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Studies on the Influence of Depth and Interval of Drip Irrigation on Yield, Water Use Efficiency and Economics of Chickpea (*Cicer arietinum* L.)

Muniyappa*, Mudalagiriyappa, B.K. Ramachandrappa, Nagaraju and A. Sathish

Department of Agronomy, UAS, GKVK, Bengaluru 560 065, (Karnataka)

*Corresponding Author E-mail: muniagron24@gmail.com

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ABSTRACT

A field experiment was conducted during rabi 2014-15 at Gandhi Krishi Vignana Kendra, UAS, Bangalore to study the effect of depth and interval of drip irrigation on growth and yield of chickpea in red sandy clay loam soil. The experiment consisted of twelve treatments which were replicated thrice in RCBD with factorial concept. The experiment consisted of two factors viz., irrigation depths; 40 per cent (D_1), 60 per cent (D_2), 80 per cent (D_3) and100 per cent pan evaporation (D_4). Irrigation intervals; 3 days (I_1) 5 days (I_2) and 7 days interval (I_3). The investigation revealed that scheduling of drip irrigation at 100 per cent pan evaporation recorded significantly higher seed yield (1780 kg ha^{-1}) which was on par with drip irrigation scheduled at 80 per cent pan evaporation (1723 kg ha^{-1}). Among the drip irrigation intervals, drip irrigation scheduled at 7 days interval recoded significantly higher seed yield (1671 kg ha^{-1}) which was on par with 5 days interval (1593 kg ha^{-1}). It was also observed that yield attributes (pods plant^{-1}, pod weight plant^{-1}, 100 seed weight and haulm yield) was also significantly higher in this treatment. Significantly higher water use efficiency was recorded in drip irrigation scheduled at 40 per cent pan evaporation (72.14 kg ha-cm^{-1}) and at 7 days interval (63.35 kg ha-cm^{-1}). Drip irrigation scheduled at 100 per cent and 80 per cent pan evaporation recorded higher gross returns (₹68,836 ha^{-1} and ₹ 66,618 ha^{-1} respectively), net returns (₹31,793 ha^{-1} and ₹ 29,975 ha^{-1} respectively) and B: C (1.86 and 1.82 respectively) compared to drip irrigation scheduled at 40 per cent pan evaporation. Irrigation scheduled at 7 days interval recorded higher gross returns (₹64,654 ha^{-1}), net returns (₹29,399 ha^{-1}) and B: C (1.83) ratio compared to drip irrigation scheduled at 3 days interval.

Key words: *Chickpea, Depth, Interval, Drip irrigation, water use efficiency, Yield, Economics*

INTRODUCTION

Chickpea is a *rabi* season pulse crop grown over an area of 11.97 million hectares, producing 10.89 million tonnes with an average productivity of 764 kg ha^{-1} in the world. It represents 17 per cent of world pulse area and 17.68 per cent of world's pulse production[2]. Agronomic practices of chickpea are required to be standardized for realizing yield potential. Application of water through drip irrigation has several advantages in supplementing the water requirements of crops.

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Drip irrigation is designed to eliminate the problems like evaporation, percolation and seepage of water which in turn results in higher water use efficiency. Hence, drip irrigation is being recognized as an important method of water management in modern agriculture.

Irrigated agricultural development has a high priority in the present world where production of food must keep pace with a rapidly increasing population. It is clear that with high yielding varieties in hand, higher agricultural production is expected from efficient use of available water resources. Irrigation plays an important role in chickpea productivity. Average chickpea yield under rainfed condition is 12-15 q ha^{-1}, while irrigated chickpea is 18-23 q ha^{-1}. Lack of irrigation and suitable variety under delayed sowing were the hindrances for higher productivity. It is an established fact that crop production suffers not only from moisture stress but also from over irrigation or unscientific use of water, as it affects crop growth and yield. It also spoils the land by way of increased salt accumulation, deteriorating the soil physical condition and leaching out the nutrients. Scientific irrigation scheduling, according to developmental rhythm of plant and in accordance with climatic demand is one of the ways to increase water use efficiency. Recently high yielding varieties responded to higher levels of irrigation and nutrients are evolved and therefore, better irrigation scheduling and intervals have prime importance in chickpea production. Drip irrigation system offer great promise for exploiting the yield potential of chickpea. These facts call for the intensive study on possibility of more effective utilization of water using different depths and intervals through drip irrigation method so that production benefits can be maximized.

