Original Research Article

INFLUENECE OF DIFFERENT IRRIGATION SCENARIO'S UNDER MULCHED AND NON-MULCHED CONDITION ON SOIL MOISTURE, YIELD AND WUE OF RIDGE GOURD (*Luffa acutangula*, L.)

ABSTRACT

A field experiment was conducted on Ridge gourd during rabi season of 2021-22 and 2022-23 at the Experimental Research Plot Soil and Water Engineering, CAE, Raichur. The study aimed to assess the efficacy of a sensor and evapotranspiration based irrigation system in varying irrigation levels, comparing the performance between mulched and non-mulched conditions. The use of sensor-based irrigation at 100% field capacity under mulched has shown positive outcomes, leading to a notable enhancement in crop production by about 9.40% additionally, this approach has resulted in a significant conservation of irrigation water, with savings of approximately 12.35% compared to the treatment involving irrigation at 100% evapotranspiration under mulched, but without the use of sensors. Across the treatments, the water application efficiency ranged from 94.13 to 91.37%. The highest water use efficiency was observed in the treatment with irrigation at 100% FC under mulched condition on pooled basis (0.20 t ha^{-1} mm^{-1}). The sensor based drip irrigation system under mulched is an economically viable option to be recommended among farmers in arid and semi-arid climate. Despite the higher initial setup costs, farmers can achieve significant cost savings in the long run due to lower water usage, better yields, and minimised labour requirements.

Key words: Sensor, Evapotranspiration, Field capacity, Irrigation and Yield

1. INTRODUCTION

In India, where 60-70% economy depends on agriculture, there is a great need to modernize the conventional agricultural practices for the better productivity. Due to unplanned use of water, the ground water level is decreasing day by day [1]. The most important factor for the agriculture is timely and ample supply of water. But due to uncertain rainfall and water scarcity in land reservoirs, we are not able to make proper use of agricultural resources and also unplanned used of water results in to wasting of water on large proportion. With the increase in agricultural activity and competitive demand from different sectors, it has become important to economize on the use of water. We can optimize use of water by adopting sensor base irrigation system.

Irrigation plays a pivotal role in modern agriculture, significantly impacting soil moisture levels, water use efficiency and ultimately crop yields. The management of irrigation scenarios, including timing, frequency and volume, has emerged as a critical concern for farmers and researchers alike. This comprehensive study delves into the multifaceted relationship between irrigation scenarios and their outcomes in agriculture. The availability of water resources, climate variability and the increasing global demand for food necessitate a nuanced examination of irrigation strategies. As we explore the effect of irrigation scenarios on soil moisture, water use efficiency and crop yield, which aims to shed light on the optimal approaches for ensuring agricultural sustainability, productivity and resilience in a changing world. Through irrigation management, various irrigation scheduling techniques have been developed such as water balance method, soil water content or soil water potential, plant stress monitoring, computer models and charts to increase irrigation water use efficiency [2-3]. Combination of different irrigation scheduling methods has been practiced and endorsed as a means of optimizing irrigation scheduling of crops and preventing water wastage [4-5]. The purpose of the present study is to investigate the effect of different irrigation scenarios under mulched and non-mulched conditions in semi-arid region of ridge gourd.

2. MATERIAL AND METHODS

The field trials were conducted at the Experimental Research Plot, Department of Soil and Water Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur located at 16^0 12′ 8.34″ N latitude and 77^0 19′ 49.47″ E longitude with an elevation of 394 m above mean sea level (MSL). Irrigation water was used from a tube well which was 93.0 m deep and pumped water was stored in farm pond.

2.1 Experimental Setup

The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. The experiment consisted of eight treatments in each replication and it was replicated thrice as mentioned under Table 1.

2.2 Field observations

The field observations comprised of recording soil moisture and yield parameter. Soil samples were collected at pre-scheduled timings for the estimation of available nitrogen, phosphorus and potassium.

