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GROWTH PARAMETERS, YIELD ATTRIBUTES, YIELD AND QUALITY OF CHICKPEA (*CICER ARIETINUM* L.) AS INFLUENCED BY DEPTH AND INTERVAL OF DRIP IRRIGATION

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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 investigation revealed that scheduling of drip irrigation at 100 percent E_{pan} recorded significantly higher seed yield (1780 kg ha^{-1}) and haulm yield (2414 kg ha^{-1}) which was on par with drip irrigation scheduled at 80 percent E_{pan} (1723 kg ha^{-1}) and (2300 kg ha^{-1}). Among the drip irrigation intervals, drip irrigation scheduled at 7 days interval recorded significantly higher seed yield (1671 kg ha^{-1}) and haulm yield (2303 kg ha^{-1}) which was on par with 5 days interval (1593 kg ha^{-1}) and (2204 kg ha^{-1}). It was also observed that growth parameter (plant height, number of branches, total dry matter production $plant^{-1}$), yield attributes (pods $plant^{-1}$, pod weight $plant^{-1}$,) was also significantly higher in this treatment. Higher protein content (21.52 %) and (21.52 %) were recorded with drip irrigation scheduled at 80 per cent E_{pan} and at 7 days interval. Significantly higher protein yield (383.25 kg ha^{-1}) and (361.62 kg ha^{-1}) were recorded with drip scheduled at 100 percent E_{pan} at 7 days interval.

KEYWORDS: drip irrigation, haulm yield, growth parameter.

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 percent of world's pulse production (Anon., 2012a). India is one of the important chickpea growing countries in Asia with an area of 9.93 million hectares and production of 9.53 million tonnes with a productivity of 960 kg ha^{-1} (Anon., 2014). During the period 1991-93 to 2010-11, highest increase in productivity of chickpea has been recorded in Andhra Pradesh (124 per cent), followed by Karnataka (63 percent), Maharashtra (52 %) and Gujarat (40 %). There exists a good scope for further enhancement in productivity in states like Karnataka. Karnataka is one of the major chickpea producing state in the country and is being grown over an area of 8.03 lakh hectares with an annual production of 3.95 lakh tonnes, having an average productivity of 518 kg ha^{-1} (Anon., 2012b).

The high nutritional value makes chickpea an important food particularly in famine prone areas of the world. The leaves are eaten as vegetable, drinks are prepared from the plant exudates, the green seeds are consumed raw, roasted or boiled and the dry seeds can be used to prepare amazing array of different dishes. No crop other than chickpea is covered on all its surfaces with acid exudates and as a consequence has very few insect problem. Chickpea is also credited with the ability of atmospheric nitrogen fixation through symbiotic process and it has been estimated that chickpea has the capacity to fix 140 kg N ha^{-1} in a growing season (Rupela and Saxena, 1987). The fixed N not only can meet the requirements of the legume for maximum grain formation, but can also be available for use by subsequent crops after mineralization of chickpea crop residues.

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. The reason for low productivity of chickpea in Karnataka may be due to lack of proper scheduling of irrigation, balance nutrition, weed management etc. Among various factors affecting, proper scheduling of irrigation is the key factor for enhancing the productivity of crop, particularly through drip because water is a scarce commodity and key natural resource for any crop production particularly in arid and semiarid regions, where availability of irrigation water possess a serious threat to sustainability of crop production and therefore it is considered as liquid gold. Recently high yielding varieties response 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. Hence, an attempt has been made to find out the effect of depth and interval of drip irrigation on growth, yield attributes, yield and quality of chickpea.

MATERIALS & 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 & DISCUSSION

Yield and its attributes indirectly depend on growth attributes *viz.* plant height, number of branches, leaf area, leaf area index, dry matter production and effective nodules number. In the present study, scheduling of drip irrigation at 100 per cent E_{pan} recorded significantly higher plant height (43.7 cm) which was on par with drip irrigation scheduled at 80 per cent E_{pan} (42.3), shorter plant height was recorded with drip irrigation at 40 per cent E_{pan} (31.4 cm). Among the irrigation intervals, drip irrigation scheduled at 7 days interval recorded the significantly higher plant height (40.9 cm) which was on par with 5 days interval (39.9 cm) at harvest (Table 1). This was due to the availability of the optimum soil moisture to the crop though out the crop period. These results are in accordance with the findings of Solanki *et al*. (2011) in chickpea, Mahalakshmi *et al*. (2011) in pigeon pea and sefer Bozkurti *et al*. (2011). Higher number of primary branches was observed in drip irrigation scheduled at 100 percent E_{pan} (3.5) which was on par with scheduling of drip irrigation at 80 percent E_{pan} (3.5) and significantly higher number of primary branches was recorded in scheduling drip irrigation at 7 days interval (3.4) and it was on par with 5 days interval (3.3) at harvest (Table 1).

