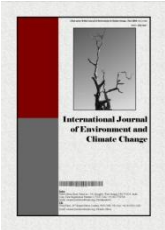

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Evaluating the Irrigation Regimes and Fertigation Schedule of Red Gram (Co (Rg) - 7) under Drip Irrigation System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Red gram occupies a unique position in Indian agriculture by constituting the regular protein supplier to the average Indian diet. Field experiments were carried out to evaluate the effect of different irrigation regimes of drip irrigation on red gram under two different of methods sowing viz., dibbling and transplanting condition during *Kharif* seasons of 2013 and 2014 at AICRP on Irrigation Water management Research block, Department of Agronomy, Agricultural College and Research Institute, Madurai. The experimental soil is clay loam in texture with low N, medium P and K content. The treatments consistst of drip irrigation at three pan evaporation ratios (40, 60 and 80 per cent PE) under two different methods of planting (dibbling and transplanting) with surface irrigation with conventional sowing and transplanting (Totally two) as a control. The study was laid out in

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Randomized Block Design (RBD) with thrice replication. The Recommended Dose Fertilizer (RDF) followed was 25:50:25 kg's NPK /ha and soil application of sulphur as basal @ 20 kg /ha was common to all the treatments. Fertigation was scheduled once in a week from 15 to 90 DAS. Seedlings were raised in protrays and Poly bag single: 6x4" (200μ) planted at 28 days (Second crop). The lateral spacing was followed was 1.5 m. The results revealed that conventional sowing (dippling) under drip irrigation with 60 percent PE and fertigation of recommended dose of fertilizer recorded significantly higher growth, yield attributes and yield. This treatment was on par with transplanting of red gram under drip irrigation at same irrigation level recommended dose of fertilizer. However, higher net income and B: C ratio was registered in conventional sowing under drip irrigation due to cost involved in raising nursery and transplanting. The conventional sowing under drip irrigation recorded water saving of 21 per cent and transplanting under irrigation recorded water saving of 36 per cent. The highest water use efficiency was observed in drip irrigation at 40 per cent PE level.

Keywords: Drip irrigation; pigeonpea; irrigation regimes; fertigation.

1. INTRODUCTION

Pigeon pea (*Cajanus cajan*) commonly known as red gram or tur is a very old crop of this country. After gram, red gram is the second most important pulse crop in the country. It is mainly eaten in the form of split pulse as 'dal'. Seeds of red gram contain about 21-28 percent protein, also rich in iron, iodine, essential amino acids like lycine, threonine, cystine and arginine etc.

India ranked first in area and production in the world with 79.65 per cent and 67.28 per cent of the world's acreage and production respectively. In productivity, Saint Vincent & Grenadines ranked first with 7926 kg/ha followed by Trinidad & Tobago and Malawi. The productivity of India was 587 kg/ha. India is the largest importer and producer where seed is sold as dhal.

Apart from its nutritive value, its soil rejuvenation qualities such as release of soil-bound phosphorus, fixation of atmospheric nitrogen, recycling of soil nutrients and addition of organic matter and other nutrients make pigeon pea as an ideal crop for sustainable agriculture in the tropical and subtropical regions of India [1].

In spite of importance of pulses in our daily diet and soil rejuvenation characters of pulse crop agricultural production, the production of pulses has not yet been increased proportionately as compared to increase in the cereal production. The average national productivity of pulses, at nearly 650 kg ha^{-1} is disappointingly low when the potential productivity is around 1.5 to 3 ton ha^{-1} in India Barik, [2]. The factors responsible for low productivity are unfavorable weather conditions, non-availability of quality seeds, improper sowing, inadequate intercultural operation, insufficient irrigation and inadequate use of fertilizers and plant protection chemicals, post-harvest techniques and socio economic constraints [3]. As water is a limiting and costly input, its judicious application needs special attention to maximizing pigeon pea yield per unit quantity of applied water [4]. The introduction of micro- irrigation systems like drip irrigation can help to bring more area under irrigation and improve the crop yield substantially [5].

Modern agriculture should ensure the required quantity of water with optimal rates of nutrients throughout the growth cycle in the most efficient manner and without degrading soil and water resources. This can be achieved through adoption of a drip fertigation system with higher water and fertilizer use efficiency. The main aim of this study was to Evaluate the Irrigation regimes and Fertigation Schedule of Red Gram (Co (Rg) - 7) under Drip Irrigation System.

