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Effect of scheduling of drip irrigation on growth, yield and water use efficiency of onion (*Allium cepa* L.)*

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Abstract : The field experiments were conducted for two seasons during summer season of 2004-05 and 2005-06 at Regional Agricultural Research Station Bijapur (Karnataka), on medium deep black soil to study the effect of scheduling of drip irrigation on the growth, yield and water use efficiency of onion (cv. Telagi Red).The experiment included three interval (main treatments) and three levels of irrigation(sub treatments) with flood irrigation as control. The results shown that shorter interval of irrigation M_1 (one day interval) recorded significantly higher bulb yield (46.93 t ha^{-1}). The yield increase in M_1 was mainly due to significantly higher performance of growth and yield parameters. The 100 per cent PE (S_3) recorded significantly higher bulb yield (50.92 t ha^{-1}) compared to 80 and 60 per cent PE and flood irrigation and this reflected in growth and yield parameters also. Significantly higher bulb yield was recorded in one day interval of irrigation at 100 per cent PE (54.91 t ha^{-1}) which was on par with two days interval of irrigation at 100 per cent PE (52.83 t ha^{-1}). Significantly higher number of leaves, leaf area, LAI and neck girth per plant and equatorial diameter, polar diameter and bulb weight were recorded in M_1S_3, M_2S_3 compared to flood irrigation. Both one day (M_1) and two days (M_2) interval of irrigation and 60 per cent PE (S_1) recorded significantly higher WUE, while the interaction effects were non-significant. The intervals and levels of irrigation and their combinations were significantly superior for WUE, compared to flood irrigation

Key words: Drip irrigation, Growth, Level of irrigation, Onion, Yield

Introduction

Onion *(Allium cepa L.)* is one of the important vegetable crops commercially grown in India. It is a member of Alliaceae family, rich in sulphur containing compounds that are responsible for their pungent odours and for many of their health promoting effects. Onion bulb is a rich source of minerals like phosphorus and calcium. It also contains protein and vitamin C. Onions are now being used in several ways as in fresh, frozen, canned, caramelized, pickled, powdered, chopped and dehydrated forms. Onion powder is a spice used for seasoning in cooking. The World Health Organization (WHO) supports the use of onions for treating poor appetite and to prevent atherosclerosis.

India is the second largest producer of onion in the world, next only to China. In India, onion is being grown in an area of 0.83 million hectares with production of 13.57 million tonnes and the productivity is 16.30 t ha^{-1} which is low. Maharashtra is the leading onion producing state followed by Karnataka, Gujarat etc. In Karnataka, onion is cultivated in an area of 1.65 lakh hectares with production of 30.32 lakh tonnes and the average productivity is 18.40 tonnes per hectare (Bijay Kumar, 2010) which is low compared to world average. In onion, water is the main limiting factor for low productivity.

Hence, judicious use of water is very essential. One aim of irrigation is to replace the daily crop evapotranspiration. Different combinations of intensity, frequency and flow rates can be customized to meet varying irrigation needs within a field (Shock *et al.*, 2005). As drip irrigation is going to save 39-62 per cent of water over flood irrigation, more area can be brought under irrigation with better yield and quality which may compensate the cost of drip installation. The farmers having fragmented smaller holdings share the common source of irrigation *i.e.* bore-well or open well with a common pumpset to lift the water and invariably follow the rotation or queue system to irrigate their crops. Keeping this in mind scheduling of irrigation experiment was planned.

Material and methods

The field experiments to study the effect of scheduling of drip irrigation in onion *(Allium cepa L.)* cv. Telagi Red were conducted during summer season of 2004-05 and 2005-06. at Regional Agricultural Research Station, Bijapur (Karnataka). The organic carbon, available nitrogen, available P_2O_5, available K_2O were 0.4 per cent, 150 kg ha^{-1}, 17.8 kg ha^{-1} and 640 kg ha^{-1} respectively in the soil. The rainfall during the period of experimentation during summer was 158.1 and 39.7 mm during 2004-05 and 2005-06, respectively. The mean weekly maximum temperature during the cropping period ranged from 29.6^0 and 40^0C during 2004-05 and 28^0 to 38.6^0C during 2005-06.