TABLE I: Growth parameters of chickpea as influenced depth and interval of drip irrigation

Treatments	Plant height (cm)	No. of primary branches $plant^{-1}$	Total dry matter accumulation (g $plant^{-1}$)	Number of effective nodules $plant^{-1}$
	At harvest			75 DAS
Irrigation depths (D)				
D_1- 40 per cent pan evaporation	31.4	2.9	6.43	15.1
D_2- 60 per cent pan evaporation	36.7	3.2	7.70	17.0
D_3- 80 per cent pan evaporation	42.3	3.5	9.31	19.0
D_4- 100 per cent Pan evaporation	43.7	3.5	9.53	19.1
S.Em.±	1.07	0.10	0.25	0.62
C.D. (P=0.05)	3.14	0.29	0.75	1.83
Irrigation intervals (I)				
I_1- At 3 days interval	34.8	3.0	6.92	15.6
I_2- At 5 days interval	39.9	3.3	8.73	18.4
I_3- At 7 days interval	40.09	3.4	9.07	18.8
S.Em.±	0.92	0.08	0.22	0.54
C.D. (P=0.05)	2.72	0.25	0.65	1.59
Interactions				
S.Em.±	1.86	0.17	0.44	1.08
C.D. (P=0.05)	NS	NS	NS	NS

Increased depths and interval of drip irrigation increased the dry matter production also. Significantly higher total dry matter production at harvest was recorded when drip irrigation scheduled at 100 per cent E_{pan} (9.53 g $plant^{-1}$) which was on par with drip irrigation scheduled at 80 per cent E_{pan} (9.31 g $plant^{-1}$). Among the irrigation intervals, drip irrigation scheduled at 7 days interval recorded significantly higher total dry matter accumulation (9.07 g $plant^{-1}$) which was on par with drip irrigation scheduled at 5 days interval (8.73 g $plant^{-1}$) at harvest. Increased dry mater production in leaf, stem, reproductive parts and total dry matter at harvest was mainly due to additional application of water through drip irrigation which led to higher relative water and increased uptake of nutrients which in turn helped in increased plant height, number of branches, leaf area and LAI. This contributed for better plant growth and ultimately increased the dry matter production. These results are in confirmation with the findings of Rajiv (2012) where he reported that scheduling of drip irrigation at 100 percent E_{pan} facilitated more availability and less interference in the absorption of moisture. This paves way for the production of more biomass leading to higher dry matter production. Adequate supply of moisture through drip irrigation would have increased its uptake and increased the dry matter. These results are in confirmation with the results of Moemeni *et al*. (2013), Kassab *et al*. (2012) and Mansur *et al*. (2010) in chickpea (Table 1).

Number of effective nodules $plant^{-1}$ showed significant variation at 75 DAS of chickpea due to drip irrigation. Scheduling of drip irrigation at 100 percent E_{pan} recorded significantly higher number of nodules $plant^{-1}$ (19.1) which was on par with drip irrigation scheduled at 80 percent E_{pan} (19.0) over other treatments. Lowest number of effective nodules plant^{-1} was recorded in drip irrigation scheduled at 40 percent E_{pan} (15.1). Among the irrigation intervals, drip irrigation scheduled at 7 days interval recorded the higher number of effective nodules per plant (18.8) and it was on par with drip irrigation scheduled at 5 days interval (18.4) and lowest number of effective nodules were notified in 3 days interval (15.6) (Table 1). Drip irrigation facilitates better availability of nutrients in plants leading to higher number of effective nodules per plant. These results are in accordance with the observations of Razzak *et al*. (2014) and Patel *et al* (2014) 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 (Ramaha *et al*. 2011). 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) and 100 seed weight (24.96 g) were observed when drip irrigation scheduled at 100 percent E_{pan} which was on par with drip irrigation scheduled at 80 percent E_{pan} (34, 11.38 g and 24.72g number of pods plant^{-1}, pod 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) and 100 seed weight (24.45) which was on par with irrigation scheduled at 5 days interval (31, 10.64 g and 23.18 g number of pods plant^{-1}, pod 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 2) 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*. (2011), Akbar *et al* (2011) and Shamsi *et al* (2010) reported increased number of pods and 100 seed weight in chickpea.

