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Effect of Deficit Irrigation and Mulching on Water Productivity and Yield of Drip-Irrigated Onion (*Allium Cepa L.*)

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Abstract: ***The most important component of photosynthesis process in plants is water, whose scarcity can directly affect agricultural production leading to food insufficiency. In a waterlimiting situation, water productivity is maximized whereas incomes are optimized. Water productivity and Onion yields, therefore need to be evaluated through the integrated practice of drip irrigation, deficit irrigation and use of mulches to determine the level of production at which income is optimized. Deficit irrigation (DI), a water management strategy involves the application of limited water supplies during moisture-sensitive crop growth stages or throughout the whole growing season to maximize productivity of the applied water by exposing plants to certain levels of water stress.Both DI and mulching were found to influence the yield and water productivity of bulb onion and other crop growth components to varying degree based on the magnitude of water stress and type of mulch used. For all treatments, it was found that polythene mulched crop gave higher output compared to straw mulched and control treatments. To determineoptimum level of production, economic analysis of the cost-benefit ratio of input and outputcan be conducted.***

Keywords: Onion, Deficit irrigation, mulching, yield, water productivity

1. Introduction

The increasing global demand for food and other agricultural products is attributed to the rapid increase in world population, which calls for urgent measures to increase water use efficiency alongside plant nutrient availability which are the two main limiting factors in crop production. This study evaluated the influence of deficient supply of water and mulching on yield and water productivity of bulb onion in a hot and sub-humid climate located within Kymore and Saptura hills agro-climatic zone.

2. Methodology

2.1 The study Area

The study was carried out at JNKVV, Krishi Nagar, Jabalpur districtwhich is located within Kymore and Saptura hills agro-climatic zone in Madhya Pradesh State. The site is situated on latitude 23.21^{o} N and longitude 79.96^{o} E and altitude of 411.8 m above sea level. It receives mean annual rainfall ranging from 1000 to 1500 mm with a mean minimum and maximum temperature of 17^{o}C and 32^{o}C respectively. The type of soil in the area is medium and deep clay loam with medium to low available water content.

2.2 Experimental design

The experiment was set up in a split-plot, RCBD layout with three replications of combined deficit irrigation and mulching treatmentsunder drip irrigation system.The dimensions of each plot was4 m x 5 m, with three nested plots consisting of three different treatments.

2.3 Treatments

The studywas laid out with six main plots each with three sub-plots in three replications. The crop was exposed to five water stress levels at vegetative and late season growth stages while the control plots received adequate amount of irrigation water.

Main treatments
T1-100% ETc (No moisture stress), T2-90% ETc, (10% deficit irrigation), T3-80% ETc, (20% deficit irrigation), T4-70% ETc, (30% deficit irrigation), T5-60% ETc, (40% deficit irrigation) andT6-50% ETc, (50% deficit irrigation)

Sub-treatments
C-Control (No mulch), P–Polythene mulch and S–Straw mulch

2.4 Field Preparation

The field was prepared well to a good soil tilth and depth conducive for transplanting of onion seedlings.

2.5 Drip irrigation system set up

The drip irrigation system was set up to supply the six water treatments independently of one another with the use of separate control valves for each plot.

2.6 Sowing materials

Seeds were sown in a well prepared nursery on 7th November, 2019.

2.7 Transplanting

Transplanting of 8 weeks old seedlings took place on the 7th January, 2020 at a spacing of 10 cm x 15 cm. The recommended basal dose of fertilizer was applied to boost root and vegetative development, (100 kg N + 80 kg P_2O_5 + K_2O per hectare). N was applied in two splits of 50% each with the first application taking place during transplanting and the second, thirty days later.

2.8 Weeding

Weeding was done regularly to maintain a clean environment for the crop to thrive and utilize soil nutrients adequately.

2.9 Data collection

2.9.1 Yield

Yield was determined after harvesting the crop by weighing out onion bulbs using a weighing balance and translating into production per unit area of land.

2.9.2Water productivity

It was determined by taking the weight of crop produced from a unit volume of water used (kg/m^3) per treatment.