The experiment was laid out in split plot design with one control and three replications. There were nine treatment combinations comprising of three main treatments of intervals of irrigation(one, two and three days) and three sub treatments of levels of irrigation(60.80 and 100 % PE) and flood irrigation (farmers practice) as control**.**

After transplanting, up to the seventh day common irrigation (100% PE) was provided daily to all the drip irrigation treatment plots for the better and uniform initial establishment of the crop and it was included while computing the total water applied to respective treatments. The drip irrigation scheduling was imposed from the eighth day of transplanting. The daily evapotransiration reading recorded by USWB class A Pan

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Evaporimeter was converted to reference ET (ET_0) by multiplying with Pan co-efficient (Kp) or Pan factor (0.8) after considering relative humidity and rainfall. Then ET of the crop (ET_{crop} was obtained by multiplying ET_0 with crop coefficient (Kc). The crop coefficient values were used as suggested by Bandyopadhyay *et al.* (2003). The water to be applied to the plots according to the treatments was worked out using the formula given below:

Quantity of water to be applied (litres) = ETc (cm) x area (ha) x 100000

Ten plants from each plot were selected randomly and tagged for recording growth parameters *viz.*, plant height, number of leaves, leaf area (Mahesh Babu, 1984) and leaf area index (Sestak *et al.*, 1972) and neck girth. Yield parameters *viz.*, polar diameter, equatorial diameter, bulb weight were recorded from the plants used for recording observations. The bulb yield per hectare was worked out based on the plot yield.

In the drip irrigation treatments, daily consumptive use of water was worked out based on the crop ET and at the end of the season the seasonal consumptive use of water was calculated and expressed in cm. In the control (flood irrigation) plot, irrigation water given was quantified after knowing the discharge rate and irrigation time. Then at the end of the season total irrigation water applied was worked out. The analysis and interpretation of data were done using the Fisher's method of analysis of variance technique as described by Gomez and Gomez (1984).

Results and discussion

The data in Table 1 reveals that scheduling of drip irrigation at shorter intervals i.e., at one day (M_1) and two days (M_2) significantly increased the growth parameters like plant height (61.58 and 60.25 cm, respectively), number of leaves (8.81 and 8.71, respectively), leaf area (466.47 and 462.02 sq.cm, respectively), leaf area index (4.15 and 4.11, respectively) and neck girth (1.38 and 1.37 cm, respectively) as compared to three days interval (M_3). The crop like onion performs better when irrigation is given on depletion of 15-20 per cent soil moisture of the field capacity. The shorter interval of irrigation at one day (M_1) and two days (M_2) ensure the moisture in the crop root zone nearly at 15-20 per cent depletion from field capacity. Drip irrigation system maintains soil physical conditions in congenial form for plants growth by maintaining optimum soil-water-balance around plant bases. Probably, this may be the reason for better performance of growth parameters by the treatments with shorter intervals of irrigations *viz.*, one and two days. Similar results were obtained by Batra and Pandita (1984) for number of leaves per plant and plant height; Palled *et al.*, (1988) for plant height; Neeraja *et al.* (2000) leaf area and LAI; Channagoudar and Janawade (2004) for plant height, number of leaves per plant, leaf area and leaf area index. Haque *et al.* (2004) for higher plant height and neck thickness; Gethe *et al.* (2006) for plant height, number of leaves and neck thickness.

Among the different levels, irrigation given at 100 per cent PE (S_3) recorded significantly higher plant height (66.56 cm), number of leaves (9.55), leaf area (506.24 cm^2), LAI (4.49) and neck girth (1.30 cm) per plant as compared to 60 and 80 per cent PE. The quantity of water lost through evapotranspiration is being replenished through drip irrigation directly at the base of the crop may be the reason for significantly better performance of growth parameters by 100 per cent PE (S_3) and this obviously due to maintenance of soil moisture regime in the root zone closer to field capacity. When moisture in the root zone is closer to field capacity, the nutrient availability is high and the plant does not experience moisture stress at any stage of growth and development. Similar results of improved crop growth with irrigation or re-watering near field capacity reported by Abby and Joyce (2004) for plant height, number of leaves and neck girth, Satyendra Kumar *et al.* (2007) for growth parameters. The similar results were obtained by Galbiatti *et al.*(1992) for plant height and number of leaves and Anon., (2001) for plant height, number of leaves and neck thickness in onion and garlic.

