pea or lentil, and has greater drought tolerance when stored subsoil water is available (McKay et al. [16]). Excess soil-moisture *or* irrigation enhances vegetative growth and decreases chickpea grain yield.

Irrigation during the pre-flowering period and at early pod fill resulted in increased yield at several locations in India (Saxena [10]). Irrigation prolonged the reproductive period of chickpea and produced higher total biomass and more pods per plant. Conversely, 100-seed weight and harvest index were reduced (ICRISAT [11]).

Kadam et al. [8] assessed the yield potential of chickpea under four different irrigation management levels. They found that irrigating the crop at an IW/CPE ratio of 0.4 through mini sprinkler recorded the highest grain (2617 kg/ha) and stover (4188 kg/ha) yield of chickpea.

Table 2. Mean effect of irrigation and varieties on yield and yield attributing characters of chickpea at Magura Sadar Upzilla

Treatments	Plant height (cm)	No of branch/ plant (nos)	Pod/ plant (nos)	Seed/pod (nos)	Seed yield (t ha^{-1})
T_1	53.75	2.51	62.02	1.51	1.87
T_2	51.37	2.26	57.57	1.26	1.34
T_3	47.62	2.31	45.20	1.15	0.61
T_4	46.00	2.24	43.80	1.22	0.55
$LSD_{0.05}$	3.38	0.43	20.19	0.23	0.31
V_1	51.55	2.35	56.25	1.38	1.20
V_2	48.01	2.23	52.71	1.20	0.97
V_3	49.50	2.41	47.23	1.28	0.95
$LSD_{0.05}$	2.93	0.37	17.48	0.21	0.31

Table 3. Water requirement and water use efficiency of chickpea at Magura Sadar Upazila

Treatments	No. of irrigation	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion (cm)	Water requirement (cm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
T_1	0	0	0	7.11	7.11	1870	263.01
T_2	1	2.50	0	6.23	9.73	1340	137.72
T_3	2	5.00	0	4.98	11.98	610	50.92
T_4	2	5.00	0	5.13	12.13	550	45.34

Rinaldi et al. [15] studied the response of different irrigation scheduling at specific crop phases of chickpea in Southern Italy (soil was vertisol, and the climate is Mediterranean environment). Different irrigation scheduling were compared – A: one irrigation (50 mm) at flowering; B: one irrigation (50 mm) at pod filling; – C: irrigation of 40 mm of water, every time that soil moisture reached the threshold of 25% of plant available water (PAW) measured with TDR probes at 0-60 cm depths (idem at 25%); D: idem at 50%; E: idem at 75%; F: Rainfed, a not irrigated control. They noted that total plant biomass was related to water availability and radiation interception. But in good conditions of available water there was a lengthening of the crop cycle, with reduction of pod growth, harvest index and nutrient toward the seeds. Consequently, the best values of water use efficiency were found in the treatment irrigated with 50 mm only at flowering or at pod filling.

Sarkar et al. [17] conducted study for increasing cropping intensity in dry, Baind area (North-western region) of Bangladesh, utilizing profile soil moisture and supplemental irrigation. For chickpea, they investigated four irrigation regimes: no irrigation + no mulch; irrigation + mulch; irrigation at flowering stage + no mulch; irrigation at pod formation stage + no mulch. They used our cultivars. In case of mean effect of irrigation treatments; agronomic and yield attributes like plant height, branch per plant, pod per plant, 100 seed weight, as well as seed yield were not significantly different. They noted varietal difference in case of 100 seed weight and seed yield. Ali et al. [18] concluded that non-rice crops (e.g. lentil, chickpea, etc.) can be cultivated relying on rainfall provided that stored soil moisture is utilized through immediate land preparation.

In general, total plant biomass is related to water availability and radiation interception. But in good condition of available soil water, there is an excessive vegetation growth, and lengthen crop period, with reduction of pod growth, harvest index and nutrient toward the seeds of chickpea (Rinaldi et al. [15]). This happened in our case. Moemeni et al. [9] also reported that supplemental irrigation in Chickpea increased (compared to non-irrigated treatment) leaf area index, leaf area ratio, growth rate and relative growth rate after 68 days.

3.2 Total Water Use and Water Use Efficiency

Table 3 summarizes the water requirement and water use efficiency of chickpea under different irrigation regimes. The highest seed yield as well as water use efficiency (263.01 kg ha^{-1} cm^{-1}) was also found in control (T_1) treatment, which received no irrigation.

From the Table 3, it is evident that irrigation supply increased seasonal ET, but without benefit for seed yield. As a result, the water use efficiency in irrigated treatment decreased. In essence, irrigation water use efficiency is the function of yield and water applied, and decreases with increasing irrigation, unless percentage increase in yield exceeds the percentage increase in irrigation water.

4. CONCLUSION

The results of the study revealed that irrigation had detrimental effect on all yield attributes and seed yield. The seed yield gradually reduced when irrigation was applied. The highest seed yield was obtained from control treatment which received no irrigation. The highest water use efficiency was also found in control (non-irrigated) treatment. Thus, from the results it can be concluded that under the prevailing climatic and soil condition, the chickpea cultivars do not need any irrigation at Magura location, rather it reduces yield.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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