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Effect of irrigation levels on vegetative growth and yield characteristics in white onion (*Allium cepa* L.) in Konkan region

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■ **ABSTRACT :** An experiment was conducted at College of Agricultural Engineering and Technology, Dapoli to assess the effect of irrigation levels on vegetative growth and yield characteristics in white onion on micro-irrigation system. In the present investigation white onion variety Alibag local was tested under three irrigation levels namely I_1 (no deficit), I_2 (20% deficit) and I_3 (40 % deficit) on mini-sprinkler (M_1) and micro-sprinkler (M_2) irrigation methods, while the conventional check basin method was taken as control. The maximum average yield was attained in irrigation level I_1 as 39.82 t/ha, whiles the minimum average yield of 24.97 t/ha was recorded for irrigation level I_3. The maximum yield of 42.37 t/ha was recorded for treatment combination M_2I_1 followed by treatment combinations M_1I_1 (37.26 t/ha) and M_2I_2 (36.03 t/ha). In control treatment the yield of 17.52 t/ha was recorded. The maximum water use efficiency 14.51 q/ha-cm was reported in treatment combination M_2I_1 and the minimum water use was found 10.98 q/ha-cm in treatment combination M_1I_3. The fertilizer use efficiency followed the same trend. The maximum fertilizer use efficiency 176.12 was recorded in treatment combination M_2I_1 and minimum 99.54 was obtained in treatment combination M_1I_3. In control fertilizer use efficiency was 73.01, which was lowest amongst all treatments.

■ **KEY WORDS :** Deficit irrigation, White onion, Mini-sprinklers, Micro-sprinklers

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Onion (*Allium cep*a L.) is an important vegetable crop. As a result of the changes in climatic conditions, irrigation systems, soil properties and new released varieties the water requirements of onion plant needs more studies. Onion is a shallow-rooted plant that requires frequent irrigation to achieve good yield. Accordingly excessive amount of water is generally applied to fields. On irrigated land the onion crop is regarded as a fairly large consumer of water. Onions under water deficiency decrease in its evapotranspiration and consequently yield (Sammis *et al.*, 2000) and Olalla *et al*. (2004) in drip irrigation experiment reported that the lower volume of water received, the higher the efficiency obtained.

Water is the most vital input in agriculture and has made a significant contribution in providing stability to food grain production and self sufficiency. India has 2.4 per cent of land mass and 4 per cent fresh water resources of the World, but supports 17 per cent of the World population. In the country 91.6 per cent of the water is used for irrigation purpose as compared to 84 per cent in Asia and 71 per cent in the World (FAO, 1999). The total geographical area of India is 328.72 Mha, out of which 142 Mha is the cultivated area. It is estimated that out of the total cultivated area, only 35 per cent is irrigated and remaining 65 per cent is sown under rain fed condition. Tremendous efforts have been made in the past to increase the irrigated area through construction of large number of surface irrigation projects and through groundwater resources. As a result, the irrigated area has jumped by almost 250 per cent from what it was in 1950-51. The ultimate irrigation potential in the country is tentatively estimated at 140 Mha, comprising 58.47 Mha through major and medium irrigation projects and 81.54 Mha from minor irrigation projects, which the country was achieved from 1950-51 up to 2002-03 (Narayanmoorthy, 2006). Kadayifci *et al.* (2005) reported that bulb and dry matter production were highly dependent on appropriate water supply. Mermoud *et al.* (2005) showed that irrigation frequency plays an important role on the development and yield of the onion crop. Irrigating twice a week instead of once a day (and thus, increasing the irrigation depth) was found to cause an increase of the water storage through the whole root zone, a better crop water availability and higher yield. Bekele and Tilahun (2007) observed that water deficit at first and fourth growth stages had insignificantly effect on yield as compared to optimum application. If the water deficit is in the second and third growth stages, or during all stages as 25 per cent ETc, 50 per cent ETc and 75 per cent ETc water deficit, the yield were significantly different from optimal irrigation. All deficit levels increased the water use efficiency of onion from a minimum of 6 per cent by stressing the crop. Sarkar *et al*. (2008) reported that at lower irrigation quantities the water use efficiency is higher.