The treatment combinations of one day interval with 100 per cent PE (M_1S_3) and two days interval with 100 per cent PE (M_2S_3) recorded significantly higher plant height, number of leaves, leaf area and LAI per plant in pooled over the seasons. Onion roots seldom grow deeper than 15 cm depth and it is a close spaced vegetable which performs better when irrigated at soil moisture depletion of 15-20 per cent of field capacity. Hanson *et al.* (2003) reported that there was no yield benefit in onion of two subsurface drip irrigations per day and irrigation frequencies of one irrigation per day or two irrigations per week are appropriate in medium to fine textured soils. Kadam *et al.* (2006) reported that, best results are obtained in onion when

Table 1. Effect of scheduling of drip irrigation on growth parameters of summer onion (pooled)

Treatment	Plant height (cm)	No. of leaves per plant	Leaf area (sq.cm)	Leaf area index	Neck girth (cm)
Interval of irrigation(M)					
M_1 (1 day interval)	61.58	8.81	466.47	4.15	1.38
M_2 (2 days interval)	60.25	8.71	462.02	4.11	1.37
M_3 (3 days interval)	55.92	8.03	425.61	3.78	1.26
S.Em ±	0.79	0.09	6.62	0.06	0.02
C.D. (0.05)	2.57	0.28	21.58	0.19	0.06
Level of irrigation (S)					
S_1 (60% PE)	49.99	7.16	379.47	3.37	1.13
S_2 (80% PE)	61.20	8.83	468.39	4.16	1.39
S_3 (100% PE)	66.56	9.55	506.24	4.49	1.5
S.Em ±	1.01	0.13	8.44	0.07	0.03
C.D. (0.05)	2.93	0.37	24.63	0.22	0.07
Interaction (M x S)					
M_1S_1	50.25	7.21	381.59	3.39	1.13
M_1S_2	62.25	8.9	472.04	4.2	1.4
M_1S_3	72.25	10.31	545.79	4.85	1.62
M_2S_1	50.22	7.2	381.97	3.39	1.13
M_2S_2	61.55	9.03	478.82	4.26	1.42
M_2S_3	68.99	9.91	525.26	4.67	1.56
M_3S_1	49.50	7.07	374.86	3.33	1.11
M_3S_2	59.81	8.57	454.31	4.04	1.35
M_3S_3	58.46	8.44	447.67	3.98	1.33
S.Em ±	1.25	0.15	9.78	0.09	0.03
C.D. (0.05)	4.15	0.46	28.78	0.25	0.09
Flood irrigation (Control)	56.87	8.12	430.39	3.83	1.28
S.Em ±	2.52	0.32	21.18	0.19	0.06
C.D. (0.05)	5.21	0.65	43.63	0.4	0.13

PE - Pan evaporation

Table 2. Effect of scheduling of drip irrigation on bulb yield, yield parameters, yield and water use efficiency in summer onion (pooled)

