International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 3069-3073

Received: 04-11-2020
Accepted: 12-12-2020

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Influence of different irrigation scheduling through micro sprinkler on growth and yield of chickpea

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DOI: https://doi.org/10.22271/chemi.2021.v9.i1aq.11699

Abstract
A Field experiment entitled, "Influence of different irrigation scheduling through micro-sprinkler on growth and yield of chickpea" was conducted at the farm of All India Co-ordinated Research Project on Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (M.S.) India during the *Rabi* season 2017-18. The experiment was laid out in Randomized Block Design with six irrigation treatments replicated four times. The treatments were consisting of applying irrigation through micro sprinkler at 0.3, 0.45, 0.6, 0.75 and 0.9 IW/CPE ratio, irrigation at 25 CPE and applying surface irrigation at 50 CPE. The growth in terms of plant height, plant spread, number of branches per plant and dry matter accumulation were observed to be significantly more in treatment of irrigation at 0.9 IW/CPE ratio. However surface irrigation at 50 mm CPE and 0.75 IW/CPE ratio with micro-sprinkler were at par with 0.9 IW/CPE ratio. Similarly, the yield contributing characters *viz*., weight of pods per plant, weight of seeds per plant, test weight were significantly higher in 0.9 IW/CPE ratio irrigation as compared to other treatments. The grain yield increased with increase in irrigation depth with IW/CPE ratio. The irrigation applied at 0.9 IW/CPE ratio produced significantly superior grain yield (23.35 q ha^{-1}) over other irrigation treatments but the difference with surface irrigation at 50 mm CPE (22.80 q ha^{-1}) and irrigation at 0.75 IW/CPE ratio (21.51 q ha^{-1}) grain yield was not significant. The irrigation through micro sprinkler at 0.75 IW/CPE ratio can be advisable for chickpea cultivation in semi-arid area. The grain yield at lower 0.3 IW/CPE ratio (16.13 q ha^{-1}) was lowest among all the treatments due to insufficient soil moisture and its distribution in root zone under inadequate depth (7.5 mm). The total irrigation water used in 0.75 IW/CPE ratio was (253 mm). The water use efficiency decreased with increase in IW/CPE ratio. The net monetary returns and B:C ratio was highest in surface irrigation.
Based on the above findings, it could be concluded that growing of chickpea with irrigation scheduling at surface irrigation was beneficial for achieving higher productivity and B:C ratio. Nevertheless, under water scarcity condition micro sprinkler at 0.75 IW/CPE ratio better in practice.

Keywords: Irrigation scheduling, micro-sprinkler, chickpea, seasonal water requirement, economics

Introduction
Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally. Chickpea is grown in more than 50 countries. Asia accounts 89.7% of the area in chickpea production, followed by 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe. It occupies an area of 13.98 million hector with an annual production of 13.73 million metric tonnes with average productivity of 982 $kgha^{-1}$. Overall, India's contribution towards global chickpea area and production is about 75% and 81% respectively. So the global trend follows the Indian trend in chickpea area and production. During 2017-18, 10.57 million hector of chickpea and 11.15 million metric tonnes of production with average productivity of 1054.9 kg ha^{-1} were in India. (Anonymous, 2017-18). Maharashtra is the 2nd largest chickpea growing state in the country. It is cultivated on an area of 2.0 million hector of land with an annual production of 1.76 million metric tonnes and average productivity as 880 kg ha^{-1}. In Maharashtra, Amaravati district leads in chickpea production with a share of (8%) followed by Ahmednagar (7%), Akola (7%), Hingoli (6%) (Anonymous, 2017-18) [1].
Ahmednagar district of Maharashtra which lies in semi-arid western Maharashtra, the cultivation of chickpea is mostly done as rainfed sole crop on residual soil the in month of October – November. In this area the average annual rainfall about 625 to 750 mm and