2.9.3Plant height

The height of the plants was measured from the ground level to the tip of the top-most leaf in centimeters at intervals of thirty days after planting until maturity.

2.9.4Number of leaves

The total number of green leaves per plant was counted every thirty days from each plot based on the treatments and replication after which an average number of leaves per plant was computed.

2.10 Irrigation scheduling

To determine Irrigation scheduling,the Penman-Monteith equationwas used to compute the reference evapotranspiration (ETo) from which crop evapotranspiration was determined at different growth stages of the crop from establishment to maturity.

$$ETc = ETo \times kc$$

Where ETc – crop evapotranspiration, ETo – reference evapotranspiration and kc –crop coefficient.

2.11 Method of analysis

Data collected was analyzedby use ofthe Analysis of Variance (ANOVA) method.

3. Results and Discussion

The results obtained and the discussion of the findings were summarized and presented under the following topics;

3.1 Bulb yield

The highest mean production (tons/ha) per sub-treatment was recorded from T1Pfollowed by T1S, T2S and subsequent straw mulched treatments. However, T3S recorded about the same yield as T2Cand T4p (Fig. 1 & Table 1). Polythene mulched treatments recorded the highest yield among all the sub-treatments straw mulched treatments. As water stress increasedbeyond T4, all sub-treatments recorded the lowest yield within their respective plots.

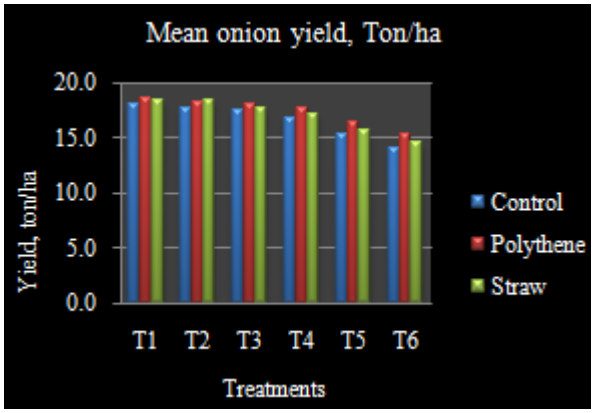

Figure 1: Mean Onion yield in tons/ha

Table 1: Mean Onion crop yield, ton/ha

Treatments	T1	T2	T3	T4	T5	T6
Control	18.0	17.7	17.5	16.8	15.3	14.0
Polythene	18.5	18.3	18.0	17.7	16.3	15.3
Straw	18.4	18.4	17.7	17.1	15.7	14.6

3.2 Bulb diameter

The deficit irrigation and mulching influenced the onion bulb size. The highest mean equatorial (Eq) diameter of bulbs was obtained from T1P and T2P followed by T1S, T2S and T3P respectively. The least recorded equatorial mean diameter was obtained from control treatment T6C whose diameter was less than the overall mean value of 5.2 cm (Fig. 2 & Table 2)