2.2.1 Soil moisture

Soil samples were collected at 5, 10 and 20 cm depth from drip irrigated ridge gourd plot of different treatments to know the effect of different irrigation scenario's under mulched and non-mulched conditions on soil moisture content. The samples were then dried inside the hot air oven at 105°C for 36 hr for the determination of soil moisture. The measurements were repeated for 30 days interval after sowing.

2.2.2 Crop yield (t ha^{-1})

The fruit yield per hectare was worked out based on the fruit weight per net plot and expressed in tons per hectare.

2.3 Efficiency parameter

2.3.1 Application efficiency of irrigation

Equation (1) is used for the estimation of application efficiency of drip irrigation system:

$$e_a = \frac{e \times q_{min} \times T}{V} \times 100 \qquad \ldots 1$$

Where,

e_a=Application efficiency, %

e=Total number of emitters

q_{min}= Minimum emitter flow rate, lhr^{-1}

T=Total duration of irrigation, hr

V=Total volume of water applied, l.

2.3.2 Water use efficiency (WUE)

The WUE of each treatment was estimated by equation 2 [6] in kg ha^{-1} mm^{-1}.

$$\text{Water use efficiency (WUE)} = \frac{\text{Total crop yield (kg ha}^{-1}\text{)}}{\text{Total amount of water applied (mm)}} \qquad \dots 2$$

Table 1. The treatment and crop details of the experimental setup

Treatment Details	Crop Details
T_1 : SDIS under mulched condition water application at 100% field capacity level	**Crop:** Ridge gourd (*Luffa acutangula*, L.)
T_2 : SDIS under non-mulched condition water application at 100% field capacity level	**Variety:** Naga F_1
T_3 : SDIS under mulched condition water application at 80% field capacity level	**Spacing:** 120×90 cm
T_4 : SDIS under non-mulched condition water application at 80% field capacity level	**Season:** *Rabi* 2021-22 and 2022-23
T_5 : Surface drip irrigation under mulch condition water application at 100% ET level	**Location:** Experimental plots, SWE, CAE, Raichur
T_6 : Surface drip irrigation under non-mulched condition water application at 100% ET level	
T_7 : Surface drip irrigation under mulched condition water application at 80% ET level	
T_8 : Surface drip irrigation under non-mulched condition water application at 80% ET level	
SDIS : Sensor based drip irrigation system, ET : Evapotranspiration	

3. RESULTS AND DISCUSSION

3.1 Characterization of Soil

The soil in the experiment site belongs to sandy clay texture at 0-40 cm depth. The basic infiltration rate of 1.47 cm h^{-1} was recorded. The inverse auger hole experiment showed hydraulic conductivities of 11.31 and 2.72 cm d^{-1} at 0-20 and 20-40 cm soil depths, respectively. The available of nitrogen, phosphorus and potassium in the soil at depths of 0-20 cm and 20-40 cm were measured. The available of nitrogen, phosphorus and potassium in the soil were recorded as 106.47, 15.54, and 253.26 kg ha^{-1}, respectively, at the topmost layer. In the subsequent layers, the concentrations were found to be 97.74, 10.67 and 296.17 kg ha^{-1} at 30-40 cm depth, respectively.

3.2 Soil moisture

Soil moisture was significantly influenced by the different irrigation scenarios under mulched and non-mulched conditions of ridge gourd during different crop growth stages at 5, 10 and 20 cm depth of soil. The pooled data of soil moisture content was represented in the Table 2.

Irrigation scenario's under mulched and non-mulched conditions influenced the soil moisture at 5 cm depth of the soil significantly during the course of crop development. Among all the treatments, irrigation at 100% ET under mulched condition has recorded higher soil moisture at surface of soil *i.e.,* 22.98, 23.06, 23.53 and 22.66% at 30, 60, 90 and 103 DAS followed by irrigation at 100% ET under non-mulched condition and the lowest soil temperature was recorded in the treatment response to irrigation at 80% FC under non-mulched condition *i.e.,* 16.49, 16.75, 17.05 and 16.07% at 30, 60, 90 and 103 DAS.