Treatment	Equatorial diameter (cm)	Polar diameter (cm)	Bulb weight (g)	Yield ($t\ ha^{-1}$)	WUE ($t\ ha\ cm^{-1}$)
Interval of irrigation (M)					
M_1 (1 day interval)	5.15	5.41	53.29	46.93	1.02
M_2 (2 days interval)	5.09	5.32	52.80	46.47	1.01
M_3 (3 days interval)	4.87	5.22	48.64	42.80	0.94
S.Em ±	0.06	0.06	0.76	0.67	0.02
C.D. (0.05)	0.21	NS	2.48	2.17	0.05
Level of irrigation (S)					
S_1 (60% PE)	4.52	4.81	43.34	38.16	1.09
S_2 (80% PE)	5.23	5.46	53.53	47.12	1.01
S_3 (100% PE)	5.36	5.67	57.86	50.92	0.87
S.Em ±	0.07	0.08	0.97	0.85	0.02
C.D. (0.05)	0.21	0.23	2.83	2.48	0.05
Interaction (M x S)					
M_1S_1	4.59	4.85	43.54	38.37	1.10
M_1S_2	5.23	5.43	53.95	47.52	1.02
M_1S_3	5.62	5.92	62.38	54.91	0.94
M_2S_1	4.54	4.82	43.65	38.41	1.10
M_2S_2	5.26	5.48	54.73	48.16	1.03
M_2S_3	5.48	5.66	60.04	52.83	0.91
M_3S_1	4.44	4.77	42.84	37.70	1.08
M_3S_2	5.21	5.47	51.92	45.69	0.98
M_3S_3	4.97	5.42	51.16	45.02	0.77
S.Em ±	0.11	0.12	1.22	0.98	0.02
C.D. (0.05)	NS	NS	3.30	2.87	NS
Flood irrigation (control)	4.92	5.18	49.19	43.28	0.39
S.Em ±	0.18	0.19	2.43	2.13	0.04
C.D. (0.05)	0.36	0.40	5.02	4.41	0.09

Note: NS – non significant, PE -Pan Evaporation

crop was irrigated at 20 per cent soil moisture depletion compared to 30, 40 and 50 per cent of soil moisture depletion levels in a micro sprinkler irrigation system.

When compared with flood irrigation, the effect due to interval of irrigation was significant for number of leaves and neck girth. Significantly higher number of leaves were recorded with irrigation at one day (8.81 cm) interval (M_1). In the flood irrigation where the soil moisture fluctuates from excess or saturation on the day of irrigation to field capacity to different degrees of dryness and virtually plant suffers due to moisture stress just before the next irrigation. Because of this reason, crop performance was comparatively poor in flood irrigation. The findings of many researchers as highlighted earlier suggest that, fairly shorter interval of irrigation - replenishes soil moisture on 15-20 per cent depletion, depending upon the type of soil, climate and season of cultivation (Table 1).

In comparison with flood irrigation, higher level of irrigation at 100 per cent PE (S_3) recorded significantly higher growth parameters *viz.*, plant height, number of leaves, leaf area, LAI and neck girth. The higher level of irrigation at 100 per cent PE replaces the water lost through evapotranspiration (consumptive use) and thereby maintains soil moisture at root zone at low tensions during crop growing period, thus ensuring adequate soil water, air and nutrients throughout the crop growth period. Similar results were reported by Galbiatti *et al.* (1992) and Anon., (2002 and 2003).

Significantly higher plant height, number of leaves, leaf area and LAI were recorded with M_1S_3 and M_2S_3 (Table 1). The reason for the better performance of these growth parameters due to the shorter interval with higher level of irrigation may be attributed to optimum soil water- air- balance around plant root zone. Similar results were reported by Galbiatti *et al.* (1992); Anon., (2002 and 2003); Hanson *et al.* (2003); Abby and Joyce (2004) and Kadam *et al.* (2006).

Neck girth is one of the important growth parameters which indicates vigour of the plant. The irrigation at one day (M_1) and two days interval (M_2),irrigation at 100 per cent PE and combination M_1 and M_2 with 100 per cent PE increased the neck girth significantly and this may be due to increased plant height, number of leaves and leaf area per plant. Similar findings were also reported by Haque *et al.* (2004) and Gethe *et al.* (2006) for interval for interval of irrigation, Galbiatti *et al.* (1992) and Anon., (2002 and 2003) for irrigation levels and combination effects.

In comparison with flood irrigation (control), 100 per cent PE and the interactions of M_1S_3, M_2S_2 and M_2S_3 recorded significantly higher neck girth. Irrigations at shorter intervals of one or two days with 80 or 100 per cent PE also maintain the soil moisture closer to field capacity. Similar results were also reported by Galbiatti *et al.* (1992) and Anon., (2001 and 2002).

