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MAXIMIZING CHICKPEA YIELD THROUGH STRATEGIC IRRIGATION SCHEDULING UNDER OVERHEAD SPRINKLER SYSTEMS

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Article Info

Keywords: Chickpea, Critical growth stages, Irrigation scheduling, Yield.

Abstract

A field experiment entitled "Scheduling of irrigation at different growth stages of chickpea under overhead sprinkler" was conducted at Agricultural Research Station, Repoli during *Rabi* 2015-16, 2016-17, 2017-18 and 2018-19 to study the response of irrigation on growth, yield and quality of chickpea and estimate water requirement of chickpea in medium black soil. The experiment was laid out in randomised block design with 7 treatments and three replications. The treatment consist of Irrigation levels {I_1 : Irrigation scheduled at seedling stage (20 DAS), **I_2**: Irrigation scheduled at flowering stage (40 DAS), **I_3**: Irrigation scheduled at grain filling stage (60 DAS), **I_4** : Irrigation scheduled at seedling and flowering stage (20 and 40 DAS), **I_5**: Irrigation scheduled at seedling and grain filling stage (20 and 60 DAS), **I_6**: Irrigation scheduled at flowering and grain filling stage (40 and 60 DAS) and **I_7**: Irrigation scheduled at seedling, flowering and grain filling stage(20,40 and 60 DAS)} with **I_0**: Control. From the four years data it can be concluded that irrigation scheduling at seedling and flowering stage proved to be significantly highest in grain yield of chickpea, where water use efficiency was 8.34 kg/ha-mm. The water use efficiency was highest when irrigation was scheduled at flowering stage (14.58 kg/ha-mm). Irrigation at grain filling stage could not produce significant effect on grain yield. Irrigation at seedling and flowering stage could increase the yield by 78.07 % over unirrigated chickpea, whereas only one irrigation at flowering stage yielded 55.65 % increase in grain yield as compare to unirrigated chickpea. The maximum Total cost (Rs. 42474 ha^{-1}), Gross return (Rs. 43560 ha^{-1}), Net return (Rs. 1086 ha^{-1}) and BC ratio (1.03) recorded by treatment (I_4) irrigation scheduled at seedling and flowering stage (20 and 40 DAS).

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INTRODUCTION

Title: Maximizing Chickpea Yield through Strategic Irrigation Scheduling under Overhead Sprinkler Systems

Introduction

Chickpea (Cicer arietinum L.) is an important grain legume crop, widely cultivated for its high nutritional value and economic significance throughout the world (FAOSTAT, 2018). The global production of chickpea has increased considerably in recent years, reaching approximately 17 million metric tons in 2018, with major contributions from India, Australia, and Canada (FAOSTAT, 2018). Despite its importance, chickpea productivity remains relatively low, mainly due to biotic and abiotic stresses, including diseases, pests, and drought (Jukanti et al., 2012). With increasing global population and changing climate, there is a growing need to develop effective strategies to enhance chickpea yield and ensure food security (Jukanti et al., 2012). One of the critical factors influencing chickpea yield is water availability, which significantly affects plant growth, development, and yield potential (Passioura, 2006). Chickpea is primarily cultivated in semi-arid regions, where water scarcity and drought are major constraints to crop production (Mall et al., 2009). Therefore, optimizing irrigation management is crucial to improving chickpea yield, particularly in water-limited environments (Gaur et al., 2008). Overhead sprinkler irrigation systems have been increasingly used in agriculture due to their potential advantages, such as uniform water distribution, reduced soil evaporation, and minimal water loss (Stambouli et al., 2012). However, the efficiency of overhead sprinkler irrigation systems in enhancing chickpea yield largely depends on the strategic scheduling of irrigation events, considering crop water requirements, soil moisture conditions, and climatic factors (Mall et al., 2009). Several studies have shown that appropriate irrigation scheduling can significantly increase chickpea yield and water use efficiency (WUE) by maintaining optimal soil moisture levels and avoiding water stress during critical growth stages (Gaur et al., 2008; Mall et al., 2009).