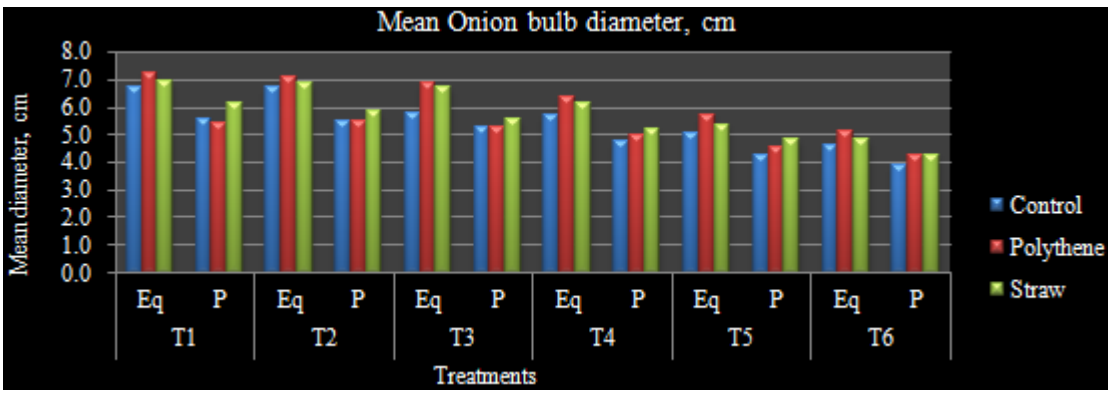

Figure 2: Mean Onion bulb diameter, cm

Table 2: Mean Onion bulb diameter, cm

Treatments	T1		T2		T3		T4		T5		T6	
	Eq	P	Eq	P	Eq	P	Eq	P	Eq	P	Eq	P
Control	6.4	5.6	6.3	5.3	5.7	4.8	5.4	4.5	4.9	4.0	4.5	3.6
Straw	6.1	5.3	6.0	5.3	5.9	5.1	5.5	4.7	4.9	4.2	4.6	3.9
Polythene	6.7	5.8	6.7	5.7	6.2	5.2	5.8	5.1	5.4	4.6	4.9	4.0

3.3 Plant height

The deficit irrigation and mulching did not affect significantly the height of the plants. The highest mean plant height was recorded from treatments T1, T2and T3. The lowest mean plant height was obtained from T6. The plant height recorded from control treatments ranged from 48.3 to 65.7 cm whereas those from polythene and straw mulched treatments ranged from 51.3 to 65.0 cm and 50.0 to 64.7 cm respectively (Fig 3 and Table 3).

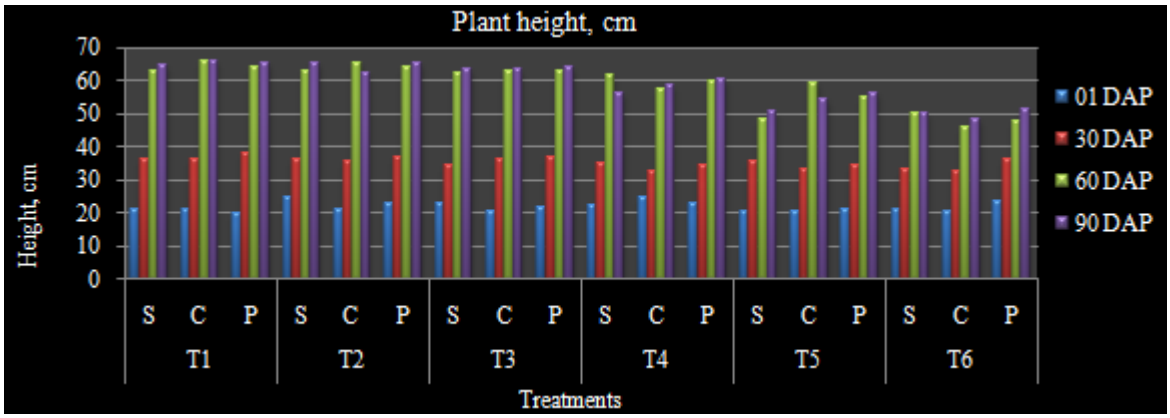

Figure 3: Mean plant height (cm)

Table 3: Mean plant height

Treatments	T1			T2			T3			T4			T5			T6		
	S	C	P	S	C	P	S	C	P	S	C	P	S	C	P	S	C	P
01 DAP	21	21	20	25	21	23	23	21	22	22	25	23	20	21	21	21	20	24
30 DAP	36	36	38	36	35	37	34	36	37	35	32	34	36	33	34	33	32	36
60 DAP	63	66	64	63	65	64	62	63	63	62	58	60	48	59	55	50	46	48
90 DAP	65	66	65	65	62	65	63	63	64	56	59	60	51	54	56	50	48	51

3.4 Number of leaves

The number of leaves per plant ranged from 7 to 12 from all treatments (Table 3 & Fig. 3). The number of leaves per plant was affected by deficit irrigation and mulching. The highest leaf number was obtained from treatments T1, T2 and T3 which received100%ETc, 90%ETc and 80%ETc. The treatments which received the least amount of water also experienced the lowest number of leaves per plant. The overall mean number of leaves was obtained from treatment T4 with 10 leaves (Fig 4 and Table 4).