At 10 cm the soil moisture got raised by 0.24-0.59, 0.32-1.45, 0.46-1.17 and 0.25-0.98% at 30, 60, 90 and 103 DAS across all the treatments respectively (Table 2). The maximum soil moisture fluctuation found in the treatments irrigation under non-mulched condition *i.e.*, T_2, T_4, T_6 and T_8 compared to the treatments irrigation under mulched condition *i.e.*, T_1, T_3, T_5 and T_7 treatment.

The lower depths maintained higher soil moisture than the surface in all the treatments at 20 cm, the transfer of heat from surface to sub surface soil might be the reason. The drop in soil moisture at 10 and 20 cm were lesser compared to drop at 5 cm. The soil moisture at 5cm depth is lower compared to 10 cm depth under different treatments. At the same time soil moisture has been found maximum under the treatment pertaining to irrigation with mulched conditions when compared to treatment pertaining to irrigation under non-mulched conditions. A higher loss of soil moisture may have occurred in the treatments including irrigation under non-mulched i.e., T_2, T_4, T_6 and T_8 due to increased soil evaporative loss and root water absorption from upper soil layers compared to the treatments irrigation under mulched condition *i.e.*, T_1, T_3, T_5 and T_7 treatment. The similar results are obtained by few researchers [7-9].

Table 2. Soil moisture (%) as influenced by different irrigation scenarios under mulched and non-mulched condition during different growth stages of ridge gourd

Treatment details	Soil depth											
	5 cm				10cm				20 cm			
	30 DAS	60 DAS	90 DAS	103 DAS	30 DAS	60 DAS	90 DAS	103 DAS	30 DAS	60 DAS	90 DAS	103 DAS
T_1	21.29	21.41	22.22	20.52	21.87	22.25	22.73	21.50	22.63	22.25	23.38	22.52
T_2	19.96	20.22	20.77	19.44	20.55	21.43	21.74	20.07	21.83	21.42	22.66	21.71
T_3	17.68	17.99	17.83	17.23	18.16	18.96	18.73	17.67	18.40	19.42	19.62	18.12
T_4	16.49	16.75	17.05	16.07	17.29	18.20	18.22	16.86	18.04	18.99	19.15	17.77
T_5	22.98	23.04	23.53	22.66	23.23	23.36	23.99	23.07	23.45	23.66	24.25	23.30
T_6	21.70	21.83	22.23	21.36	22.29	22.57	23.14	22.15	22.98	22.69	23.85	22.87
T_7	19.16	19.44	20.00	18.59	19.40	20.22	20.62	18.84	20.10	20.70	21.55	19.50
T_8	17.98	18.48	18.86	17.71	18.38	19.26	19.75	18.01	19.13	20.04	20.86	18.71
S.Em±	**0.70**	**0.71**	**0.83**	**0.72**	**0.85**	**0.74**	**0.75**	**0.80**	**0.81**	**0.80**	**0.78**	**0.75**
C. D. @ 5%	**2.13**	**2.15**	**2.52**	**2.19**	**2.59**	**2.24**	**2.27**	**2.42**	**2.46**	**2.42**	**2.37**	**2.26**

3.3 Crop Yield

The data recorded on crop yield per hectare in ridge gourd as influenced by different irrigation scenarios under mulched and non-mulched conditions is presented in Table 3.

Crop yield per hectare was significantly higher in the treatment pertaining to irrigation at 100% FC under mulched condition (T_1) on pooled basis (45.49 kg ha^{-1}) followed by treatment irrigation at 100% ET under mulched condition (T_5) *i.e.*, 41.21 kg ha^{-1}. In contrast, the treatment involving irrigation at 80% FC under non-mulched condition (T_4) recorded significantly lower crop yield per hectare on pooled basis (23.52 kg ha^{-1}).

Higher yield can be attributed to maintenance of field capacity at root zone. The root development was observed to be higher in sensor-based irrigation. Proper irrigation management is acquired by the sensor-based irrigation system which can ensure that ridge gourd plants receive adequate water during the critical growth stages, leading to healthier and more vigorous growth and minimize the water related stress factor. The similar results are obtained by few researchers [10-11].