MATERIALS AND METHODS

The experiment was conducted at Zonal Agricultural Research Station, GKVK, University of Agricultural Sciences, Bengaluru during *rabi* 2014-15. The soil of the experimental site was red sandy loam having medium in available nitrogen (263 kg ha^{-1}), phosphorous (43.5 kg ha^{-1}) and potassium (228 kg ha^{-1}). During the cropping season a total of 32.2 mm rainfall was received. The average maximum air temperature of 32.2°C in the month of March, 2015 and minimum temperature of 15.2°C during the month of January, 2015 were recorded. The variety used in the investigation was JG-11. The experiment consisted of twelve treatments which were replicated thrice in RCBD with factorial concept. The experiment consisted of two factors *viz*., irrigation depths; 40 per cent (D_1), 60 per cent (D_2), 80 per cent (D_3) and100 per cent pan evaporation (D_4). Irrigation intervals; 3 days (I_1) 5 days (I_2) and 7 days interval (I_3). In drip irrigation methods, according to treatments, required quantities of water were applied depending on the treatments by using the pan evaporation values collected by USWB class A pan evaporator method, required quantities of fertilizers were applied at the time of sowing.

RESULTS AND DISCUSSION

Yield attributes in chickpea

Significant differences in yield attributes of chickpea were due to irrigation treatments. In general, drip irrigation method had higher application efficiency and supplied water to root zone with a lower discharge rate not more than infiltration rate of soil[9]. Maintenance of ideal moisture in drip irrigated treatments, therefore resulted in higher yield and yield attributes. In this study, significantly higher number of pods per plant (37), pod weight per plant (12.65 g), seed weight per plant (8.65 g) and 100 seed weight (24.96 g) were observed when drip irrigation scheduled at 100 per cent E_{pan} which was on par with drip irrigation scheduled at 80 per cent E_{pan} (34, 11.38 g, 8.53

g, 24.72g number of pods plant^{-1}, pod weight plant^{-1}, seed weight plant^{-1} and 100 seed weight respectively) compared to drip irrigation scheduled at 40 per cent $E_{pan.}$ And drip irrigation scheduled at 7 days interval had significantly higher number of pods per plant (34), pod weight per plant (11.37 g), seed weight per plant (8.58 g) and 100 seed weight (24.45) which was on par with irrigation scheduled at 5 days interval (31, 10.64 g, 7.86 g and 23.18 g number of pods plant^{-1}, pod weight plant^{-1}, seed weight plant^{-1} and 100 seed weight respectively). The increased yield attributes with increased depth and interval of drip irrigation was due to higher chlorophyll content with enhanced photosynthetic activity and higher uptake of nutrients (Table 1) and thereby increased plant dry matter production in the pod setting phase which improved the pod development and number of pods per plant and finally contributed for higher productivity. These observations were similar to the findings of Mahalakshmi *et al*[5]., and Akbar *et al*[1]., increased number of pods and 100 seed weight in chickpea.

Yield of chickpea

Yield of chickpea also differed significantly due to water management practices. Seed yield of chickpea differed significantly due to depth and interval of drip irrigation. Among the different irrigation depths, significantly higher seed yield (1780 kg ha^{-1}) was recorded with scheduling of drip irrigation at 100 per cent E_{pan} than all other treatments except scheduling of drip irrigation at 80 per cent E_{pan} which had recorded on par seed yield (1723 kg ha^{-1}). Lower seed yield was recorded when drip irrigation was scheduled at 40 per cent E_{pan} (1264 kg ha^{-1}). Among the irrigation intervals, drip irrigation scheduled at 7 days interval had recorded significantly higher seed yield (1671 kg ha^{-1}) and it was on par with the drip irrigation scheduled at 5 days interval (1593 kg ha^{-1}) and the lower yield was recorded at 3 days interval (1397 kg ha^{-1}) (Table 4.13). The increase in yield with increased depth and interval of drip irrigation was due to increased yield attributes such as number of pods plant^{-1}, pod yield plant^{-1}, 100 seed weight and seed weight plant^{-1} at 100 per cent E_{pan} at 7 days interval of drip irrigation. The increased supply of moisture and good response by plants resulted in enhanced translocation of nutrients to reproductive parts *viz*. pods, grains etc[3]. Haulm yield differed significantly due to depth and interval of drip irrigation (Table 2). Significantly higher haulm yield (2414 kg ha^{-1}) was recorded with scheduling of drip irrigation at 100 per cent E_{pan} and was on par with scheduling of drip irrigation at 80 per cent E_{pan} (2300 kg ha^{-1}). Lower haulm yield was recorded with scheduling of drip irrigation at 40 per cent E_{pan} (1831 kg ha$^{-1)}$. Among the irrigation intervals, drip irrigation scheduled at 7 days interval was recorded higher haulm yield (2303 kg ha^{-1}) and it was on par with drip irrigation scheduled at 5 days interval (2204 kg ha^{-1}). However, lower haulm yield was recorded with 3 days interval (1950 kg ha^{-1}). The additional supply of moisture through drip irrigation might have led to increased leaf area and number of branches per plant which resulted in higher dry matter accumulation and ultimately lead to higher haulm yield. Further the enhancement of haulm yield might be due to the enhanced supply and subsequent translocation of nutrients to plant parts. Similar findings were reported by Mansur *et al*[6]., Vijayakumar Choudhary[10] and Vishwanath *et al*[12]. The impact of depth and interval of drip irrigation was found non-significant. However, numerically higher harvest index (0.42) was recorded in drip irrigation scheduled at 100 per cent E_{pan} and the lower harvest index was recorded in drip irrigation scheduled at 40 per cent E_{pan} (0.40). Among the irrigation intervals higher harvest index was recorded in drip irrigation scheduled at 7 days interval (0.42) and the lower harvest index recorded in drip irrigation scheduled at 3 days interval.