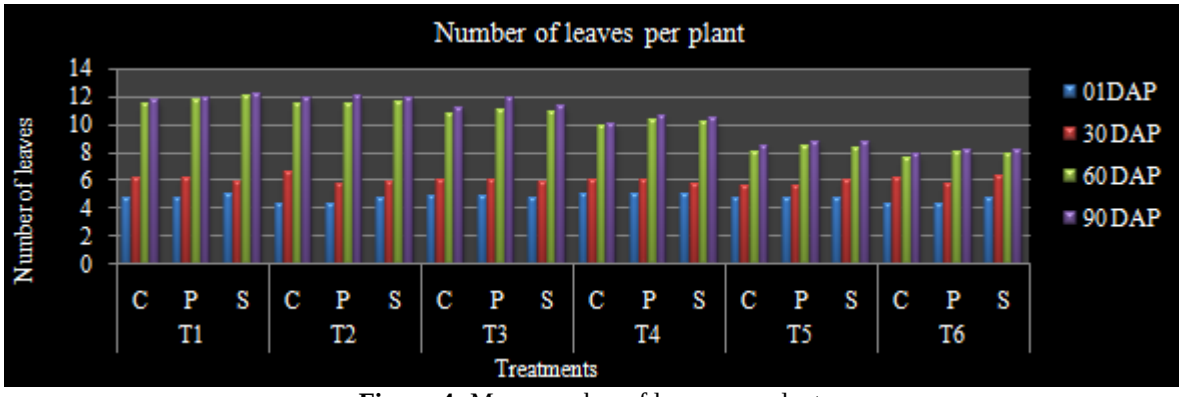

Figure 4: Mean number of leaves per plant

Table 4: Mean number of leaves per plant

Treatments	T1			T2			T3			T4			T5			T6		
	C	P	S	C	P	S	C	P	S	C	P	S	C	P	S	C	P	S
01DAP	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5
30 DAP	6	6	6	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6
60 DAP	12	12	12	11	11	12	11	11	11	10	10	10	8	8	8	8	8	8
90 DAP	12	12	12	12	12	12	11	12	11	10	11	10	8	9	9	8	8	8

3.5 Water productivity

The highest water productivity (WP) was obtained from all irrigation treatments of polythene mulched crop which peaked at T5 and T6 and least at T1. Polythene mulched onion recorded the highest WPat treatment T6 whereas the control treatment gave the highest and lowest at T4 and T1 respectively.

Table 5: Water productivity of bulb onion

Treatments	T1	T2	T3	T4	T5	T6
Control	3.7	3.9	4.1	4.3	4.2	4.2
Straw	3.8	4.0	4.2	4.4	4.4	4.5
Polythene	3.9	4.1	4.3	4.5	4.7	4.7

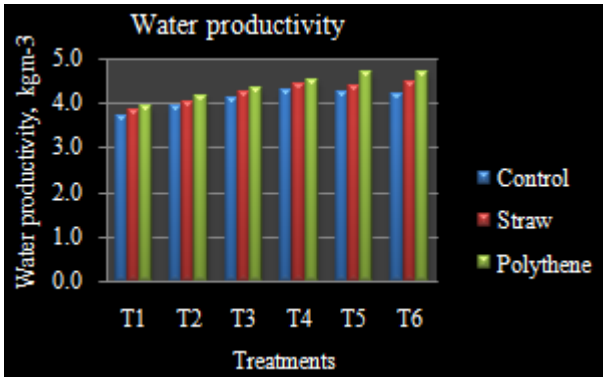

Figure 5: Water productivity of drip irrigated Onion, kgm^{-3}

4. Conclusion

Deficit irrigation (DI) and mulching significantly affected yield, water productivity and the diameter of bulb onion particularly the treatments which received 60%ETc and 50%ETc. On the other hand there was no significant effect of DI and mulching on the number of leaves per plant and the plant height.

5. Acknowledgement

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