Original Research Article

Effect of Drip Irrigation and Inter Cropping Systems in Maize

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ABSTRACT

Aims: The main aim of the study is to reduce the irrigation quantity for maize and intercrop adds extra value to the sole crop by generating additional income to the farmers.
Study design: Factorial Randomised Block Design (FRBD).
Place and Duration of Study: Eastern block farm, Tamil Nadu Agricultural University, Coimbatore during summer *and Kharif* 2021.
Methodology: Maize as a sole crop and inter crop was grown under drip and flooded conditions. To quantify the irrigation with different set of irrigation as treatments (75% PE, 100% PE and 125% PE) was followed. Irrigation under flooded conditions was quantified using parshall flume. Different inter crops like Lab Lab, Green gram, Black Gram and Cow pea was raised within the rows of maize. The duration of inter crops was less than 60 days than that of maize.
Results: During its peak cob formation stage (61-90 days), the quantity of water applied to the plant was higher with 125 % PE (205858.8 l/day) followed by 100% PE (123515.3 l/day) and 75 % PE (164687.1 l/day). The higher plant height was observed with 280.5 cm in Maize + Lab Lab followed by black gram, green gram and cowpea. Irrigation level varied significantly with 100% open pan evaporation on plant growth (254.8 cm) followed by 75% open pan evaporation. Interaction effect was significant in Maize + Lab Lab cropping system alone, irrespective of the irrigation treatments (75, 100, 125 % PE and flooding).
Conclusion: Water requirement with the month and stage wise during the crop growth clearly indicates that the minimum amount of water is required for the crop growth and development.

Keywords: Drip irrigation, Open Pan evaporation, Effective rainfall, Parshall flume

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1. INTRODUCTION

Maize is a fodder as well as food crop grown all over the world in Latin America, Asia, America, China etc., In terms of maize output, The United States of America (USA), which accounts for 35.9% of global production (Global corn production, 2017-2018). When compared to China and the rest of the world (5.1–5.5 t/ha), the United States has the highest maize yield (> 9.6 t/ha) with a productivity of 5.26 t/ha [13]. Maize is India's third most important food crop, after rice and wheat. India ranks fourth in terms of area and seventh in terms of production among maize-growing countries, accounting for roughly 4% of global maize area and 2% of total production. In 2018-19, India's maize area increased to 9.2 million hectares [4].

Kharif maize accounts for approximately 83% of India's maize land, while *Rabi* maize accounts for only 17 percent. Over 70% of *Kharif* maize land is rainfed, with many biotic and abiotic stresses prevalent [7]. Maize cultivated under rainfed circumstances, despite the use of flood irrigation. Irrigation demand uncertainty grew from 2020 to 2039 to 2060–2079, with corn and soybean demand generally declining over time. Corn yields are lowered as a result of rising temperatures and a shift in peak irrigation [15]. Climate change is a major contributor to climate variability and water scarcity, which resulted in a decrease of maize production [1]. Water supply expansion for varied development needs frequently has two repercussions.

The first step is to reduce water usage through a variety of programmes that employ cutting-edge water-saving technology, such as water-saving irrigation techniques. Incentives and disincentives can also be used to reduce water use, such as providing water price reductions to commercial water users whose water demands are met by direct rainwater [3]. Water saving technology like micro irrigation is an appropriate tool for irrigation and crop water reduction to meet the water demand of irrigation for the crops [12]. Drip irrigation is a way of delivering water directly to the soil in the root areas of plants, reducing common mishaps such as soil erosion, deep percolation, and runoff. The best crop coefficient irrigation method is to schedule water with open pan evaporation under drip irrigation [12].