With the existing practices, water use efficiency is only about 40 per cent. Available estimates indicate that by 10 per cent increase in water use efficiency, country can gain about 50 million tons of additional food grain production from the existing irrigated area. Both sprinkler and drip irrigation are mainly the advanced techniques, which will replace the surface irrigation methods and help to bring more area under irrigation with increased productivity. These methods have very high irrigation efficiency, which can save water from 30 to 60 per cent and are adaptable on hilly terrain and light soils (Mane and Ayare, 2011).

■ METHODOLOGY

The experiment was conducted at Research Farm at College of Agricultural Engineering and Technology, Dapoli to study the response of white onion to deficit irrigation. The experiment was laid out with six treatment combinations and control. The six treatments were arranged randomly on the field. The factorial design included two factors *viz.*, irrigation methods and irrigation levels. This treatment combination was compared with the control treatment *i.e.* with check basin irrigation. All the treatments were replicated for four times. The statistical design of lay out was adopted as Factorial Randomized Block Design. Irrigation methods were assigned to factors and levels.

Factors (Irrigation methods) :

The irrigation methods details given as follows :

M_1 = Mini-sprinkler

M_2 = Micro-sprinkler

Control (Check Basin) .

Factor consisted of two treatments *viz.*, mini sprinkler irrigation and micro sprinkler irrigation. In mini sprinkler irrigation system, it consisted of mini sprinklers of 450 lph discharge placed at 5.0 m × 5.0 m spacing with riser height of 0.75 m at operating pressure of 2.0 kg/cm^2. Similarly, the micro sprinkler irrigation system, the micro sprinklers of 26 lph discharge placed at 1.5 m × 1.5 m spacing with riser height of 0.75 m at operating pressure of 1.5 kg/cm^2.

Levels (Irrigation levels) :

The irrigation levels are as follows :

I_1 = No deficit

I_2 = 20 per cent deficit

I_3 = 40 per cent deficit

Treatment combinations :

$T_1 = M_1 I_1$ $T_2 = M_1 I_2$

$T_3 = M_1 I_3$ $T_4 = M_2 I_1$

$T_5 = M_2 I_2$ $T_6 = M_2 I_3$

Control

The irrigation for mini and micro irrigation system was scheduled on alternate day. For control treatment irrigation was scheduled after 4 days interval at the net depth of 50 mm.

■ RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under following heads :

Average weight of bulb :

Individual effect of irrigation levels and irrigation methods on average weight of bulb :

The individual effect of irrigation levels as well as irrigation methods on average weight of white onion bulb was analyzed statistically and results are reported in Table 1.

Table 1 : Effect of irrigation levels and irrigation methods on average weight of bulb

Treatments	Average weight of bulb (g)
Irrigation levelss	
I_1	102.37
I_2	92.65
I_3	81.97
S.E. ±	0.90
C.D. (P=0.05)	2.68
Control	72.26
Irrigation methods	
M_1	89.56
M_2	95.09
S.E. ±	0.73
C.D. (P=0.05)	2.18

Among these parameters, irrigation level was found most influencing parameter on affecting average weight of onion bulbs. The irrigation level I_1 showed the significantly higher average weight of onion bulbs as compared with control and irrigation levels I_2 and I_3. Similarly, the irrigation level I_2 and I_3 have shown the same trend. The irrigation level I_2 and I_3 were significantly superior over control. This shows the response of crop to irrigation and as the irrigation level increased the average weight of onion bulbs increased and it was maximum at no deficit irrigation level for both the irrigation methods. The result is in conformity with those obtained by Zayton (2007).

The irrigation methods affected the average weight of onion bulbs significantly. The irrigation method M_2 showed significantly superior results as compared to control as well as to irrigation method M_1. Both the irrigation methods have shown significantly superior results as compared with control. This indicates that the need to adopt modern irrigation methods like micro-sprinkler and mini-sprinkler for obtaining maximum bulb weight and productivity over traditional methods.