Recent advances in irrigation scheduling techniques, including soil moisture sensors, remote sensing, and crop simulation models, have provided valuable tools for optimizing irrigation management in chickpea production (Singh et al., 2018). Soil moisture sensors can provide real-time information on soil moisture status, enabling precise irrigation scheduling based on actual crop water requirements (Singh et al., 2018). Remote sensing techniques, such as satellite imagery and aerial photography, can estimate crop water requirements and monitor crop stress at a larger scale, facilitating the development of site-specific irrigation strategies (Moran et al., 2018). Crop simulation models, such as the Decision Support System for Agrotechnology Transfer (DSSAT), can predict crop growth, yield, and water requirements under different irrigation scenarios, assisting in the evaluation and selection of optimal irrigation strategies (Hoogenboom et al., 2012).

The objective of this article is to review the recent literature on maximizing chickpea yield through strategic irrigation scheduling under overhead sprinkler systems. The article will discuss the critical growth stages of chickpea in relation to water requirements, the role of irrigation scheduling in enhancing yield and WUE, and the recent advances in irrigation scheduling techniques for chickpea production. The article will also highlight the challenges and future research directions to further optimize irrigation management and improve chickpea yield under changing climate conditions.

MATERIALS AND METHODS

A field experiment entitled “Scheduling of irrigation at different growth stages of chickpea under overhead sprinkler” was conducted at Agricultural Research Station, Repoli during *Rabi* 2015-16, 2016-17, 2017-18 and 2018-19 to study the response of irrigation on growth, yield and quality of chickpea and estimate water requirement of chickpea in medium black soil. The experiment was laid out in randomised block design with 7 treatments and three replications. The treatment consist of Irrigation levels {I_1 : Irrigation scheduled at seedling

stage (20 DAS), **I_2**: Irrigation scheduled at flowering stage (40 DAS), **I_3**: Irrigation scheduled at grain filling stage (60 DAS), **I_4**: Irrigation scheduled at seedling and flowering stage (20 and 40 DAS), **I_5**: Irrigation scheduled at seedling and grain filling stage (20 and 60 DAS), **I_6**: Irrigation scheduled at flowering and grain filling stage (40 and 60 DAS) and **I_7**: Irrigation scheduled at seedling, flowering and grain filling stage(20,40 and 60 DAS)} with **I_0**: Control. The crop was sown with spacing 45 cm x 20 cm and seed rate 70 kg per ha. The FYM 5 tons/ha and recommended dose of fertilizer 25 kg N/ha, 50 kg P_2O_5 /ha and 50 kg K_2O/ha was
applied as a basal dose at the time of sowing. The depth of applied irrigation water was 50 mm. One common pre sowing irrigation was given to all treatments.

RESULTS AND DISCUSSION

Data presented in Table 1 revealed that day to 50 percent flowering, days to maturity and no. of grains plant^{-1} showed significant variation due to different irrigation scheduling. Number of grains plant^{-1} was significantly higher in treatment (I_4) irrigation scheduled at seedling and flowering stage (20 and 40 DAS) as compare to rest of the treatments and it was at par with irrigation scheduled at flowering stage (40 DAS). However, no. of grains pod^{-1} dose not differed significantly due to different irrigation scheduling. The similar results were reported by [2] and [3].

Data from Table 2 reveled that grain weight plant^{-1} (g) and no. of pods plant^{-1} was significantly higher in treatment (I_4) irrigation scheduled at seedling and flowering stage (20 and 40 DAS) and it was at par with irrigation scheduled at flowering stage (40
DAS). Grain yield (kg ha^{-1}) showed variation from 308.10 to 834.28 kg ha^{-1} in pooled data. The statistically significant grain yield (834.28 kg ha^{-1}) of chickpea was observed in the treatment (I_4) receiving Irrigation scheduled at seedling and flowering stage (20 & 40 DAS) over rest of the treatments. The lowest yield recorded in treatment (I_7) receiving Irrigation scheduled at seedling, flowering and grain filling stage (20, 40 and 60 DAS). The same finding also reported by [2] and [3].

Data from Table 3 indicate that, Irrigation scheduling at seedling and flowering stage proved to be significantly highest in grain yield of chickpea, where water use efficiency was 8.34 kg/ha-mm. The water use efficiency was highest when irrigation was scheduled at flowering stage (14.58 kg/ha-mm). Irrigation at grain filling stage could not produce significant effect on grain yield. The similar finding also reported by [2] and [3]. Irrigation at seedling and flowering stage could increase the yield by 78.07% over unirrigated chickpea, whereas only one irrigation at flowering stage yielded 55.65 % increase in grain yield as compare to unirrigated chickpea.