2. MATERIAL AND METHODS

Experiment was carried out at eastern block farm (field no. 75) of Tamil Nadu agricultural university, Coimbatore. The field was ploughed with fine tilth using cultivator followed by rotavator. The broad bed furrow (bbf) was formed with 90 cm bed and 30 cm furrow size by tractor drawn implement (bb former). Drip was laid out in the field with lateral diameter of 16 mm, lateral spacing of 1.2 m, emitter distance of 0.4 m with emitter capacity of 4 lph. In between the rows of maize, different inter crops were grown, including lab lab Co (Gb) 14, black gram (Co-7), green gram (Co-7), and cowpea Co (cp) 7. Intercrops like pulses are cultivated with inter row spacing of 30 x 10 cm and maize with intra row spacing of 60 x 25 cm. date of sowing for maize based inter cropping was sown on 20/03/2021 and date of harvest for intercrops varied at different dates based on its maturity. Maize was harvested on 07/07/2021. the Factorial Randomised block Design (FRBD) was utilized in this study to conduct the experiment. the intercropping system was used as the first component (a), and the second factor (b) was used with different irrigation treatments, including DI at 125 PE, DI at 100 PE, DI at 75 PE and conventional furrow irrigation. Three replications was randomized as per the treatments. gross plot area per plot was 5 x 3.6 m. since, the furrow size was 0.3 m for each bed. irrigation was done once in every three days. Irrigation was measured from the vegetative stage to till the plant reached its maturity. rainfall, open pan evaporation, crop coefficient, and number of plants/m^2 were also used to calculate irrigation for drip-irrigated plots. a bed can have up to 83 plants in total length of 25 m i.e., (83 plants x 45 beds) = 3735 plants in total; 1245 plants/treatments for 40 cents of net plot area. The plant population count is useful for water quantification for the plant needs on each day. During summer 2021, the crop was grown. The plant was varied based on irrigation levels. The total number of emitters was determined by multiplying the bed length by the distance between the two emitters. Each emitter could provide 4 lph of irrigated water; this factor was multiplied by the total number of emitters, and irrigation volume was converted to each set of irrigation treatments. In the instance of open pan evaporation, irrigation volume increased as the number of pan evaporation rate increases is given in eqn. (1).

Water requirement = Pe x Kp x Kc x WP x a – Re (1)

Factors: Kp – 0.7; WP – 0.8 (80 %); Area = 0.6 x 0.25 = 0.15

Pe	– Pan evaporation rate (mm/day)
Kp	– Crop Coefficient
Kc	– Crop Coefficient
WP	– Wetting percentage
A	– Area in m^2
Re	– Effective rainfall

Kc values for Drip irrigated Maize

Stages	Duration in days	Ratio
Initial	0-30 days	0.69
Crop development	31-60 days	1.20
Mid-season	61-90 days	1.23
Late season	91-110 days	0.79

Mean while, irrigation was assessed using a parshall flume under typical furrow irrigation. Parshall flume, a water flow metering device; has converging inlet and diverging outlet. This flume is placed at the displacement at the surface of the ground, where the irrigation flows using 2 inch poly vinyl chloride pipe. The irrigation quantity was comparatively higher than drip irrigation. Since, the flow rate is higher than the drippers. The quantity to determine the irrigation depends on the throat width of the flume. 6 inch throat was used in this study for quantification. This quantity of irrigation was calculated using parshall flume calculator using online programme *i.e.,* irrigation in the Pacific [8] Northwest (2) . The equation for determining the irrigation in the partial flume is

$$Q = 2.06Ha^{1.58} \qquad (2)$$

Where,

Q = Flow Rate in cfs,
Ha = Height in feet

3. RESULTS AND DISCUSSION

3.1. Irrigation for the month wise during Summer 2021

The data on different irrigation quantity was given in Table 1. During the cropping season, with the total average evaporation of 33.7 mm, 3.4 mm of rainfall and 2.1 mm of effective rainfall; the highest evaporation (7.5 mm) was recorded during March followed by 6.6 mm in April, June and July. The water requirement during the May recorded higher with 15716.9 l/day for 75 % PE. During June recorded the higher water requirement of 15010.5 l/day for 100 % PE and 18763.1 l/day for 125 % PE followed by May and April. In 125 percent PE, watering the field took 5.2 hours in May and 4.2 hours in June. All other treatments ran faster when drippers were employed for irrigation. This could be due to seasonal factors such as the need for longer irrigation times during the summer, resulting in a larger irrigation quantity required for plant growth and development [10].

Table 1. Month wise irrigation quantity during *Summer* 2021

Month	Evp.	RF	Effective RF.	Water requirement l/day (once in 3 days)			Time requirement (Hrs.)		
				75%PE	100%PE	125%PE	75%PE	100%PE	125%PE
Mar.	7.5	0.0	0.0	8136.1	10848.1	13560.1	2.2	2.9	3.6
Apr.	6.6	1.1	0.7	8573.3	11431.2	14288.9	2.3	3.1	3.8
May	6.4	0.8	0.5	15716.9	11787.7	19646.1	3.1	4.2	5.2
Jun.	6.6	0.5	0.3	11257.9	15010.5	18763.1	2.9	3.8	4.8

Jul.	6.6	1.0	0.6	8233.5	10977.9	13722.4	2.2	3.0	3.7
Total	**33.7**	**3.4**	**2.1**	**59698.9**	**44774.1**	**74623.4**	**17**	**12.7**	**21.1**

3.2. Irrigation at phenological stages of crop growth

The average water requirement for the different phenological stages of crop growth is given in Table 2. The initial stage of germination requires lesser water followed by tasseling and silking stage (31-60), in the order of 125% PE>100% PE>75% PE. Similarly, during the harvesting stage (91-110), the irrigation requirement for the crop is lesser than vegetative stage (Farooq *et al.,* 2009). During its peak cob formation stage (61-90 days), the quantity of water applied to the plant was higher with 125 % PE (205858.8 l/day) followed by 100% PE (123515.3 l/day) and 75 % PE (164687.1 l/day). The reason behind the uptake of water by the maize is because of higher plant metabolism during its initial phase of establishment and plant cellular uptake decreases progressively to its harvesting stage [2].