Interaction effect of irrigation levels and irrigation methods on average weight of bulb :

The interaction effect of irrigation levels and irrigation methods on average weight of onion bulb has been depicted in Table 2.

Table 2 : Effect of interaction of irrigation levels and irrigation methods on average weight of bulb

Treatments	Average weight of bulb (g)			Mean
	I_1	I_2	I_3	
M_1	99.55	90.95	78.19	89.56
M_2	105.18	94.34	85.75	95.09
Mean	102.37	92.65	81.97	
	Method	Level	Int I x M	
S.E. ±	0.73	0.90	1.27	
C.D. (P=0.05)	2.78	2.68	3.78	
Control		72.26		

The interaction effect of irrigation levels and irrigation methods on average weight of onion bulbs was also significant. The significantly higher average weight of onion bulbs was observed in both the irrigation methods for all irrigation levels as compared to control. The average weight of onion bulbs in treatment combination M_2I_1 (105.18 g) was higher than all other treatments as well as control (72.26 g). The average weight of onion bulbs in treatment combination M_1I_3 (78.19 g) was lower than all other treatments but significantly higher than control.

Bulb yield :

Individual effect of irrigation levels and irrigation methods on average bulb yield :

The individual effect of irrigation levels as well as irrigation methods on average bulb yield of white onion was analyzed statistically and results are reported in Table 3.

Among these parameters, irrigation level was found most influencing parameter on bulb yield. The irrigation level I_1 showed the significantly higher bulb yield as compared with control and irrigation levels I_2 and I_3. Also, the irrigation levels I_2 and I_3 were significantly superior over control. This showed the response of white onion crop to irrigation and on applying the deficit irrigation the yield of crop was decreased. The higher yield was obtained in full irrigation and reduced significantly from full irrigation to deficit irrigation level. The result is in conformity with those obtained by Zayton (2007), Bekele and Tikahun (2007), Kumar *et al.* (2008), Owusu-Sekyre and Anodh (2011), Pejic *et al.* (2011).

Table 3 : Effect of irrigation levels and irrigation methods on average bulb yield of white onion

Treatments	Average yield (t/ha)
Irrigation levels	
I_1	39.76
I_2	33.50
I_3	24.97
S.E. ±	0.41
C.D. (P=0.05)	1.22
Control	17.52
Irrigation methods	
M_1	30.70
M_2	34.78
S.E. ±	0.58
C.D. (P=0.05)	1.72

The irrigation methods affected the bulb yield significantly. The irrigation method M_2 was significantly superior over control as well as over irrigation method M_1. Both the irrigation methods have shown significantly superior results as compared with control. In the control the bulb yield was lowest due to poor soil aeration. This indicates the need to adopt modern irrigation methods like micro-sprinkler and mini-sprinkler for minimizing the water loss, obtaining better bulb production and productivity over traditional methods.

Interaction effect of irrigation levels and irrigation methods on average bulb yield :

The interaction effect of irrigation levels and irrigation methods on average bulb yield has been depicted in Table 4.

Table 4 : Effect of interaction of irrigation levels and irrigation methods on average bulb yield of white onion

Treatments	Average yield (t/ha)			Mean
	I_1	I_2	I_3	
M_1	37.26	30.96	23.89	30.70
M_2	42.37	36.03	26.04	34.78
Mean	39.82	33.50	24.97	
	Method	Level	Int I x M	
S.E. ±	0.33	0.41	0.58	
C.D. (P=0.05)	1.00	1.22	1.72	
Control		17.52		

The interaction effect of irrigation levels and irrigation methods on average bulb yield was significant. The higher bulb yield was obtained in both the irrigation methods for all irrigation levels as compared to control. The bulb yield in treatment combination M_2I_1 (42.37 t/ha) was highest than all other treatments as well as control (17.52 t/ha). The bulb yield in treatment combination M_1I_3 (23.89 t/ha) was lower than all other treatments but significantly superior over control (17.52 t/ha).