cultivated on residual soil moisture. It is grown on moderately heavy, medium and light alluvial soil. Though cultivation of chickpea is mostly done as a rainfed crop and thus its yield is subjected to moisture stress during crop growth resulting into low productivity. Obviously in order to get full benefits from irrigation, it should be given at the right time, in right amount and in right way. Another issue related with water use in agriculture that it is applying through conventional method of irrigation i.e. surface irrigation. This irrigation method is mostly practiced throughout Maharashtra. Farmers are lacking in the knowledge of efficient methods of irrigation water application and try to apply as much water as possible to field. The available water can be used judiciously through pressurized irrigation even though it is ample or limited. By this way, there is great need to utilize present water source for more area under as well as minimizing the problems of water logging, soil salinity and crop wilting.

Chickpea is very sensitive to water availability in root zone, since it has got relatively shallow root zone and requires more frequent drainage; therefore, many times crop-water-yield relationship is quite complex. This is because of the economic yield of chickpea not only depends upon total water supplied during growing season but also on its allocation throughout the period. Most of the time, low yields of such a valued crop could also be attributed to improper irrigation quantity applied by the farmers. This necessitates proper planning and applying it through pressurized irrigation methods, such as sprinkler and drip irrigation. In sprinkler irrigation method about 20 to 30 percent saving in irrigation water and 80 to 90 percent irrigation efficiency is achieved over traditional method.

Chickpea responses well to sprinkler irrigation and its yields can be increased up to 20-30% if supplemental irrigation is provided. Some farmers are used overhead type of sprinkler irrigation system. However overhead sprinkler irrigation is suitable for large farm size normally on 0.5 to 1 ha. Most of the farmers of western Maharashtra are possessing low land holding and in this view the use of micro sprinkler system which is smaller form of overhead sprinkler is seems to be a more appropriate. It is useful in increasing productivity by 10-35 per cent with 30-35 per cent water saving and especially suited for those close growing crops and thus, can be conventially used to all cereals, pulses, oilseed and vegetables. In closed spaced crops like chickpea micro sprinkler method could play effective role in obtaining potential yields with judicious management of irrigation water. But the proper information is needed to guide farmers, when and how much to irrigate with controlled micro sprinkler irrigation practices in order to reduce the unwanted effect of water stress on crop yield.

Materials and method

An experiment "Influence of different irrigation scheduling through micro-sprinkler on growth and yield of quality of chickpea" was conducted during the *Rabi* season, 2017-18 at at the farm of All India Co-ordinated Research Project on Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (M.S.). Agro-climatically, the area falls under the scarcity zone of Maharashtra with annual average rainfall of 520 mm, which is mostly erratic and uncertain in nature. The experimental plot was uniform and leveled with well drained, medium black clay soil, alkaline in nature with pH as 8.30. The soil depth was 60 cm with hydraulic conductivity and organic carbon as 1.0 cm/h and 0.65%, respectively. The soil texture was clay with 12.30% coarse sand, 23% silt and 45.66% clay with medium depth. The bulk density of soil was 1.34 g/cm3 and electrical conductivity was 0.49 dSm-1.The soil was high in available N (215 kg/ ha), and P (12.78 kg/ha) and very high in available K (420 kg/ha) content. The soil was having moisture contents at field capacity, permanent wilting point and available soil moisture as 34.95, 18.14 and 16.81%, respectively.

The present investigation with four replications, six irrigation treatments of irrigation schedules under micro-sprinkler were studied in Randomized Block Design. The scheduling of irrigations was done on the basis of different IW/CPE ratio *viz*. 0.30, 0.45, 0.60, 0.75, 0.90. The irrigation in micro sprinkler was applied at 25 mm CPE. One treatment of surface irrigation at 50 mm CPE was also taken as control. In surface irrigation 50 mm irrigation water was applied every irrigation.