Table 2. Quantity of irrigation at phonological stages of crop growth during *Summer* 2021

Phenological stages of crop growth	Water requirement in treatment and stage wise (l/day)		
	100% PE	**75 % PE**	**125 % PE**
0-30 days	102096.2	76572.2	127620.3
31-60 days	149635.6	93262.7	155437.9
61-90 days	164687.1	123515.3	205858.8
91-110 days	63450.8	39117.1	65195.2
Total	**479869.7**	**332467.3**	**554112.2**

3.3. Irrigation for the flooded conditions during summer 2021

The data on irrigation for flooding during *Summer* is prescribed in Table 3. The hours of operation of the values to irrigate the flooded plots was peak during the first three days of irrigation (1^{st}, 4^{th}, 7^{th} day), as it requires life irrigation and it takes time to wet the top and below the surface of the soil [11]. Successive irrigation other than life irrigation requires lesser amount because of saturation of soil. Regardless of the inter cropping system, 66th day seems lesser irrigation due to heavier rainfall (22 mm) than the preceding days of irrigation. In the soil, adequate soil moisture retention prevails and ensures that the soil is never fully dry [6].

Table 3. Irrigation quantity for flooding during *Summer* 2021

Day of irrigation	Hrs. of irrigation	Amount of irrigation (*9.6 lps)	Day of irrigation	Hrs. of irrigation	Amount of irrigation (*9.6 lps)
1	6.0 hr	207360	49	4.2 hr	145152
4	6.0 hr	207360	53	4.5 hr	155520
7	6.0 hr	207360	60	3.0 hr	103680
11	5.5 hr	190080	66	2.0 hr	69120
15	5.8 hr	200448	73	3.5 hr	120960

19	5.6 hr	193536	78	3.9 hr	134784
23	5.9 hr	203904	84	3.3 hr	114048
27	5.5 hr	190080	91	3.2 hr	110592
31	4.0 hr	138240	96	3.1 hr	107136
40	3.8 hr	131328	102	3.3 hr	114048
45	4.0 hr	138240			

3.4. Effect of plant height on maize based intercropping system at different irrigation levels

The increase in plant height was noticed at various stages of crop development, as shown in Table 4. Maize + Lab Lab cropping had the maximum plant height (63.5 cm) at 30 DAS, followed by Maize + Black gram cropping system. Plant height was much lower in all other treatments. The irrigation levels and their interaction effects obtained non-significant results on plant height. At 60 DAS, except the irrigation levels, all other treatment showed significant results on plant growth. The Maize + Lab Lab cropping method produced the most increased plant height, followed by black gram, green gram, and cowpea. Maize solo cropping resulted in shorter plants. Irrigation levels had no peculiar effect on crop growth. Interaction effects on intercropping and irrigation levels were significant, with a maximum plant height of 183.1 cm in the Maize + Lab Lab cropping system on 75 percent open pan evaporation, which is comparable to 100 percent open pan evaporation in maize based intercropping on cow pea and green gram. Maturity stage had a significant relation on plant growth at 90 DAS, The higher plant height was observed with 280.5 cm in Maize + Lab Lab followed by black gram, green gram and cowpea. Irrigation level varied significantly with 100% open pan evaporation on plant growth (254.8 cm) followed by 75% open pan evaporation. Interaction effect was significant in Maize + Lab Lab cropping system alone, irrespective of the irrigation treatments (75, 100, 125 % PE and flooding). Lesser plant height may be due to the stress and excessive irrigation during the growth phases and development and optimized plant height was noticed due to its optimum soil moisture and nutrient uptake by the roots [2].

Table 4. Effect of maize based intercropping system on plant height of maize during *Summer* 2021