Water use efficiency

Water use efficiency, the ratio of pod yield to total water input, was found to be increased with drip irrigation (Table 3). Similar findings were reported by Mahalakshmi *et al*[5]., in pigeonpea. Increased in water productivity was attributed to increase pod yield with reduce level of water consumption. In the present investigation, drip irrigation scheduled at 100 percent E_{pan} consumed higher amount of water (414 mm) compared to drip irrigation scheduled at 40 per cent E_{pan} (175 mm). Among the irrigation intervals, drip irrigation scheduled at 3 days interval consumed higher amount of water (302 mm) compared to 7 days interval (282 mm). Drip irrigation scheduled at 40 per cent E_{pan} recorded significantly higher water use efficiency (72.41 kg ha-cm^{-1}) over drip irrigation scheduled at 100 per cent E_{pan} (43.02 kg ha-cm^{-1}). Among the irrigation intervals, drip irrigation scheduled at 7 days interval was recorded significantly higher water use efficiency (63.5 kg ha-cm^{-1}) compared to 3 days interval (48.74 kg ha-cm^{-1}).The increased water use efficiency in drip irrigated treatments was mainly due to considerable saving of irrigation water, greater increase in yield of crop and higher nutrient uptake. This was in concordance with Pradeep[7], Rajiv[8], Mahalakshmi *et al*[5]., and Vinayak *et al*[11]. These studies revealed that supplying water to soil nearer to the plant without much loss of water resulting in higher water productivity.

Economics

For successful adoption of any technology by the farmers, it should be technically feasible and economically viable. Keeping this in view, price analysis of any technology for the benefit of farmers to take suitable marketing decisions is foremost important.

Higher cost of cultivation (₹ 37,042 ha^{-1}) was recorded with scheduling of drip irrigation at 100 per cent E_{pan} this was due to higher cost of installation of drip irrigation system and its maintenance and it consumed more amount of water as compared to drip irrigation scheduled at 40 per cent E_{pan} (₹ 37,142 ha^{-1}). Among the irrigation intervals, drip irrigation scheduled at 3 days interval was recorded higher cost of cultivation (₹ 38,341 ha^{-1}). This was due to the frequent irrigations that inturn leads to higher labour cost. And lower cost of cultivation was recorded in drip irrigation scheduled at 7days interval (₹ 35,255 ha^{-1}). Higher gross returns was recorded in drip irrigation scheduled at 100 per cent E_{pan} (₹ 68,836 ha^{-1}) and 7 days interval (₹ 64,654 ha^{-1}). The higher gross return in these treatments was due to higher seed yield as a result of higher moisture availability and better utilization of nutrients throughout the crop growth period. The lower gross returns were obtained when drip irrigation scheduled at 40 per cent E_{pan} (₹ 48,907 ha^{-1}) and at3 days interval (₹ 54,061 ha^{-1}). Drip irrigations scheduled at 100 per cent E_{pan} and 7 days interval recorded higher net returns (₹ 31,793 and ₹ 29,399 respectively) (Table 4). This was mainly attributed to higher seed yield with higher gross income and lower cost of cultivation. The lower net returns (₹ 12,765 and ₹ 15,720 ha^{-1}) were obtained with drip irrigation scheduled at 40 per cent E_{pan} and 3 days interval. Drip irrigation scheduled at 100 per cent E_{pan} was found to be highly economical (1.86) as compared to drip irrigation scheduled at 40 per cent E_{pan} (1.36). Among the irrigation intervals, drip irrigation scheduled at 7 days interval was recorded higher B: C ratio (1.83) and the lower benefit cost ratio was observed with drip irrigation scheduled at 3 days interval (1.41). This was mainly due to increase in gross return as a result of higher yield and market price of chickpea. These results are in conformity with the results of Pradeep[7] and Hanchinamani[4] in chickpea. The combined effect was found non-significant in yield attributes, yield and water use efficiency of chickpea.