2. MATERIALS AND METHODS

A field experiment was conducted under drip irrigation to evaluate the impact irrigation regimes and fertigation schedule on red gram at AICRP on Irrigation Water Management Research block, Department of Agronomy, Agricultural College and Research Institute, Madurai, during *Kharif* seasons of 2013 and 2014. The treatment consists of drip irrigation at three pan evaporation ratios (40, 60 and 80 per cent PE) under two different methods of planting (dibbling and transplanting) and surface irrigation with soil application of fertilizers (recommended dose) at 0.6 IW/ CPE ratio treated as a control. The experiment was laid out RBD with three replications. The variety used for the study was Co (RG) 7. Seedlings were grown in protrays

and twenty eight days seedlings were transplanted in the main field. Based on the results of the first experiment, one additional treatment, i.e. seedling grown in polybag (30 days) with surface application was included in the second experiment. The Recommended Fertilizer Dose (RDF) of 25:50:25 kg NPK/ha was followed. The entire P was applied as basal and the remaining N and K were applied through fertigation (Urea and white potash) in equal doses at weekly interval starting from 15 DAS and continued up to 90 days. Sulphur @ 20 kg/ha was applied to all the treatments as basal. Irrigation was given as per treatment based on pan evaporation. Surface irrigation was given at an IW/CPE ratio of 0.6. The lateral spacing of 1.5 m with double row (75 x 30 cm) geometry was adopted under drip irrigation and spacing of 45 x 30 cm was adopted in surface irrigation.

3. RESULTS AND DISCUSSION

3.1 Growth and Yield Attributes of Red Gram

The red gram is grown in rain-fed as well as irrigated condition. By adopting desirable production technologies with high resource use efficiency of water and nutrients, there is possible to bring more area under red gram cultivation with increased productivity (Table 1).

The method of irrigation and irrigation regimes had significant influence on growth and yield attributes of red gram during all the stages of observation in both the years of study. During the *kharif* season of 2013 (first experiment), maximum plant height of 154.2 cm was registered when red gram was transplanted under drip irrigation at 80 percent PE and fertigation of RDF (T_8) and this treatment was on par with conventional sowing under drip irrigation at 80 percent PE and fertigation of RDF (T_5) with a value of 146.5 cm. The lowest value of 108.6 cm was recorded in conventional sowing under surface irrigation at 0.6 IW/CPE ratio with soil application of RDF (T_1). Except plant height, highest value for all other parameters like Leaf Area Index (LAI) (4.21), No of branches plant^{-1} (9.7), No of pods plant^{-1}(224.4), test weight (11.7g) and grain yield (1430 Kg/ha) were registered when red gram was transplanted under drip irrigation at 60 per cent PE and fertigation of 100 per cent RDF (T_7). This treatment was on par with conventional sowing under drip irrigation at 60 percent PE and fertigation RDF(T_4) with LAI (4.08), No of branches plant^{-1}(9.4), No of pods plant^{-1}(219.4), test weight (11.3g) and grain yield (1400 Kg/ha) respectively. The lowest value of the all growth and yield parameters were recorded under conventional sowing and surface irrigation at 0.6 IW/CPE ratio with soil application of RDF (T_1).

In a second experiment (2014), the highest plant height of 158 cm was registered in conventional sowing under drip irrigation at 80 percent PE and fertigation of RDF (T_5) and this was comparable with when red gram was transplanted under drip irrigation at 80 percent PE and fertigation of RDF (T_8). The highest LAI of 4.47 was in highest in conventional sowing under drip irrigation at 80 percent PE and fertigation of RDF (T_5) and it was on par with conventional sowing under drip irrigation at 60 percent PE and fertigation of RDF (T_4). The yield attributing parameters viz., No of branch plant^{-1}(9.7), No of pods plant^{-1}(270), test weight (11.5g) and grain yield (1640 Kg/ha) was highest with conventional sowing under drip irrigation at 60 percent PE and fertigation of RDF (T_4). This treatment was comparable with transplanting of red gram under drip irrigation at 60 percent PE and fertigation of RDF (T_7), for number of branches plant^{-1}(9.3), test weight (11.2g) and grain yield (1600 Kg/ha) except for No of pods plant^{-1}(265) where Conventional sowing under drip irrigation at 80 percent PE and fertigation of RDF (T_5). The lowest value of growth and yield attributes of red gram registered in conventional sowing under surface irrigation at 0.6 IW/CPE ratio with soil application of RDF in both years of study.

Conventional sowing under drip irrigation at 60 percent PE and fertigation (25:25 kg NK/ha) of RDF was maximum growth and yield attributes red gram under drip irrigation system. When water was released in the root zone through drip irrigation maintains soil: air ratio at an optimum level for plant growth and development and maintains soil moisture to near to field capacity. This favourable physical condition with increased nutrient availability in the soil throughout the growing season ultimately resulted in higher growth and development. These findings are corroborated by findings of Rajendran et al. [5].