	30 DAS					60 DAS					90 DAS				
	D_1	**D_2**	**D_3**	**D_4**	**Mean**	**D_1**	**D_2**	**D_3**	**D_4**	**Mean**	**D_1**	**D_2**	**D_3**	**D_4**	**Mean**
T_1	60.7	66.7	71.1	55.7	**63.5**	183.1	139.9	139.3	163.5	**156.5**	281.1	286.2	276.5	278.1	**280.5**
T_2	55.0	61.6	65.3	49.3	**57.9**	148.8	159.9	135.7	159.0	**150.9**	270.7	251.2	238.3	265.1	**256.3**
T_3	50.7	62.9	61.1	45.7	**55.1**	141.5	168.0	159.1	148.2	**154.2**	247.4	253.4	226.8	214.0	**235.4**
T_4	50.3	62.6	61.0	43.3	**54.7**	151.0	168.2	156.2	144.7	**155.0**	214.8	225.4	234.3	236.0	**227.6**
T_5	49.1	60.3	59.0	44.0	**52.9**	134.3	134.3	138.8	128.0	**133.8**	246.5	257.8	242.8	203.9	**237.7**
Mean	**53.2**	**62.9**	**63.3**	**48.1**		**151.7**	**154.1**	**145.8**	**148.7**		**252.1**	**254.8**	**243.7**	**239.4**	
	T	**D**	**TXD**			**T**	**D**	**TXD**			**T**	**D**	**TXD**		

SEd	5.7	5.1	11.4	5.6	5.0	11.3	2.5	2.2	5.0
CD	11.5	NS	NS	11.4	NS	22.8	5.0	4.4	10.0

T1 - Maize + Lab Lab; T2 - Maize + Black gram; T3 - Maize + Green gram; T4 - Maize + Cowpea; T5 - Maize sole crop D_1 –75% PE; D_2 –100% PE; D_3 –125% PE; D_4 – Irrigation by flooding, NS - Non-Significant; DAS - Days after sowing

3.5. Effect of plant height on maize based intercropping system on intercrops at different irrigation levels

Irrigation levels and intercropping cropping system on maize had significant relationship on crop growth (Table 5). Lab Lab cropping system registered the higher plant height due to its genetic character [9]. At 30 DAS, the lower plant height was observed in Maize + Green gram cropping system (19.3 cm). Interaction effects had non significant results on crop growth. At 60 DAS, 100 % PE had a maximum plant growth of 50.9 cm which is on par with 125 % PE (48.5 cm). Significant result between the inter cropping systems and irrigation levels was noticed by registering its greatest height of 67.9 cm in 125 % PE of Lab Lab cropping system. At harvest, Lab lab (99.5 cm) followed by black gram had higher plant height. Irrigation levels on 100 % PE observed higher plant height of 73.7 cm followed by 75% PE, 125 % PE and flooding. Significant results on interaction effect were observed with maximum plant on 100 % PE in Maize + Lab Lab cropping system (102.9 cm). Remaining all other treatment combination, recorded the reduced plant height (cm).

Table 5. Effect of maize based intercropping system on plant height of intercrops during *Summer* 2021

	30 DAS					**45 DAS**					**At Harvest**				
	D_1	**D_2**	**D_3**	**D_4**	**Mean**	**D_1**	**D_2**	**D_3**	**D_4**	**Mean**	**D_1**	**D_2**	**D_3**	**D_4**	**Mean**
T_1	38.2	40.4	38.5	33.2	**37.6**	54.4	63.2	56.3	67.9	**60.4**	100.2	102.9	98.1	97.0	**99.5**
T_2	23.5	25.1	25.0	22.4	**24.0**	47.9	48.4	42.1	33.4	**42.9**	68.7	69.5	60.4	63.6	**65.6**
T_3	17.4	21.2	18.7	20.0	**19.3**	31.2	46.5	42.9	28.2	**37.2**	48.4	52.0	43.6	43.6	**46.9**
T_4	24.8	25.5	26.4	22.5	**24.8**	47.2	45.7	52.7	41.8	**46.8**	65.8	70.4	61.4	59.2	**64.2**
Mean	**26.0**	**28.1**	**27.1**	**24.5**		**45.1**	**50.9**	**48.5**	**42.8**		**70.8**	**73.7**	**65.9**	**65.9**	
	T	**D**	**TXD**			**T**	**D**	**TXD**			**T**	**D**	**TXD**		
SEd	1.1	1.0	2.2			2.1	1.8	4.2			0.4	0.4	0.8		
CD	2.3	2.0	NS			4.2	3.8	8.5			0.8	0.7	1.7		

T1 - Maize + Lab Lab; T2 - Maize + Black gram; T3 - Maize + Green gram; T4 - Maize + Cowpea; T5 - Maize sole crop D_1 –75% PE; D_2 –100% PE; D_3 –125% PE; D_4 – Irrigation by flooding, NS - Non-Significant; DAS - Days after sowing

4. CONCLUSION

Water is the major constraints of agriculture and food production. The water productivity of a crop and demand of water goes on increasing trend with the present climate. Under future climate, cultivation of crop under flooded conditions is difficult and drip irrigation is the best suitable tool for increasing productivity. Intercrop in maize with various pulses based cropping system adds value by adding soil nutrients to the sole crops and control weeds.

With the present study it could be concluded that minimum amount of irrigation is adequate for crop growth and development.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

Term: RF – Rainfall; Evp – Evaporation; lph – litres per hour