The maximum Total cost (Rs. 42474 ha^{-1}), Gross return (Rs. 43560 ha^{-1}), Net return (Rs. 1086 ha^{-1}) and BC ratio (1.03) recorded by treatment (I_4) irrigation scheduled at seedling and flowering stage (20 and 40 DAS).

From the four years data it can be concluded that irrigation scheduling at seedling and flowering stage proved to be significantly highest in grain yield of chickpea, where water use efficiency was 8.34 kg/ha-mm. The water use efficiency was highest when irrigation was
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Table 1: Effect of scheduling of irrigation on Days to 50 percent flowering, Days to maturity, No. of grains plant^{-1} and No. of grains pod^{-1} of chickpea

Treatments	Days to 50 percent flowering					Days to maturity					No. of grains plant^{-1}					No. of grains pod^{-1}				
	2016	2017	2018	2019	Pooled	2016	2017	2018	2019	Pooled	2016	2017	2018	2019	Pooled	2016	2017	2018	2019	Pooled
I_1 : Irrigation scheduled at seedling stage (20 DAS)	34.33	47.33	34.00	35.67	37.83	63.67	76.67	65.00	64.00	67.33	45.73	40.07	36.66	50.23	45.34	1.20	1.01	1.01	1.17	1.10
I_2: Irrigation scheduled at flowering stage (40 DAS)	41.00	50.67	41.33	41.67	43.67	69.00	78.67	68.67	68.33	71.17	57.10	72.53	61.33	60.10	63.24	1.27	1.10	1.03	1.27	1.17
I_3 : Irrigation scheduled at grain filling stage (60 DAS)	32.67	46.33	32.67	33.33	36.25	64.33	78.00	64.67	65.00	68.00	42.37	40.03	41.61	50.00	44.13	1.17	1.04	0.99	1.17	1.09
I_4 : Irrigation scheduled at seedling and flowering stage (20 & 40 DAS)	41.00	51.33	41.67	41.33	43.83	68.67	79.00	68.33	68.67	71.17	54.63	79.20	75.31	64.70	66.18	1.33	1.11	1.13	1.33	1.23
I_5 : Irrigation scheduled at seedling and grain filling stage (20 and 60 DAS)	37.67	47.67	37.67	38.67	40.42	63.00	73.00	63.00	63.33	65.58	30.87	28.80	40.07	43.50	34.39	1.17	1.01	1.00	1.17	1.09
I_6: Irrigation scheduled at flowering and grain filling stage (40 and 60 DAS)	39.67	50.67	40.00	39.67	42.50	68.67	79.67	68.33	69.33	71.50	48.40	60.07	56.37	48.60	52.36	1.13	1.07	1.00	1.13	1.08
I_7 : Irrigation scheduled at seedling, flowering and grain filling stage (20,40 & 60 DAS)	36.67	50.33	35.67	38.00	40.17	63.67	77.33	64.00	65.00	67.50	28.20	24.60	39.67	39.50	30.77	1.20	0.99	0.95	1.20	1.09
I_0 : Control	41.00	50.00	41.33	42.00	43.58	70.67	79.67	74.00	73.33	74.42	50.70	51.27	39.21	49.13	50.37	1.23	1.05	0.98	1.23	1.13
S Em±	0.62	1.14	0.95	0.52	0.53	0.57	1.48	1.24	0.70	0.50	3.81	3.63	2.45	3.53	1.98	0.07	0.05	0.05	0.08	0.05
C.D. at 5 %	1.89	NS	2.87	1.58	1.62	1.71	NS	3.78	2.12	1.50	11.58	11.01	7.43	10.71	6.02	NS	NS	NS	NS	NS

Table 2: Effect of scheduling of irrigation on Grain weight plant^{-1} (g), Number of pods plant^{-1} and Grain yield (kg ha^{-1}) of chickpea

Treatments	Grain weight plant^{-1} (g)					Number of pods plant^{-1}					Grain yield (kg ha^{-1})				
	2016	2017	2018	2019	Pooled	2016	2017	2018	2019	Pooled	2016	2017	2018	2019	Pooled
I_1 : Irrigation scheduled at seedling stage (20 DAS)	6.67	6.33	6.73	8.67	7.10	35.53	37.67	36.20	42.73	38.03	396.67	570.49	400.33	382.67	437.54