In micro-sprinkler, the depth of water applied during each irrigation (cm) were worked out using the following formula.

$$\text{Ratio} = \frac{\text{Irrigation water (IW)}}{\text{Cumulative Pan Evaporation (CPE)}}$$

Depth of irrigation water for Micro sprinkler

= IW/CPE ratio x 25 mm CPE

$$\text{Depth of surface irrigation} = \frac{(FC - PWP)}{100} \times B.D \times \text{Root zone depth}$$

The volume of water was calculated for each treatment by using the following relationship given below in equation.

$$V = A \times D$$

Where

V = Volume of water (lit)

A = Area of plot (m^2)

D = Depth of irrigation water for respective treatment (mm)

The time of operation was calculated for each treatment by using the following relationship given below in equation.

$$T = \frac{V}{Q \times N}$$

Where

T=Time of operation (hr)

V= Volume of water (lit)

Q = Discharge of micro sprinkler ($lithr^{-1}$)

N = Number of micro sprinkler in a plot

$$T = \frac{V}{Q}$$

Where

T =Time required to irrigate the plot (min.)

V = Volume of water (lit)

Q = Discharge of water flow through replogle flume ($lit\ min^{-1}$)

Water use efficiency in different treatments was calculated by using following formula (Michael, 2008).

$$WUE = \frac{Y}{Cu}$$

Where
Y = grain yield (kg ha^{-1})
Cu = Total water use (mm)

Results and Discussion
The growth parameters *viz*. Plant height, branches, plant spread, number of branches and dry matter per plant were found maximum in 0.9 IW/CPE ratio (Table 1). But it was on par with treatment T_6 and T_4 i.e. surface irrigation and 0.75 IW/CPE ratio. The irrigation application through micro sprinkler at 0.3, 0.45, 0.6 IW/CPE ratio. The result reveals that in T_5 i.e. irrigation at 0.9 IW/CPE ratio larger irrigation depth of 22.5 mm was applied, therefore available moisture in soil was almost near to the field capacity. This moisture was helpful for easy availability of nutrients, so as to uptake of the plant. In T_1, T_2 and T_3 the depth of water applied was low i.e. 7.5, 11.25 and 15 mm, hence enough moisture content was not available and it was below the field capacity. For this reason the uptake of nutrients from the root zone was low that caused improper mixing of water and nutrients.
The results are close conformity with Srinivasulu *et al.*, (2011) [10] i.e. irrigation scheduling in chickpea at 0.9 IW/CPE ratio showed significantly higher plant height, spread, branches, dry matter (32.1 cm) as compared to 0.5, 0.7IW/CPE ratio and farmers practice.

Table 1: Mean plant height, spread, number of branches and dry matter chickpea at harvest as influenced by different irrigation treatments

Sr. no	Treatments IW/CPE ratio	Plant height (cm)	Plant spread (cm)	No. Of branches per plant	Dry matter accumulation per plant (gm)
1.	T_1: 0.3	35.80	22.05	13.93	30.55
2.	T_2: 0.45	36.65	23.61	14.05	32.48
3.	T_3: 0.6	37.36	23.78	14.85	33.38
4.	T_4: 0.75	42.20	24.30	16.50	35.00
5.	T_5: 0.9	44.40	26.85	17.35	36.50
6.	T_6: Surface Irrigation	43.75	25.48	16.00	35.75
	General mean	40.06	24.34	15.44	33.78
	S.Em ±	1.30	0.97	0.93	1.02
	CD at 5%	3.94	2.94	2.81	3.07