3.4 Efficiency parameters

3.4.1 Application efficiency of irrigation

Water application efficiency shows how effectively the irrigation water is applied to the field, *i.e.*, the percentage of water applied is stored in the crop root zone as required and available for plant use. The amount of water application and schedule was same for all the treatments. The variation in water application among the treatments occurred as a result of variation of drip emitter discharge rates. The average water application efficiencies recorded under treatments are presented in Table 4. It is observed that application efficiency was higher in the treatment response to irrigation at 100% FC under mulched condition on pooled basis (94.13%) and lowest in 80% FC under non-mulched condition on pooled basis (91.37%). Similar findings also obtained by researcher [12].

Table 3. Influence of different irrigation scenario's on Crop yield of ridge gourd under mulched and non-mulched conditions

Treatment details	Crop yield (t ha^{-1})		
	2021-22	2022-23	Pooled data
T_1	46.28	44.70	45.49
T_2	43.05	39.18	41.12
T_3	27.45	25.38	26.42
T_4	23.48	23.56	23.52
T_5	43.18	39.24	41.21
T_6	37.68	35.40	36.54
T_7	33.20	31.18	32.19
T_8	30.05	28.15	29.10
S.Em±	**1.53**	**1.36**	**1.42**
C. D. @ 5%	**4.65**	**4.12**	**4.32**

3.4.2 Water use efficiency

The data on effect of different irrigation scenario's under mulched and non-mulched conditions on water use efficiency of ridge gourd is presented in Table 4. The different irrigation scenario's under mulched and non-mulched conditions significantly influenced the water productivity of ridge gourd in 2021-22 as well as on pooled basis. Among different Irrigation scenario's under mulched and non-mulched conditions significantly higher water use efficiency was observed in T_1 *i.e.*, irrigation at 100% FC under mulched condition on pooled basis (0.20 t ha^{-1} mm^{-1}), followed by irrigation at 100% FC under non-mulched condition (T_2) *i.e.*, 0.18 t ha^{-1} mm^{-1}. The lower water use efficiency was observed in T_4 *i.e.*, irrigation at 80% FC under mulched condition on pooled basis (0.11 t ha^{-1} mm^{-1}). The above results were agreement with the researcher [13].

Table 4. Influence of different irrigation scenario's on water application and water use efficiency of ridge gourd under mulched and non-mulched conditions

Treatment details	Water application efficiency (%)	Water use efficiency (t ha^{-1} mm^{-1})		
		2021-22	2022-23	Pooled data
T_1	94.13	0.21	0.18	0.20
T_2	92.45	0.20	0.16	0.18

T_3	92.83	0.14	0.12	0.13
T_4	91.37	0.12	0.11	0.11
T_5	93.11	0.17	0.14	0.16
T_6	92.37	0.15	0.13	0.14
T_7	92.04	0.17	0.14	0.15
T_8	92.72	0.15	0.12	0.14
S.Em±	**0.20**	**0.01**	**0.01**	**0.01**
C. D. @ 5%	**NS**	**0.02**	**0.02**	**0.02**

4. CONCLUSION

The implementation of sensor-based irrigation management systems facilitates the provision of an optimal quantity of water to agricultural crops, hence fostering their optimal growth. As a result, this phenomenon serves to promote the development of more resilient vegetation, fosters the establishment of a well-developed root system and ultimately leads to higher agricultural productivity. Increased water use efficiency with the decreased level of water input through drip was noticed. Minimum water use efficiency was recorded in treatment consisting of irrigation at 80% FC under mulched condition on pooled basis (0.11 t ha^{-1} mm^{-1}). The need for sensor-based irrigation is steadily growing and holds significant potential for future development. Controlling soil moisture levels not only saves time but also mitigates the potential for human error. The advent of sensor-based applications in the field of agriculture has facilitated the potential for enhancing production, efficiency and profitability through the implementation of precision agricultural techniques.

5. REFERENCES

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