Water use efficiency :

The water use efficiency is the ratio of yield obtained in a particular treatment to the depth of water applied. The maximum water use efficiency was obtained in treatment combination M_2I_1 (14.51 q/ha-cm) followed by M_2I_2 (14.14 q/ha-cm) (Table 5). The minimum water use efficiency occurred in treatment M_1I_3 (10.98 q/ha-cm), while the control (1.75 q/ha-cm) treatment was having very less water use efficiency.

Table 5 : Water use efficiency for different treatment combinations

Treatments combinations	Depth of water applied (cm)	Yield (q/ha)	Water use efficiency (q/ha-cm)	% increase in yield over control
M_1I_1	29.58	372.57	12.60	112.62
M_1I_2	25.66	309.60	12.07	76.68
M_1I_3	21.75	238.89	10.98	36.33
M_2I_1	29.14	422.69	14.51	141.22
M_2I_2	25.31	357.81	14.14	104.19
M_2I_3	21.49	260.43	12.12	48.62
Control	100.00	175.23	1.75	–

It is revealed from the data presented in Table 5 that the WUE ranged from 10.98 q/ha-cm to 14.51 q/ha-cm for different treatment combinations. The maximum WUE was reported in irrigation level I_1 (No deficit) and minimum in irrigation level I_3 (40% deficit). The increase in WUE was largely due to reduction in total water applied. The maximum 141.22 per cent increase in yield over control was recorded in treatment M_2I_1, followed by treatment M_1I_1 (112.62%) and treatment M_2I_2 (104.19%).

Fertilizer use efficiency :

It was observed that the maximum fertilizer use efficiency was obtained in treatment combination of M_2I_1 (176.12) followed by treatment combinations of M_1I_1 (155.24) and M_2I_2 (149.09). The fertilizer use efficiency for control treatment was lowest (73.01), which indicate that application of fertilizer with increased irrigation level will not help in efficient use of fertilizers. In control this might be due to leaching of fertilizers, while for other treatment combinations higher fertilizer use efficiency was reported for the higher irrigation levels. The fertilizer use efficiency for different treatments combinations has shown in Table 6.

Table 6 : Fertilizer use efficiency for different treatment combinations

Treatments combinations	Yield (q/ha)	Quantity of fertilizers applied (q/ha)	Fertilizer use efficiency
M_1I_1	372.57	2.40	155.24
M_1I_2	309.60	2.40	129.00
M_1I_3	238.89	2.40	99.54
M_2I_1	422.69	2.40	176.12
M_2I_2	357.81	2.40	149.09
M_2I_3	260.43	2.40	108.51
Control	175.23	2.40	73.01

Conclusion :

– The irrigation level I_1 (No deficit) and micro-sprinkler (M_2) individually gave superior results for growth parameters of white onion as compared to rest of all other treatments.
– The treatment (M_2I_1) of irrigation level I_1 (No deficit) and micro-sprinkler (M_2) found to be superior on influencing on growth parameters of white onion.
– The maximum yield was obtained when the full amount of irrigation water was applied, but the water productivity was highest when 20 per cent deficit of irrigation water was applied. Hence, if water is not a limiting factor, full amount of water should be applied in order to get maximum yield. But when water is limiting, 20 per cent deficit treatment gives a comparable yield. The 20 per cent water saved could help to irrigate additional land.
– The maximum water use efficiency of 14.51 q/ha-cm, 14.14 q/ha-cm and 12.60 q/ha-cm were recorded in the treatments M_2I_1, M_2I_2 and M_1I_1, respectively.
– The total yield and water use efficiency were found greater, when no deficit treatment applied.
– The maximum fertilizer use efficiency of 176.12, 155.24 and 149.09 were recorded in the treatments M_2I_1, M_1I_1 and M_2I_2, respectively. The maximum FUE was found in irrigation level I_1 (No deficit) for micro-sprinkler method.

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