Yield
This reveals that The maximum number of pods, weight of pods, weight of seeds per plant (g) and hundred seed weight (g) was recorded as 57, 24.3 g, 21.1 g and 27.2 g respectively, in 0.9IW/CPE ratio, which was at par with treatment T_6 and T_4 i.e. surface irrigation and 0.75 IW/CPE ratio.
The maximum grain yield 23.3 q $ha^{-1}$was recorded in treatment T_5 i.e. irrigation at 0.9 IW/CPE ratio which was significantly superior over all other irrigation treatments except surface irrigation treatment and 0.75 IW/CPE ratio under micro sprinkler. The significantly lowest grain yield was 16.13 q ha^{-1} recorded in treatment T_1 i.e. irrigation with micro-sprinkler at 0.3 IW/CPE ratio. In treatment T_2, T_3 and T_4 grain yield was recorded as 17.7, 18.74 and 22.51 q ha^{-1} respectively.
The micro sprinkler method of irrigation provided optimum depth of irrigation that resulted into adequate soil moisture status in root zone throughout crop growth period. Moreover, the micro-climatic conditions in terms of reduced temperature and increased relative humidity in crop canopy also favored by applying water in sprinkling form. Higher vegetative growth and synthesis of more photosynthates coupled with better translocation and partitioning from source to sink resulted more number of well filled pods with more number.
This finally resulted in the higher grain and straw yield per plant as well as hundred seed weight. The grain yield is a function of number and weight of grain and thus the grain yield was lowest in T_1 due to lowest number and weight of grain obtained. These results are in close conformity Pawar *et al.*, (2013) [9] i.e. irrigation scheduling in chickpea at 1.0 IW/CPE ratio showed significantly higher grain yield (24.74 q ha^{-1}) as compared to 0.6, 0.8, 1.2 IW/CPE ratio and irrigation at critical growth stages.

Seasonal water requirement
The seasonal water requirement was estimated higher in 0.9 IW/CPE ratio (303 mm). (Table no.3) The seasonal water requirement for surface irrigation, 0.75, 0.6, 0.45, 0.3 IW/CPE ratio was 300, 253, 202,152 and 101 mm respectively. The variation of water requirement was mainly due to variation in irrigation depth. The 22.5 mm water depth applied at 0.9 IW/CPE ratio whereas in 0.3 I W/CPE ratio it was only about 7.5 mm. Thus, larger irrigation depth (303 mm) produced higher grain yield (23.35 q ha^{-1}) in T_5 and vice versa.
The seasonal water requirement of chickpea in this area is varied from 250-300 mm (Ilhe *et al.*, 2006) [6]. The similar results were obtained in this study that water requirement of significantly at par treatments i.e. T_5, T_6 and T_4 are 303,300 and 253 mm respectively. The results pointed out that chickpea crop good response to irrigation irrespective of irrigation method as when irrigated with lower amounts of irrigation, the yields were reduced.

Quality parameters
The protein content in seed was not influenced by different treatments. The mean protein content in seed was 22.19 per cent. The protein content decreased with decrease in IW/CPE ratio of soil. It was registered maximum (22.55 per cent) in irrigation treatment T_5 i.e. irrigation with micro-sprinkler at 0.9 IW/CPE ratio. The lowest protein content in grain was (21 per cent) was recorded in irrigation at 0.3 IW/CPE ratio. (Table no.3) This might be due to dilution effect. Similar results were reported by Kulhare *et al.*, (1988) [5].
Higher protein content was recorded higher in 0.9 IW/CPE ratio. It was due to increased availability and uptake of nutrients under high moisture conditions which boosted the synthesis of amino acids and protein (Dixit *et al*., 1993) [4].

Economics
The higher cost of cultivation was observed in T5 (Rs. 50206 ha-1). In surface irrigation treatment the cost of cultivation was (Rs. 43875 ha-1). The cost of cultivation in T1 was lowest (Rs. 48641 ha-1) due to minimum water utilized.

Table 2: Mean number of pods, weight of pods, weight of grains per plant and Hundred seed weight grain yield, straw yield, Biological yield, Harvest index, protein content, seasonal water requirement of chickpea at harvest as influenced by different irrigation treatment