I_2: Irrigation scheduled at flowering stage (40 DAS)	9.67	10.93	9.07	9.93	9.90	39.00	69.60	58.20	47.60	53.60	608.00	1042.47	628.67	637.67	729.20
I_3 : Irrigation scheduled at grain filling stage (60 DAS)	6.13	6.80	7.80	9.67	7.60	37.40	42.53	42.17	42.13	41.06	397.67	687.53	426.67	414.00	481.47
I_4 : Irrigation scheduled at seedling and flowering stage (20 & 40 DAS)	11.27	11.87	11.07	9.67	10.97	45.33	69.67	66.77	48.47	57.56	673.00	1160.12	758.33	745.67	834.28
I_5 : Irrigation scheduled at seedling and grain filling stage (20 and 60 DAS)	6.60	5.00	6.07	8.00	6.42	28.13	34.78	39.67	37.13	34.93	313.33	593.09	343.33	375.00	406.19
I_6: Irrigation scheduled at flowering and grain filling stage (40 and 60 DAS)	9.40	9.53	7.10	8.73	8.69	38.73	57.33	56.10	42.67	48.71	586.33	794.81	528.67	408.33	579.54
I_7 : Irrigation scheduled at seedling, flowering and grain filling stage (20,40 & 60 DAS)	4.80	4.67	6.57	6.40	5.61	23.60	31.67	41.53	33.00	32.45	255.67	313.09	361.00	302.67	308.10
I_0 : Control	7.60	9.27	6.00	7.63	7.63	38.73	50.67	40.13	39.80	42.20	410.00	650.99	409.33	403.67	468.50
S Em±	0.67	0.58	1.01	0.53	0.40	2.68	3.43	5.32	2.44	2.03	36.65	58.73	41.59	35.89	21.30
C.D. at 5 %	2.03	1.76	3.07	1.60	1.22	8.14	10.41	16.13	7.40	6.16	111.18	178.15	126.15	108.85	64.61

Table 3: Effect of scheduling of irrigation on Percent increase in yield over control and Irrigation water use efficiency (kg/ha mm)

Treatments	**Grain yield (kg ha^{-1})**	**Percent increase in yield over control**	**Irrigation water use efficiency (kg/ha mm)**
I_1 : Irrigation scheduled at seedling stage (20 DAS)	437.54	-6.61	8.75
I_2: Irrigation scheduled at flowering stage (40 DAS)	729.20	55.65	14.58
I_3 : Irrigation scheduled at grain filling stage (60 DAS)	481.47	2.77	9.63
I_4 : Irrigation scheduled at seedling and flowering stage (20 & 40 DAS)	834.28	78.07	8.34
I_5 : Irrigation scheduled at seedling and grain filling stage (20 and 60 DAS)	406.19	-13.30	4.06
I_6: Irrigation scheduled at flowering and grain filling stage (40 and 60 DAS)	579.54	23.70	5.80
I_7 : Irrigation scheduled at seedling, flowering and grain filling stage (20,40 & 60 DAS)	308.10	-34.24	2.05
I_0 : Control	468.50		
S Em±	21.30		
C.D. at 5 %	64.61		

***water applied= 50 mm**

Table 4: Economics of chickpea in different treatment as affected by different scheduling of irrigation

Treatments	**Total cost (Rs ha^{-1})**	**Gross return (Rs ha^{-1})**	**Net return (Rs ha^{-1})**	**BC ratio**
I_1 : Irrigation scheduled at seedling stage (20 DAS)	37660	22810	-14850	0.60
I_2: Irrigation scheduled at flowering stage (40 DAS)	40203	38070	-2133	0.95
I_3 : Irrigation scheduled at grain filling stage (60 DAS)	38046	25130	-12916	0.66
I_4 : Irrigation scheduled at seedling and flowering stage (20 & 40 DAS)	42474	43560	1086	1.03
I_5 : Irrigation scheduled at seedling and grain filling stage (20 and 60 DAS)	38747	21200	-17547	0.55
I_6: Irrigation scheduled at flowering and grain filling stage (40 and 60 DAS)	40254	30240	-10014	0.75
I_7 : Irrigation scheduled at seedling, flowering and grain filling stage (20,40 & 60 DAS)	39252	16090	-23162	0.41
I_0 : Control	36577	24450	-12127	0.67
S Em±	-	-	-	-
C.D. at 5 %	-	-	-	-