Under surface irrigation method where irrigation interval is longer (8-10 days) with fluctuations in soil moisture are relatively large as compared to high frequency (2 days interval) in drip irrigation [6] and this might have affected the crop growth and yield contributing characters resulting in reduced crop yields.

Table 1. Effect of different irrigation regimes and fertigation on growth characters and yield attributes of red gram

Treatments	2013						2014					
	Plant height (cm)	LAI	Number of branches plant	Number of pods / plant	Test weight (g)	Grain yield (kg/ha)	Plant height (cm)	LAI	Number of branches plant	Number of pods / plant	Test weight (g)	Grain yield (kg/ha)
T_1	108.6	3.41	7.9	166.2	8.8	1012	118.0	3.62	7.0	184	9.5	1205
T_2	126.5	3.54	8.1	172.8	9.1	1054	120.0	3.73	7.3	192	9.9	1170
T_3	129.6	3.71	8.8	188.2	10.5	1212	134.0	3.82	8.5	240	10.8	1420
T_4	140.4	4.08	9.4	219.4	11.3	1400	149.0	4.45	9.7	270	11.5	1640
T_5	146.5	3.62	8.4	179.4	10.2	1100	158.0	4.47	9.2	265	11.0	1520
T_6	132.5	3.98	9.1	200.1	10.7	1269	138.0	3.95	8.0	235	10.5	1385
T_7	145.5	4.21	9.7	224.4	11.7	1430	147.0	4.35	9.3	262	11.2	1600
T_8	154.2	3.81	8.7	191.5	10.4	1112	156.0	4.32	9.0	254	11.0	1475
T_9	-	-	-	-	-	-	125	3.81	7.6	210	10.1	1230
SEd	6.39	0.15	1.23	8.67	0.54	57.98	8.18	0.073	0.56	14.78	0.29	45.5
CD (P=0.05)	13.71	0.33	2.64	18.59	1.16	124.37	17.33	0.154	1.19	31.34	0.61	91.3

T1: Conventional sowing under surface irrigation at 0.6 IW/CPE ratio, T2: Transplanting under surface irrigation at 0.6 IW/CPE ratio, T3: Conventional sowing under drip irrigation at 40per cent PE, T4: Conventional sowing under drip irrigation at 60per cent PE, T5: Conventional sowing under drip irrigation at 80per cent PE, T6: Transplanting under drip irrigation at 40per cent PE, T7: Transplanting under drip irrigation at 60per cent PE , T8: Transplanting under drip irrigation at 80per cent PE , T9: Transplanting 30 days old seedlings grown in polybag and surface irrigation at 0.6 IW/CPE rati

Table 2. Water use efficiency of different irrigation regimes and fertigation of red gram

Treatments	2013				2014			
	IW (mm)	ER (mm)	Total water use (mm)	WUE (kg/ha/ mm)	IW (mm)	ER (mm)	Total water use (mm)	WUE (kg/ha/mm)
T_1	500	7	571	1.77	450	136	786	1.53
T_2	450	49	499	2.11	400	125	525	2.23
T_3	298	49	348	3.48	324	94	418	3.40
T_4	458	44	502	2.79	486	84	570	2.88
T_5	610	38	649	1.69	648	63	711	2.14
T_6	234	30	264	4.79	274	83	357	3.88
T_7	352	26	378	3.78	381	73	454	3.52
T_8	469	22	492	2.26	508	52	560	2.54
T_9	-	-	-	-	400	125	525	2.34

T1: Conventional sowing under surface irrigation at 0.6 IW/CPE ratio, T2: Transplanting under surface irrigation at 0.6 IW/CPE ratio, T3: Conventional sowing under drip irrigation at 40per cent PE, T4: Conventional sowing under drip irrigation at 60per cent PE, T5: Conventional sowing under drip irrigation at 80per cent PE, T6: Transplanting under drip irrigation at 40per cent PE, T7: Transplanting under drip irrigation at 60per cent PE , T8: Transplanting under drip irrigation at 80 percent PE , T9: Transplanting 30 days old seedlings grown in polybag and surface irrigation at 0.6 IW/CPE ratio

Table 3. Effect of different irrigation regimes and fertigation on economics of red gram

Treatments	2013				2014			
	Net income (Rs./ha)	B:C ratio	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs./ha)	B:C ratio	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)
T_1	24425	1.78	31235	55660	30150	1.87	32120	60250
T_2	24566	1.74	33404	57970	23500	1.67	35000	58500
T_3	29384	1.79	37276	66660	33000	1.86	38000	71000
T_4	39724	2.07	37276	77000	44000	2.15	38000	82000
T_5	23224	1.62	37276	60500	38000	2.00	38000	76000
T_6	30350	1.77	39445	69795	29500	1.74	39750	69250
T_7	39205	1.99	39445	78650	40250	2.01	39750	80000
T_8	21715	1.55	39445	61160	34000	1.85	39750	73750
T_9	-	-	-	-	26000	1.73	35500	61500