No.	Treatments IW/CPE ratio	Number of pods/ plant	Weight of pods/ plant (g)	Weight of grains/ plant (g)	Hundred seed weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)	Protein content in seed (%)	Seasonal water requirement (mm)
1.	T_1: 0.3	48.25	20.10	17.9	23.77	16.13	23.28	39.40	40.91	21.00	101
2.	T_2: 0.45	50.75	21.65	18.48	24.96	17.70	25.23	42.93	41.24	21.20	152
3.	T_3: 0.6	52.50	21.85	19.12	25.31	18.74	26.55	45.00	41.64	21.91	202
4.	T_4: 0.75	55.25	23.33	20.10	26.68	22.51	29.87	52.38	41.86	21.95	253
5.	T_5: 0.9	57.00	24.30	21.81	27.22	23.35	31.83	55.17	42.32	22.55	303
6.	T_6: Surface Irrigation	55.75	23.39	20.72	26.88	22.80	31.10	53.90	42.30	22.53	300
	General mean	53.25	22.55	19.66	25.77	20.03	27.97	47.96	41.71	22.19	219.4
	S. Em ±	1.44	0.77	0.78	0.45	0.61	0.66	1.12	0.27	0.77	
	C.D. at 5%	4.32	2.33	2.36	1.36	1.85	1.99	3.38	0.82	NS	

The greater gross monetary (Rs. 105923 ha^{-1}) estimated in treatment T_5 i.e. 0.9 IW/CPE ratio. However, highest net monetary returns (Rs. 59555 ha^{-1}) were reported in treatment T_6 i.e. surface irrigation. The lowest gross monetary returns (Rs. 73300 ha^{-1}) and net monetary returns (Rs.24659 ha^{-1}) were reported in treatment 0.3 IW/CPE ratio. The B:C ratio was higher in surface irrigation (2.36) as compared to treatment 0.9 IW/CPE Ratio (2.1).(Table no.4)

Table 3: Economics of chickpea as influenced by various treatments

Treatment IW/CPE ratio	Fixed cost (Rs ha^{-1})	Operational cost (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio	Net profit / mm water applied
T_1 : 0.3	7703	40938	48641	73300	24659	1.51	244
T_2 : 0.45	7703	41282	48985	80403	31418	1.64	206
T_3 : 0.6	7703	41520	49223	85111	35888	1.73	177
T_4 : 0.75	7703	42305	50008	102131	50027	2.04	197
T_5 : 0.9	7703	42503	50206	105923	55717	2.11	183
Surface irrigation	1480	42395	43875	103430	59555	2.36	198
Mean	6665	41823	48456	90966	42510	1.88	199

Conclusions

1. The irrigation applied through micro sprinkler at 0.9 IW/CPE ratio showed favorable effects on growth and yield contributing characters of chickpea resulting with higher grain yield (23.35 q ha-1).The surface irrigation (22.8 q ha-1) and 0.75 IW/CPE (22.51q ha-1) were at par with 0.9 IW/CPE ratio in clayey soil under semi arid zone in Rabi season.
2. The water use of chickpea crop through micro sprinkler was 303 mm in 0.9 IW/CPE ratio, 253 mm in 0.75 IW/CPE ratio and 300 mm in surface irrigation.
3. The moisture distribution pattern throughout the crop growth period was more in 0.9 IW/CPE ratio at surface, 15 and 30 cm soil depth as compared to surface irrigation.
4. Irrigation at 0.9 IW/CPE ratio enhanced the yield remarkably. The beneficial effect of moisture regimes on vegetative growth reflected in increasing the yield of chickpea significantly in 0.9 IW/CPE ratio than those of 0.3, 0.45 and 0.6 IW/CPE. However, yield increase did not reflected on gross monetary returns due to initial cost of micro-sprinkler irrigation system. For the same season net monetary returns and B:C ratio were high in surface irrigation as it had low initial cost.

All conclusions should be based on micro sprinkler, irrigation scheduling studies on growth, On the basis of the results obtained, it can be concluded that, chickpea (Var. Digvijay) cultivated in clayey soil under micro-sprinkler method of irrigation should be irrigated at 0.75 IW/CPE ratio to obtain better growth and to improved yield. However, good B:C ratio was obtained in surface irrigation. Hence, traditional method of surface irrigation is best in practice to chickpea under normal water availability condition. Under limited water availability conditions, it is advisable to use micro sprinkler with 0.75 IW/CPE ratio.

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