The bulb yield of the onion increased significantly with shorter interval of surface drip irrigation. (Table 2) Irrigation scheduled at one day interval recorded significantly higher bulb yield (46.93 $t\ ha^{-1}$) over three days interval (42.80 $t\ ha^{-1}$), and it was at par with two days interval (46.47 $t\ ha^{-1}$). Increase in the bulb yield is mainly attributed to positive association between yield and yield contributing parameters like bulb weight and size in terms of equatorial and polar diameter of the bulb. Irrigation with one day and two days interval significantly influenced the equatorial diameter of the bulb which determines the bulb weight and that in turn decides the bulb yield. Significantly increased bulb equatorial diameter was recorded with one day (5.15 cm) and two days (5.09 cm) interval of irrigation (4.87 cm) compared to three days interval. Whereas influence on polar diameter was non-significant. Bulb weight of onion also increased significantly by one day (M_1) and two days (M_2) interval of irrigation (53.29 and 52.80 g, respectively) over three days interval (M_3). Increased bulb equatorial diameter and bulb weight of onion by one day (M_1) and two days (M_2) interval of irrigation may be due to the better performance of growth parameters like plant height, number of leaves, leaf area and neck girth. The shorter interval of irrigation ensures optimum growth of the crop by assuring balanced water and nutrient supply throughout the crop growth period. Similar result for bulb yield was reported by Quadir *et al.* (2005).

Irrigation with 100 per cent PE (S_3) recorded significantly higher bulb yield (50.92 $t\ ha^{-1}$) compared to 80 (47.12 $t\ ha^{-1}$) and 60 per cent (38.16 $t\ ha^{-1}$) PE. Increased bulb yield with 100 per cent PE (S_3) may be attributed to significant increase in yield attributing characters like bulb equatorial diameter(5.36 cm), polar diameter(5.67 cm) and bulb weight (57.86 g). The better performance of yield parameters with 100 per cent PE (S_3) may be attributed to significant increase in growth parameters. Similar results for higher bulb yield were reported by Galbiatti *et al.* (1992), Anonymous (2001 and 2002) and Hanson and May (2004).

Among the treatment combinations of interval and level of irrigation one and two days interval with 100 per cent PE (M_1S_3 and M_2S_3) recorded significantly higher bulb yield. The increased bulb yield due to irrigation at one or two days interval with 100 per cent PE was due to significantly higher bulb equatorial diameter (5.62 and 5.48 g, respectively), polar diameter (5.92 and 5.66 g, respectively) and bulb weight (62.38 and 60.04, respectively). Similar findings for higher bulb yield were reported by Anonymous (2002 and 2003) and Quadir *et al.* (2005). Both one day (M_1) and two days (M_2) interval of irrigation and 60 per cent PE (S_1) recorded significantly higher WUE, while the interaction effect was non-significant. Compared to flood irrigation, all the intervals and levels of irrigation and their combinations were significantly superior for WUE (Table 2).

When compared with flood irrigation (farmer's practice), the effect due to interval of irrigation on bulb yield was non-significant whereas irrigation at 100 per cent PE was significantly superior over flood irrigation. Among the interactions, M_1S_3 (54.91 t ha^{-1}), M_2S_2 (48.16 t ha^{-1}) and M_2S_3 (52.83 t ha^{-1}) recorded significantly higher bulb yield over flood irrigation. This may be attributed to better performance of growth and yield parameters and in turn this was because of balanced availability of moisture, air and nutrients throughout the crop growth period.

The interaction M_1S_3 and M_2S_3 recorded significantly higher and on par gross returns (₹ 247043 and ₹ 237743 ha^{-1} respectively), net returns (₹ 206658 and ₹ 197708 ha^{-1} respectively) and B: C (6.12 and 5.94 respectively). Compared to flood irrigation, significantly higher gross returns, net returns and B:C ratio was recorded with M_1S_2, M_1S_3, M_2S_2 and M_2S_3 (Table 2). Based ib the results it can be concluded that interval of one or two days irrigation with 100 per cent PE irrigation level individually and their combinations found optimum for higher bulb yield and WUE over flood irrigation.

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