TABLE II: Yield attributes and yield of chickpea as influenced by depth and interval of drip irrigation

Treatments	Number of pods plant^{-1}	Pod weight (g plant^{-1})	100 seed weight (g)	Haulm yield (kg ha^{-1})	Seed yield (kg ha^{-1})
	Irrigation depths (D)				
D_1- 40 per cent pan evaporation	24	6.11	19.00	1831	1264
D_2- 60 per cent pan evaporation	29	9.70	22.31	2064	1449
D_3- 80 per cent pan evaporation	34	11.38	24.72	2300	1723
D_4- 100 per cent Pan evaporation	37	12.65	24.96	2414	1780
S.Em.±	1.26	0.49	0.66	58.08	41.67
C.D. (P=0.05)	3.70	1.46	1.96	170.35	122.23
Irrigation intervals (I)					
I_1- At 3 days interval	27	7.87	20.61	1950	1397
I_2- At 5 days interval	31	10.64	23.18	2204	1593
I_3- At 7 days interval	34	11.37	24.45	2303	1671
S.Em.±	1.09	0.43	0.57	50.30	36.09
C.D. (P=0.05)	3.21	1.26	1.69	147.52	105.86
Interactions					
S.Em.±	2.19	0.86	1.16	100.60	72.19
C.D. (P=0.05)	NS	NS	NS	NS	NS

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 percent E_{pan} and was on par with scheduling of drip irrigation at 80 percent 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*. (2010)), Vijayakumar Choudhary (2005) and Vishwanath *et al*. (2000).

Irrigation scheduling had significant influence on yield and its attributes in chickpea. 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 2). 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. (Dogan *et al.,* 2013). These results are in close confirmation with the findings of Mahalakshmi *et al*., (2011) who reported the effect of different levels of drip irrigation for improved productivity of pigeonpea and revealed that the highest pods per plant were recorded in drip irrigation scheduled at 80 percent E_{pan} which was higher than drip irrigation scheduled at 40 per cent E_{pan}. Whereas, Rajiv (2012) reported that scheduling of drip irrigation at 100 or 75 percent E_{pan} in maize recorded higher yield. The results obtained were in accordance with findings of Patil *et al*. (2011), Sahoo (2003) and Vishwanath *et al*. (2000) in maize, Patel *et al*. (2014) and Pradeep (2015) in chickpea.

Scheduling of drip irrigation at different depth and interval had no significant effect on protein content of chickpea seed. However, higher protein content of 21.52 per cent and 21.52 percent was recorded with scheduling of drip irrigation at 80 percent E_{pan} and 7 days interval respectively (Table 4.14 and fig. 11). This was mainly because of significant increase in grain nitrogen content due to proper scheduling of drip irrigation leads to proper translocation and utilization of nutrients due to availability of optimum moisture content in soil. Lowest protein content was recorded with drip irrigation scheduled at 40 per cent E_{pan} (21.40) and 3 days interval (21.40). Similar results were also reported by Pradeep (2015) in chickpea crop with scheduling of irrigation at 0.4 IW/CPE ratio. Significantly higher protein yield was recorded with scheduling of drip irrigation at 100 per cent E_{pan} (383.25 kg ha^{-1}) followed by drip irrigation scheduled at 80 percent E_{pan} (381.34 kg ha^{-1}). Lower protein yield was recorded with drip irrigation scheduled at 40 per cent E_{pan} (270.56 kg ha^{-1}). Among the irrigation intervals, irrigation scheduled at 7 days interval recorded significantly higher protein yield (361.62 kg ha^{-1}) and it was on par with drip irrigation scheduled at 5 days interval (342.43 kg ha^{-1}). However, lowest protein yield was observed in drip irrigation scheduled at 3 days interval (305.91 kg ha^{-1}) (Table 3). This increased protein yield was mainly attributed to higher seed yield. This was in consonance with Shaban (2013), Kasab *et al* (2012) and Khamssi (2011) Dixit *et al*. (1993).

TABLE III: Protein content and protein yield of chickpea as influenced by depth and interval of drip irrigation

Treatments	Protein content (%)	Protein yield (kg ha^{-1})
Irrigation depths (D)		
D_1- 40 per cent pan evaporation	21.40	270.56
D_2- 60 per cent pan evaporation	21.46	311.46
D_3- 80 per cent pan evaporation	21.52	381.34
D_4- 100 per cent Pan evaporation	21.50	383.25
S.Em.±	0.04	9.65
C.D. (P=0.05)	NS	28.31
Irrigation intervals (I)		
I_1- At 3 days interval	21.40	305.91
I_2- At 5 days interval	21.48	342.43
I_3- At 7 days interval	21.52	361.62
S.Em.±	0.04	8.36
C.D. (P=0.05)	NS	24.51
Interactions		
S.Em.±	0.07	16.72
C.D. (P=0.05)	NS	NS

CONCLUSION

This study has shown that chickpea performed equally better with scheduling of drip irrigation at 100 per cent pan evaporation and 80 per cent pan evaporation along with 7 days interval with regard to growth, yield, quality and economics. Hence, Scheduling of drip irrigation at 80% pan evaporation along with 7 days interval would be sufficient to meet the crop water requirement.

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