T1: Conventional sowing under surface irrigation at 0.6 IW/CPE ratio, T2: Transplanting under surface irrigation at 0.6 IW/CPE ratio, T3: Conventional sowing under drip irrigation at 40per cent PE, T4: Conventional sowing under drip irrigation at 60per cent PE, T5: Conventional sowing under drip irrigation at 80 percent PE, T6: Transplanting under drip irrigation at 40 percent PE, T7: Transplanting under drip irrigation at 60 percent PE , T8: Transplanting under drip irrigation at 80 percent PE , T9: Transplanting 30 days old seedlings grown in polybag and surface irrigation at 0.6 IW/CPE ratio

There is a positive correlation of N uptake with yield attributes and yield. Adequate uptake of N, P and K during the pod setting phase might have improved the pod development and the number of pods plant^{-1} and finally contributed for higher productivity. Increase in pod setting, could be attributed to the enhanced activity of auxin that might have activated the carbohydrate metabolism and mediated activities of all sucrose mobilizing enzymes, thus helped in translocation of photosynthates to developing pods [7]. The highest yield was mainly due to adequate moisture supply throughout the crop growth period, which resulted in better growth and yield attributing characters. These findings are in conformity with the findings of Prasad and Yadav [8], Tomar et al. [9], Dhabi et al. [10], and Gami and Thanki [11].

The highest water use efficiency was observed in the transplanting of red gram under drip irrigation at 40per cent PE (T_6) with a value of 4.79 and 3.88 kg ha mm^{-1} of first and second crop respectively (Table 2). The next best treatment was transplanting of red gram under drip irrigation at 60 per cent PE ($T_{7)}$ which

recorded 3.78 and 3.52 kg ha mm^{-1} for first and second crop respectively. This treatment recorded lesser water usage of 416 mm and water saving of 236 mm (36 per cent) compared to surface irrigation. This was due to reduced duration as a result of transplanting compared to conventional sowing under drip irrigation at same irrigation and fertigation level (T_4) which recorded water use efficiency of 2.79 and 2.88 kg ha mm^{-1} respectively for first and second crop respectively. Conventional sowing under drip irrigation at 60 per cent PE registered 143 mm (21 percent) water saving compared to surface irrigation. The transplanting of red gram under drip irrigation resulted in water saving of 120 mm when compared to conventional sowing under drip irrigation. These results are in accordance with findings of Velayutham and Chandrasekaran [12], Duraisamy and Manickasundaram [13], and Ravi Kumar et al. [14]. The highest water usage of 679 mm and lowest water use efficiency of 1.65 kg ha mm^{-1} was recorded in surface irrigation with soil application fertilizer.

The economics of red gram were influenced by method of irrigation and irrigation regimes (Table 3). The conventional sowing under drip irrigation recorded lesser cost of cultivation compared to transplanting under same method of irrigation level due to increased cost involved in transplanting. As a result, conventional sowing under drip irrigation at 60 per cent PE and fertigation of 100 per cent RDF recorded highest net income (Rs. 39724 and 44000) and B:C ratio (2.07 and 2.15).The next best treatment was transplanting of red gram under drip irrigation at same irrigation with recommended dose of fertilizer. The transplanting of red gram under drip irrigation resulted in water saving of 120 mm even though there was reduced income of Rs 500/ha compared conventional sowing. These findings are in conformity with findings of Mahalakshmi et al. [15]. The conventional sowing under surface irrigation at 0.6 IW/CPE ratio with soil application of RDF recorded lowest economic advantage with lesser cost of cultivation.

4. CONCLUSION

Drip irrigation is an innovative technology for maximizing the yield of red gram and fertilizer application through irrigation helps in maximizing the yield. Though the cost of cultivation is high, it was equalized by higher gross and net return obtained from higher grain yield with considerable water saving of 143 mm (21 percent) under conventional sowing and 236 mm (36 percent) under transplanting. Transplanting of red gram under drip irrigation registered water saving of 120 mm compared to conventional sowing under drip irrigation. Hence, it is advocated to adopt sowing/transplanting of red gram under drip irrigation at 60 per cent irrigation level along with fertigation of recommended dose of fertilizer (25: 50: 25 Kgs N, P & K) in equal splits once in a week from 15 to 90 days after sowing/planting can be followed to get higher yield and income with considerable water saving.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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