Table 1: Yield attributes of chickpea as influenced by depth and interval of drip irrigation

Treatments	Number of pods plant^{-1}	Pod weight (g plant^{-1})	Seed weight (g plant^{-1})	100 seed weight (g)
Irrigation depths (D)				
D_1- 40 per cent pan evaporation	24	6.11	5.90	19.00
D_2- 60 per cent pan evaporation	29	9.70	7.53	22.31
D_3- 80 per cent pan evaporation	34	11.38	8.53	24.72
D_4- 100 per cent Pan evaporation	37	12.65	8.65	24.96
S.Em.±	1.26	0.49	0.33	0.66
C.D. (P=0.05)	3.70	1.46	0.98	1.96
Irrigation intervals (I)				
I_1- At 3 days interval	27	7.87	6.51	20.61
I_2- At 5 days interval	31	10.64	7.86	23.18
I_3- At 7 days interval	34	11.37	8.58	24.45
S.Em.±	1.09	0.43	0.29	0.57
C.D. (P=0.05)	3.21	1.26	0.85	1.69
Interactions				
S.Em.±	2.19	0.86	0.58	1.16
C.D. (P=0.05)	NS	NS	NS	NS

Table 2: Yield of chickpea as influenced by depth and interval of drip irrigation

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index
Irrigation depths (D)			
D_1- 40 per cent pan evaporation	1264	1831	0.40
D_2- 60 per cent pan evaporation	1449	2064	0.41
D_3- 80 per cent pan evaporation	1723	2300	0.42
D_4- 100 per cent Pan evaporation	1780	2414	0.42
S.Em.±	41.67	58.08	0.004
C.D. (P=0.05)	122.23	170.35	NS
Irrigation intervals (I)			
I_1- At 3 days interval	1397	1950	0.41
I_2- At 5 days interval	1593	2204	0.41
I_3- At 7 days interval	1671	2303	0.42
S.Em.±	36.09	50.30	0.004
C.D. (P=0.05)	105.86	147.52	NS
Interactions			
S.Em.±	72.19	100.60	0.01
C.D. (P=0.05)	NS	NS	NS

Table 3: Water use efficiency (kg ha-cm^{-1}) as influenced by depth and interval of drip irrigation

Treatments	Total water used (IW+ER) (mm)	Water use efficiency (kg ha-cm^{-1})
Irrigation Depths (D)		
D_1- 40 per cent pan evaporation	175	72.41
D_2- 60 per cent pan evaporation	255	56.95
D_3- 80 per cent pan evaporation	335	51.66
D_4- 100 per cent Pan evaporation	414	43.02
S.Em.±	--	2.12
C.D. (P=0.05)	--	6.22
Irrigation intervals (I)		
I_1- At 3 days interval	302	48.74
I_2- At 5 days interval	301	55.94
I_3- At 7 days interval	282	63.35
S.Em.±	--	1.83
C.D. (P=0.05)	--	5.38
Interactions		
S.Em.±	--	3.67
C.D. (P=0.05)	--	NS

Table 4: Economics of chickpea as influenced by depth and interval of drip irrigation

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C
Irrigation scheduling (D)				
D_1- 40 per cent pan evaporation	36142	48907	12765	1.36
D_2- 60 per cent pan evaporation	36442	56068	19626	1.54
D_3- 80 per cent pan evaporation	36742	66618	29875	1.82
D_4- 100 per cent Pan evaporation	37042	68836	31793	1.86
Irrigation intervals (I)				
I_1- At 3 days interval	38341	54061	15720	1.41
I_2- At 5 days interval	36181	61606	25425	1.70
I_3- At 7 days interval	35255	64654	29399	1.83

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